EFSA Journal 2013;11(5):3196

SCIENTIFIC REPORT OF EFSA AND ECDC

The European Union Summary Report on antimicrobial resistance in zoonotic and indicator bacteria from humans, animals and food in 2011[1]

European Food Safety Authority[2, 3]

European Centre for Disease Prevention and Control[2, 3]

European Food Safety Authority (EFSA), Parma, Italy

European Centre for Disease Prevention and Control (ECDC), Stockholm, Sweden

ABSTRACT

The antimicrobial resistance data among zoonotic and indicator bacteria in 2011, submitted by 26 European Union Member States, were jointly analysed by the European Food Safety Authority and the European Centre for Disease Prevention and Control. Data covered resistance in zoonotic *Salmonella* and *Campylobacter* isolates from humans, food and animals, and in indicator *Escherichia coli* and enterococci isolates from animals and food. Data on methicillin-resistant *Staphylococcus aureus* in animals and food were also presented. Resistance in isolates from humans were mainly interpreted using clinical breakpoints, while animal and food isolate resistance was interpreted using epidemiological cut-off values. Resistance was commonly found in isolates from humans, animals and food, although disparities in resistance were frequently observed between Member States. High resistance levels were recorded to ampicillin, tetracyclines and sulfonamides in *Salmonella* isolates from humans, while resistance to third-generation cephalosporins and fluoroquinolones remained low. In *Salmonella* and indicator *Escherichia coli* isolates from fowl, pigs, cattle and meat thereof, resistance to ampicillin, tetracyclines and sulfonamides was also commonly detected, while resistance to third-generation cephalosporins was low. Moderate to high resistance to (fluoro)quinolones was observed in *Salmonella* isolates from turkeys, fowl and broiler meat. In *Campylobacter* isolates from human cases, resistance to ampicillin, ciprofloxacin, nalidixic acid and tetracyclines was high, while resistance to erythromycin was low to moderate. High resistance to ciprofloxacin, nalidixic acid and tetracyclines was observed in *Campylobacter* isolates from fowl, broiler meat, pigs and cattle, whereas much lower levels were observed for erythromycin and gentamicin. Among the indicator enterococci isolates from animals and food, resistance to tetracyclines and erythromycin was commonly detected. The report also presents for the first time results on multi-resistance and co-resistance to critically important antimicrobials in both human and animal isolates. Very few isolates from animals were co-resistant to critically important antimicrobials.

KEY WORDS

Antimicrobial resistance, zoonotic bacteria, indicator bacteria

[1] On request from EFSA, Question No EFSA-Q-2012-00429, approved on 15 April 2013.

[2] Correspondence: in EFSA: zoonoses@efsa.europa.eu; in ECDC: FWD@ecdc.europa.eu

[3] Acknowledgement: EFSA and ECDC wish to thank the members of the Task Force on Zoonoses Data Collection and the Food and Waterborne Disease Network who provided the data and reviewed the report. Also, the contribution of EFSA's staff members: Pierre-Alexandre Belœil, Pia Mäkelä, Patrizia Oelker, Anca Stoicescu, Lucia Senini, Anne-Laure Mouffle, Ilaria Inverardi, Francesca Riolo and Kenneth Mulligan, the contributions of ECDC's staff members: Robert Whittaker, Therese Westrell and Liselott Diaz Högberg, and the contributions of EFSA's contractors: the Animal Health and Veterinary Laboratory Agency of the United Kingdom: Christopher Teale, Lucy Brunton, Tanya Cheney, Daisy Duncan, Peter Sewell, Ian Hillis and Ruth Blackwell and the University of Hasselt: Stijn Jaspers and Marc Aerts, as well as the reviewer: Björn Bengtsson, for the support provided to this scientific output.

Suggested citation: EFSA (European Food Safety Authority) and ECDC (European Centre for Disease Prevention and Control), 2013. The European Union Summary Report on antimicrobial resistance in zoonotic and indicator bacteria from humans, animals and food in 2011. EFSA Journal 2013;11(5):3196, 359 pp. doi:10.2903/j.efsa.2013.3196.

Available online: www.efsa.europa.eu/efsajournal

EUROPEAN UNION SUMMARY REPORT

Antimicrobial resistance in zoonotic and indicator bacteria from humans, animals and food in the European Union in 2011

Issued on 15 April 2013
Published on 16 May 2013

Suggested citation: EFSA (European Food Safety Authority) and ECDC (European Centre for Disease Prevention and Control), 2013. The European Union Summary Report on antimicrobial resistance in zoonotic and indicator bacteria from humans, animals and food in 2011. EFSA Journal 2013;11(5):3196, 359 pp. doi:10.2903/j.efsa.2013.3196.

Available online: www.efsa.europa.eu/efsajournal

About EFSA

The European Food Safety Authority (EFSA), located in Parma, Italy, was established and funded by the European Union (EU) as an independent agency in 2002 following a series of food scares that caused the European public to voice concerns about food safety and the ability of regulatory authorities to protect consumers. EFSA provides objective scientific advice on all matters, in close collaboration with national authorities and in open consultation with its stakeholders, with a direct or indirect impact on food and feed safety, including animal health and welfare and plant protection. EFSA is also consulted on nutrition in relation to EU legislation. EFSA's work falls into two areas: risk assessment and risk communication. In particular, EFSA's risk assessments provide risk managers (EU institutions with political accountability, i.e. the European Commission, the European Parliament and the Council) with a sound scientific basis for defining policy-driven legislative or regulatory measures required to ensure a high level of consumer protection with regard to food and feed safety. EFSA communicates to the public in an open and transparent way on all matters within its remit. Collection and analysis of scientific data, identification of emerging risks and scientific support to the Commission, particularly in the case of a food crisis, are also part of EFSA's mandate, as laid down in the founding Regulation (EC) No 178/2002[4] of 28 January 2002.

About ECDC

The European Centre for Disease Prevention and Control (ECDC), an EU agency based in Stockholm, Sweden, was established in 2005. The objective of ECDC is to strengthen Europe's defences against infectious diseases. According to Article 3 of the founding Regulation (EC) No 851/2004[5] of 21 April 2004, ECDC's mission is to identify, assess and communicate current and emerging threats to human health posed by infectious diseases. In order to achieve this mission, ECDC works in partnership with national public health bodies across Europe to strengthen and develop EU-wide disease surveillance and early warning systems. By working with experts throughout Europe, ECDC pools Europe's knowledge in health so as to develop authoritative scientific opinions about the risks posed by current and emerging infectious diseases.

About the report

Based on Article 33 in the Regulation (EC) 178/2002, EFSA's Zoonoses Unit is responsible for examining data on zoonoses, antimicrobial resistance and food-borne outbreaks collected from the Member States in accordance with Directive 2003/99/EC[6] and for preparing the European Union Summary Report from the results. Regarding antimicrobial resistance data from 2011, this European Union Summary Report was produced in collaboration with ECDC and the Animal Health and Veterinary Laboratories Agency (AHVLA), United Kingdom and the University of Hasselt in Belgium, contracted by EFSA.

Acknowledgement

Contributions received from Robert Whittaker, Therese Westrell and Liselott Diaz Högberg from ECDC and Pierre-Alexandre Belœil, Pia Mäkelä, Patrizia Oelker, Anca Stoicescu, Lucia Senini, Anne-Laure Mouffle Ilaria Inverardi, Francesca Riolo and Kenneth Mulligan from EFSA, as well as that of Christopher Teale, Lucy Brunton, Tanya Cheney, Daisy Duncan, Peter Sewell, Ian Hillis and Ruth Blackwell from the AHVLA and Stijn Jaspers and Marc Aerts from the University of Hasselt, in the preparation of this report are kindly appreciated.

[4] Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. OJ L 31, 01.02.2002, pp. 1–24.

[5] Regulation (EC) No 851/2004 of the European Parliament and of the Council of 21 April 2004 establishing a European Centre for disease prevention and control. OJ L 142, 30.4.2004, pp. 1–11.

[6] Directive 2003/99/EC of the European Parliament and of the Council of 17 November 2003 on the monitoring of zoonoses and zoonotic agents, amending Council Decision 90/424/EEC and repealing Council Directive 92/117/EEC. OJ L 325, 12.12.2003, pp. 31-40.

Summary

Zoonoses are infections and diseases that are transmissible between animals and humans. Infection can be acquired directly from animals, or through the ingestion of contaminated foodstuffs. The severity of these diseases in humans can vary from mild symptoms to life-threatening conditions. The zoonotic bacteria that are resistant to antimicrobials are of special concern since they might compromise the effective treatment of infections in humans. In order to follow the occurrence of antimicrobial resistance in zoonotic bacteria isolated from animals and food in the European Union, information is collected and analysed from the European Union Member States.

In 2011, 26 Member States submitted information on the occurrence of antimicrobial resistance in zoonotic bacteria to the European Commission and the European Food Safety Authority, and 21 Member States submitted information to the European Centre for Disease Prevention and Control. In addition, three other European countries provided information. Assisted by its contractors, the Animal Health and Veterinary Laboratories Agency in the United Kingdom and the University of Hasselt in Belgium, the European Food Safety Authority and the European Centre for Disease Prevention and Control analysed the data, the results of which are published in this European Union Summary Report on antimicrobial resistance. Information on resistance was reported regarding *Salmonella* and *Campylobacter* isolates from human cases, food and animals, whereas data on indicator *Escherichia coli* and indicator enterococci isolates related only to animals and food. Information was reported by some Member States on the occurrence of methicillin-resistant *Staphylococcus aureus* in animals and food; the antimicrobial susceptibility of methicillin-resistant *Staphylococcus aureus* isolates was additionally reported by two countries. Data on antimicrobial resistance in isolates from human cases were mainly interpreted by using clinical breakpoints, while the quantitative data on antimicrobial resistance in isolates from food and animals were interpreted using harmonised epidemiological cut-off values that detect microbiological resistance.

The reporting of antimicrobial resistance data at isolate-based level by an important number of Member States has allowed the first analysis at the European Union level of multi-resistance and co-resistance patterns to critically important antimicrobials in both human and animal isolates, which is a new feature of the present report. Also, for certain bacterial species, antimicrobial resistance data could be analysed at the production-type level, such as broilers and laying hens of *Gallus gallus*, which allows the analysis of the data to be fine-tuned.

Antimicrobial resistance was commonly detected in isolates of *Salmonella* and *Campylobacter* from human cases as well as from food-producing animals and food in the European Union. This was also the case for indicator (commensal) *Escherichia coli* and enterococci isolated from animals and food. For many of the antimicrobials, the levels of resistance varied greatly between different Member States.

In the European Union, the occurrence of resistance in *Salmonella* isolates from cases of salmonellosis in humans was high for ampicillin, tetracyclines and sulfonamides and moderate for nalidixic acid and streptomycin, with high levels of multi-drug resistance observed in some countries. However, resistance to the critically important antimicrobials for human medicine, cefotaxime (a third-generation cephalosporin) and ciprofloxacin (a fluoroquinolone), was relatively low, although for ciprofloxacin reported resistance levels were higher in countries where epidemiological cut-off values were used as the interpretive criteria. Co-resistance to ciprofloxacin and cefotaxime among *Salmonella* isolates was low. The resistance levels also differed substantially between serovars, with higher resistance to ciprofloxacin and nalidixic acid observed in *Salmonella* Enteritidis than in *Salmonella* Typhimurium and the opposite for the other antimicrobials. There was a high level of resistance to ampicillin, ciprofloxacin, nalidixic acid and tetracyclines among *Campylobacter* isolates from human cases, with high and very high levels of multi-drug resistance observed in some countries. However, relatively low resistance was recorded to erythromycin, which is the clinically most important antimicrobial for treatment of campylobacteriosis in humans. In addition, co-resistance to ciprofloxacin and erythromycin was low among *Campylobacter jejuni* isolates.

The high proportions of *Salmonella, Campylobacter* and indicator *Escherichia coli* isolates exhibiting resistance to fluoroquinolones (ciprofloxacin) remain of concern. In *Salmonella* spp. isolates of food and animal origin, the highest occurrence of resistance to ciprofloxacin was noted in turkeys, fowl (*Gallus gallus*) and broiler meat, where the proportion of resistant isolates varied between 29 % and 50 % in the reporting Member State group. Ciprofloxacin resistance was recorded more often in broilers than in laying hens. Three Member States demonstrated a significant increasing trend for ciprofloxacin and nalidixic acid resistance and one a decreasing trend for both antimicrobials in *Salmonella* species from *Gallus gallus* over the period 2005

to 2011. Considering the indicator *Escherichia coli* isolates, the levels of ciprofloxacin resistance observed in isolates from broilers and pigs were 53.1 % and 8.3 %, respectively. Furthermore, high to extremely high resistance to fluoroquinolones was commonly observed in *Campylobacter* isolates from *Gallus gallus* and broiler meat, as well as from pigs and cattle, at levels ranging from 36 % to 78 %.

Resistance to the third-generation cephalosporin cefotaxime was observed in *Salmonella* isolates from *Gallus gallus*, turkeys, pigs, cattle and meat derived from broilers, at very low or low levels varying between 0 % and 3 %, as well as in indicator *Escherichia coli* isolates from *Gallus gallus*, pigs and cattle at levels ranging from <1 % to 6.4 %. Resistance to erythromycin was detected in *Campylobacter* isolates from *Gallus gallus,* poultry meat and pigs at levels of 2 % to 25 %.

Among *Salmonella* isolates from meat and animals, resistance to tetracyclines, ampicillin and sulfonamides was reported at levels of 7 % to 61 % and it was higher in isolates from pigs and turkeys than in those from broilers, laying hens and cattle. Resistance to ciprofloxacin and nalidixic acid was higher in *Salmonella* isolates from broilers and turkeys (33–50 %) than it was in isolates from laying hens, pigs or cattle (1–13 %). In isolates of *Campylobacter* from meat and animals, resistance was commonly detected to tetracyclines at levels up to 75 %, whereas much lower resistance was reported to gentamicin (levels lower than 7 %).

Among indicator *Escherichia coli* from broilers and pigs, resistance to tetracyclines, ampicillin and sulfonamides was commonly reported at levels of 37 % to 57 %, resistance levels being lower in laying hens (14 % to 18 %). In the case of cattle, levels of resistance to these antimicrobials fell within the range 20 % to 74 % in younger age groups, mainly fattening veal calves, but values were much lower in older cattle, mainly adult cows. In general, resistance levels were lower among isolates from cattle and layers than in isolates from broilers and pigs.

Among indicator enterococci, resistance to tetracyclines and erythromycin was common in isolates from *Gallus gallus*, pigs and cattle at levels of 23 % to 79 %, the resistance being the lowest for isolates from cattle. Resistance to vancomycin continued to be detected, albeit at very low levels (maximum 0.7 %), in enterococcal isolates from animals.

Multi-resistance (reduced susceptibility to at least three antimicrobial classes according to epidemiological cut-off values) was high in *Salmonella* isolates from broilers, turkeys and pigs and in indicator *Escherichia coli* isolates from broilers and pigs in those countries reporting isolate-based data. However, co-resistance to the clinically important antimicrobials ciprofloxacin and cefotaxime was detected in very few isolates of *Salmonella* species and indicator *Escherichia coli.* Multi-resistance was generally low in *Campylobacter jejuni* isolates from broilers, and co-resistance to ciprofloxacin and erythromycin was either not detected or recorded at low levels.

Several statistically significant national trends in resistance levels in isolates from animals and food were observed. Among *Salmonella* isolates more decreasing than increasing trends were found, whereas, in the case of *Campylobacter*, the statistically significant national trends were mostly increasing.

TABLE OF CONTENTS

1. INTRODUCTION

The antimicrobial agents used in food-producing animals in Europe are frequently the same, or belong to the same classes, as those used in human medicine. Antimicrobial resistance is the main undesirable side effect of antimicrobial use in both humans and animals and results from the continuous positive selection of resistant bacterial clones, whether these are pathogenic, commensal or even environmental bacteria. This will modify the population structure of microbial communities, leading to accelerated evolutionary trends with unpredictable consequences for human health. The use of antimicrobials can differ in humans and food-producing animals, in terms of both the methods of administration and the quantities administered; there are important variations between and within food-producing animal species, as well as between countries.

Bacterial resistance to antimicrobials occurring in food-producing animals can spread to people not only via food-borne routes but also by routes such as water or environmental contamination as well as through direct animal contact. *Campylobacter*, *Salmonella* and some strains of *Escherichia coli* (*E. coli*) are examples of zoonotic bacteria which can infect people by the food-borne route. Infections with bacteria which are resistant to antimicrobials may result in treatment failures or necessitate the use of second-line antimicrobials for therapy. The commensal bacterial flora can also form a reservoir of resistance genes which may transfer between bacterial species, including transference to organisms capable of causing disease in both humans and animals (EFSA, 2008a).

The monitoring of antimicrobial resistance in zoonotic and commensal bacteria in food-producing animals and food thereof is a prerequisite for understanding the development and diffusion of resistance, providing relevant risk assessment data, and evaluating targeted interventions. Resistance monitoring entails specific and continuous data collection, analysis and reporting that quantitatively follow temporal trends in the occurrence and distribution of resistance to antimicrobials, and should also allow the identification of emerging or specific patterns of resistance.

1.1. AMR monitoring and reporting at EU level

According to Directive 2003/99/EC on the monitoring of zoonoses and zoonotic agents, Member States (MSs) are obliged to monitor and report antimicrobial resistance in *Salmonella* and *Campylobacter* isolates from animals and food. In addition, Commission Decision 2007/407/EC[7] lays down detailed requirements on the harmonised monitoring and reporting of antimicrobial resistance of *Salmonella* isolates from various poultry populations and pigs, sampled under the corresponding national control and monitoring programmes of *Salmonella*. The monitoring and reporting of antimicrobial resistance data from the indicator organisms *E. coli* and enterococci is voluntary.

Decision 2119/98/EC[8] on setting up a network for the epidemiological surveillance and control of communicable diseases in the EU, as complemented by Decision 2000/96/EC[9] with amendment 2003/542/EC[10] on the diseases to be progressively covered by the network, established the basis for data collection on human diseases from MSs. The decisions foresee that data from the networks shall be used in the EU Summary Reports. Consequently, the European Centre for Disease Prevention and Control (ECDC) has provided data on zoonotic infections in humans, as well as their analyses, for the Community Summary Reports since 2005. Starting in 2007, data on human cases have been reported from The European Surveillance System (TESSy), maintained by ECDC.

This EU Summary Report 2011 includes data related to the occurrence of antimicrobial resistance both in isolates from animals and foodstuffs, collected in the framework of Directive 2003/99/EC, and in isolates from human cases, derived from the networks under Decision 2119/98/EC. This report is a joint collaboration between the European Food Safety Authority (EFSA) and ECDC with the assistance of EFSA's contractors, the Animal Health and Veterinary Laboratories Agency (AHVLA) in the United Kingdom and the University of

[7] Decision 2007/407/EC: Commission Decision of 12 June 2007 on a harmonised monitoring of antimicrobial resistance in *Salmonella* in poultry and pigs. OJ L153, 14.6.2007, pp. 26–29.

[8] Decision 2119/98/EC of the European Parliament and of the Council of 24 September 1998 setting up a network for the epidemiological surveillance and control of communicable diseases in the Community. OJ L268, 3.10.1998, pp. 1–7.

[9] Decision 2000/96/EC on communicable diseases to be progressively covered by the Community network under Decision No 2119/98/EC of the European Parliament and of the Council. OJ L180, 11.7.2009, pp. 22–23.

[10] Decision 2003/542/EC Commission Decision of 17 July 2003 amending Decision 2000/96/EC as regards the operation of dedicated surveillance networks. OJ L185, 24.7.2003, pp. 55–58.

Hasselt in Belgium. MSs, other reporting countries, the European Commission (EC) and the relevant European Union Reference Laboratories (EU-RL) were consulted while preparing the report. The efforts made by MSs, the reporting non-MSs as well as by the EC in the reporting of zoonoses data and in the preparation of this report are gratefully acknowledged.

The main issues when comparing antimicrobial resistance data originating from different countries are the use of different laboratory methods and different interpretative criteria of resistance. These issues have been addressed by the development of the EFSA's guidelines for harmonised monitoring and reporting of resistance in food-producing animals and food thereof. The resistance monitoring performed under these guidelines utilises epidemiological cut-off values (ECOFFs) which separate the naïve, susceptible wild-type bacterial populations from isolates that have developed reduced susceptibility to a given antimicrobial agent (Kahlmeter et al., 2003). The ECOFFs may differ from breakpoints used for clinical purposes, which are defined against a background of clinically relevant data, including therapeutic indication, clinical response data, dosing schedules, pharmacokinetics and pharmacodynamics. In the EU Summary Reports on antimicrobial resistance from 2004 to 2010, ECOFFs were applied to minimum inhibitory concentration (MIC) data to define resistant *Salmonella*, *Campylobacter*, indicator *E. coli* and indicator enterococci isolates from animals and food. The use of harmonised methods and ECOFFs ensured the comparability of data over time at country level and also facilitated the comparison of the occurrence of resistance between MSs. The same methods and principles have been applied in this 2011 Summary Report on antimicrobial resistance.

The antimicrobial susceptibility data reported to EFSA for the year 2011 for *Campylobacter*, *Salmonella*, indicator *E. coli* and indicator enterococci isolates from animals and food were analysed and all quantitative data were interpreted using ECOFFs. This report also includes results of phenotypic monitoring of resistance caused by extended-spectrum beta-lactamases (ESBLs) in *Salmonella* and indicator *E. coli*, conferring resistance to third-generation cephalosporins, as well as the first investigation at the EU level of the occurrence of complete susceptibility and multi-resistance in data reported at isolate level. A list of the antimicrobials included in this evaluation of multi-resistance can be found in Chapter 11–Materials and methods. The majority of antimicrobial resistance data reported to EFSA by MSs comprised data collected in accordance with EFSA's monitoring guidelines; quantitative disc diffusion data constituted only a small percentage of the total data and were analysed in the report as qualitative data only. This has circumvented the problem that ECOFFs are not available for the different disc diffusion methods used by MSs.

The report also encompasses resistance in *Salmonella* and *Campylobacter* isolates from human cases of salmonellosis and campylobacteriosis, respectively. These data were reported as qualitative data, mostly interpreted using clinical breakpoints, by MSs to TESSy. An important general feature of this report is that human data are largely based on susceptibility testing of clinical isolates, whereas animal data are based mainly on the testing of isolates from healthy animals, where testing has been performed in accordance with EFSA's recommendations. The data on zoonotic bacteria from humans have largely been collated and collected using clinical breakpoints. Such data are therefore not always directly comparable with data from food-producing animals and food, which have been analysed using ECOFFs. Indeed, the use of ECOFFs in animal and food isolates generally conveys the picture of 'microbiological resistance' levels in these isolates higher than 'clinical resistance' levels recorded in human isolates, where clinical breakpoints have been used. These issues are discussed further in the chapters on *Campylobacter* and *Salmonella*. Universal adoption and understanding of the distinction between clinical breakpoints and ECOFFs would enable clinicians to choose the appropriate treatment based on information relevant to the individual patient, yet would recognise that epidemiologists need to be aware of small changes in bacterial susceptibility, which may indicate emerging resistance and allow for appropriate control measures to be considered. ECOFFs, clinical breakpoints and related concepts regarding antimicrobial resistance/susceptibility are presented in detail hereafter.

1.2. Epidemiological cut-off values and clinical breakpoints

The European Committee on Antimicrobial Susceptibility Testing (EUCAST) has defined clinical breakpoints and epidemiological cut-off values. A micro-organism is defined as clinically resistant when the degree of resistance shown is associated with a high likelihood of therapeutic failure. The micro-organism is categorised as resistant by applying the appropriate clinical breakpoint in a defined phenotypic test system, and this breakpoint may alter with legitimate changes in circumstances (for example, alterations in dosing regime, drug formulation, patient factors).

A micro-organism is defined as wild-type for a bacterial species when no acquired or mutational resistance mechanisms are present to the antimicrobial in question. A micro-organism is categorised as wild-type for a given bacterial species by applying the appropriate ECOFF value in a defined phenotypic test system. This cut-off value will not be altered by changing circumstances (such as alterations in frequency of antimicrobial administration). Wild-type micro-organisms may or may not respond clinically to antimicrobial treatment. A micro-organism is defined as non-wild-type for a given bacterial species by the presence of an acquired or mutational resistance mechanism to the antimicrobial in question. A micro-organism is categorised as non-wild-type for a given bacterial species by applying the appropriate ECOFF value in a defined phenotypic test system; non-wild-type organisms are considered to show 'microbiological resistance' (as opposed to 'clinical resistance'). Clinical breakpoints and ECOFFs may be the same, although it is often the case that the ECOFF is lower than the clinical breakpoint.

Comparative advantages and disadvantages of the use of clinical breakpoints versus ECOFFs (see box hereafter) have been taken into account in the detailed specifications for harmonised monitoring schemes on antimicrobial resistance in animals and food devised by EFSA. These guidelines have been published (EFSA, 2007, 2008a) and the terminology used is that devised by EUCAST (Kahlmeter et al., 2003). As far as possible, ECOFFs have been used in this report, as recommended in the guidelines, to determine non-wild-type organisms also termed 'microbiologically resistant' organisms, and to ensure that results from different MSs are comparable. Hereafter in this report, 'microbiologically antimicrobial-resistant' organisms are referred to as 'resistant' for brevity.

CLINICAL BREAKPOINTS (CLINICAL RESISTANCE)

The clinician, or veterinarian, choosing an antimicrobial agent to treat humans or animals with a bacterial infection requires information that the antimicrobial selected is effective against the bacterial pathogen. Such information will be used, together with clinical details such as the site of infection, ability of the antimicrobial to reach the site of infection, formulations available and dosage regimes, when determining an appropriate therapeutic course of action. The in vitro *susceptibility of the bacterial pathogen can be determined and clinical breakpoints used to ascertain whether the organism is likely to respond to treatment. Clinical breakpoints will take into account the clinical behaviour of the drug following administration and assume that a clinical response will be obtained if the drug is given as recommended and there are no other adverse factors which affect the outcome. Conversely, if the clinical breakpoint indicates resistance, then it is likely that treatment will be unsuccessful. Frequency of dosing is one factor that can affect the antimicrobial concentration achieved at the site of infection. Therefore, different dosing regimes can lead to the development of different clinical breakpoints, as occurs in some countries for certain antimicrobials where different therapeutic regimes are in place. Although the rationale for the selection of different clinical breakpoints may be clear, their use makes the interpretation of results from different countries in reports of this type problematic, as the results are not directly comparable between those different countries.*

EPIDEMIOLOGICAL CUT-OFF VALUES (MICROBIOLOGICAL RESISTANCE)

For a given bacterial species, the pattern of the Minimum inhibitory concentration (MIC) distribution or the inhibition zone diameter distribution (i.e. the frequency of occurrence of each given MIC or zone diameter plotted against the MIC value or zone diameter obtained) can enable the separation of the wild-type population of micro-organisms from those populations which show a degree of resistance. The wild-type susceptible population is assumed to have no acquired or mutational resistance and commonly shows a normal distribution.

When bacteria acquire resistance by a clearly defined and efficacious mechanism, such as the acquisition of a plasmid bearing a gene which produces an enzyme capable of destroying the antimicrobial, then the MIC or zone diameter distribution commonly shows two major sub-populations, one a fully susceptible normal distribution of isolates and the other a fully resistant population which has acquired the resistance mechanism. Resistance may be achieved by a series of small steps, such as changes in the permeability of the bacterial cell wall to the antimicrobial or other mechanisms which confer a degree of resistance. In this case, there may be populations of organisms which occur lying between the fully susceptible population and more resistant populations. The epidemiological cut-off value indicates the MIC or zone diameter above which the pathogen has some detectable reduction in susceptibility. Epidemiological cut-off values are derived by testing an adequate number of isolates to ensure that the wild-type population can be confidently identified for a given antimicrobial. The clinical breakpoint, which is set to determine the therapeutic effectiveness of the antimicrobial, may fail to detect emergent resistance. Conversely, the epidemiological cut-off value detects any deviation in susceptibility from the wild-type population, although it may not be appropriate for determining the likelihood of success or failure for clinical treatment.

The EUCAST ECOFFs which should be applied to interpret the results obtained by MSs are quoted in Commission Decision 2007/407/EC. However, since this Decision was adopted, there have been some minor changes to a few of the ECOFFs for some antimicrobials. This occurs because, as more data are collected relating to more bacterial isolates, the normal distribution of the wild-type population can in some cases be better defined. This 2011 EU Summary Report interprets the antimicrobial resistance data in accordance with the current Decision. The Decision is currently undergoing review by the EC, notably on the basis of the technical specifications proposed for harmonised monitoring of antimicrobial resistance in animals and food recently issued by the EFSA (EFSA 2012a, b, c), and the expected revision in the future will update a number of the ECOFFs to be used.

1.3. Developments in the harmonised monitoring of antimicrobial resistance

The EFSA, at the request of the EC, has prepared detailed specifications for the harmonised monitoring of antimicrobial resistance in food-producing animals. These were developed by an expert working group, established under the Task Force on Zoonoses Data Collection, which recommended guidelines for the monitoring of antimicrobial resistance in *Salmonella* and *Campylobacter* (EFSA, 2007) and also in indicator *E. coli* and enterococci[11] (EFSA, 2008a). These guidelines include detailed protocols on sampling strategies, the method of susceptibility testing, the antimicrobials to be tested and the criteria for categorising isolates as susceptible or resistant, as well as making recommendations on quality control and reporting. The guidelines have been developed for use in all 27 EU MSs and have been progressively implemented. Information collected using these guidelines has formed the majority of the data on antimicrobial resistance in bacteria from animals and food published in previous reports.

The EFSA, at the further request of the EC, has reviewed and revised the detailed specifications for the harmonised monitoring of antimicrobial resistance in food-producing animals in 2012, again assembling an expert working group to carry out the tasks. The working group also focused on refining and developing the monitoring of multiple antimicrobial resistance (which has been facilitated by the collection of data which can be related to an individual isolate), while two further working groups have produced recommendations describing in detail the detection and characterisation of beta-lactamase and carbapenemase resistance and the monitoring of MRSA. Three reports have been produced (EFSA 2012a, b, c) (see box below).

DEVELOPMENTS IN THE MONITORING OF ANTIMICROBIAL RESISTANCE

EFSA has published three reports (EFSA, 2012a, b, c) describing proposals and aims for developing and enhancing the future monitoring of antimicrobial resistance. A brief synopsis of these reports is presented below.

TECHNICAL SPECIFICATIONS FOR THE ANALYSIS AND REPORTING OF DATA ON ANTIMICROBIAL RESISTANCE IN THE EUROPEAN UNION SUMMARY REPORT (EFSA, 2012a)

This report describes proposals to improve the harmonisation, analysis and reporting of data on antimicrobial resistance in animals and food collected from the MSs, based on a critical review of the EU Summary Reports which have been previously issued. It reinforces the use of epidemiological cut-off values in the monitoring programmes and makes proposals to complement the harmonised panel of antimicrobials used for susceptibility testing. A logistic regression modelling approach is recommended to assess trend significance, and this has been adopted in the current report. It suggests that weighted indicators of resistance should be designed at EU level, accounting for prevalence of bacteria, occurrence of resistance and monitoring design at national level. It considers it essential that resistance data should no longer be reported in an aggregate fashion but at isolate level in order to address the phenomenon of multi-resistance. It provides a definition and an approach to the analysis of multi-resistance as well as a list of important co-resistance patterns.

[11] *E. coli* and enterococci (i.e. *Enterococcus faecium* and *E. faecalis*) can be used as indicator organisms of, respectively, the Gram-negative and Gram-positive commensal intestinal flora. These three bacteria are commonly isolated from animal faeces; and most resistance phenotypes present in the animal populations are present in these species. In addition, the effects of use patterns of antibiotics in a given country and animal species, as well as trends in the occurrence of resistance, can be studied more accurately in indicator organisms than in food-borne pathogens because all food animals generally carry these indicator bacteria.

TECHNICAL SPECIFICATIONS ON THE HARMONISED MONITORING AND REPORTING OF ANTIMICROBIAL RESISTANCE IN *SALMONELLA*, *CAMPYLOBACTER* AND INDICATOR *ESCHERICHIA COLI* AND *ENTEROCOCCUS* SPP. BACTERIA TRANSMITTED THROUGH FOOD (EFSA, 2012b)

These recommendations introduce the concept of a threshold for animal populations and meat derived therefrom, to determine whether monitoring of those populations and the meat produced from them should be mandatory or optional. The volume of production will affect the degree of exposure of consumers and the threshold attempts to prioritise the types of production which should be monitored, based on consumer exposure. The antimicrobials for inclusion in the monitoring programme have been broadened to include additional substances which either are important from the public health perspective or provide additional information for epidemiological purposes, for example providing an insight into resistance mechanisms involved. Thus, carbapenems are extremely important antimicrobials in human medicine and constitute one of the antimicrobial options of last resort in certain multi-drug-resistant bacterial infections. A carbapenem has been included in the recommended monitoring programme, which is tiered, so that resources can be targeted cost-effectively. Analytical methods are suggested for the characterisation of Salmonella *and* E. coli *isolates which are resistant to third-generation cephalosporins, in particular to distinguish between ESBL and AmpC enzyme-producing organisms, on both phenotypic and molecular grounds. The recommendations also suggest protocols for the specific monitoring of ESBL-producing* E. coli *using selective procedures, rather than utilising randomly selected* E. coli *from non-selective culture plates. The recommendations include the inclusion of teicoplanin in the monitoring of enterococci, since the genotype relating to glycopeptide resistance may be inferred from the susceptibility to vancomycin and teicoplanin. The dilution range for ciprofloxacin is deliberately recommended to be wide, since multiple resistance mechanisms can contribute to fluoroquinolone resistance and these mechanisms may be acquired in a step-wise fashion. The recent emergence of* Salmonella *Kentucky with high-level resistance to ciprofloxacin (above or equal to 8 mg/L) illustrates the value of this recommended measure.*

TECHNICAL SPECIFICATIONS ON THE HARMONISED MONITORING AND REPORTING OF ANTIMICROBIAL RESISTANCE IN METHICILLIN-RESISTANT *STAPHYLOCOCCUS AUREUS* (EFSA, 2012c)

This report contains proposals to improve the harmonisation of monitoring of the prevalence, genetic diversity and antimicrobial resistance of methicillin-resistant Staphylococcus aureus *(MRSA) from food-producing animals and food derived from those animals by the EU MSs. The primary route of zoonotic transmission of MRSA is considered to be the occupational contact of livestock professionals with colonised animals; the role of food as a source of human colonisation or infection with MRSA is presently considered to be low. The sampling recommendations therefore prioritise food-producing animal populations previously described as reservoirs of MRSA and to a lesser extent meat produced from these animals. Monitoring of broiler flocks, fattening pigs and dairy cattle, as well as fattening veal calves and fattening turkey flocks in those countries where the domestic production exceeds 10,000,000 tons slaughtered/year is recommended every third year on a rotating basis. It is proposed that breeding poultry flocks and breeding pigs, as well as meat and raw milk products, should be monitored on a voluntary basis. The report puts forward cost-effective methods whereby MRSA monitoring could be carried out at the same time as other monitoring (for example the National* Salmonella *Control Programmes) and describes harmonised analytical methods for the identification, typing and further characterisation of MRSA. The use of a microdilution method applied to a harmonised set of antimicrobials and interpreted using EUCAST epidemiological cut-off values for antimicrobial susceptibility testing of MRSA is recommended. Full support is given to the collection and reporting of isolate-based data, in order to enable more in-depth analyses to be conducted, in particular regarding the occurrence of multi-resistance. Ongoing evolution and development of the situation relating to MRSA in animals may occur and is exemplified by the recent description of MRSA ST49 in Switzerland (Overesch et al., 2011) (see Chapter 8 for more information).*

2. MAIN FINDINGS

2.1. Main findings of the European Union Summary Report on antimicrobial resistance 2011

- In 2011, MSs reported qualitative data on antimicrobial resistance in *Salmonella* and *Campylobacter* isolates from human cases mostly interpreted by using clinical breakpoints to define the resistant isolates. In contrast, quantitative data (minimum inhibitory concentrations (MICs) and/or inhibition zone diameter (IZD) results) on antimicrobial resistance, reported for isolates from food and animals, were interpreted by using epidemiological cut-off values. Epidemiological cut-off values are often lower than clinical breakpoints, and this can result in more isolates being classified as resistant, depending on the MIC distribution.

- Antimicrobial resistance was regularly observed in isolates of *Salmonella* and *Campylobacter* from human cases as well as from food-producing animals and food in the EU. This was also the case for indicator (commensal) *Escherichia coli* (*E. coli*) and enterococci isolated from animals and food. For many of the antimicrobials, the levels of resistance varied greatly between different MSs and animal production types.

- Fluoroquinolones, such as ciprofloxacin, and third-generation cephalosporins, such as cefotaxime, are considered critically important antimicrobials in the treatment of severe salmonellosis in humans. Likewise, fluoroquinolones and macrolides, such as erythromycin, are considered critically important for treating severe *Campylobacter* infections. Therefore, special attention was paid to resistance against these substances in the analyses of the data.

- Resistance at the EU level in ***Salmonella*** spp. isolates from human cases was high (between 20 % and 30 %) to ampicillin, tetracyclines and sulfonamides. In contrast, resistance to the critically important antimicrobials ciprofloxacin and cefotaxime was relatively low (on average <10 % and <1 %, respectively). Higher resistance levels to ciprofloxacin were reported by the few countries using epidemiological cut-off values as interpretative criteria in human data.

- Multi-resistance (defined as reduced susceptibility to at least three antimicrobial classes) was high in human *Salmonella* isolates in some countries; however, there were low levels of co-resistance to ciprofloxacin and cefotaxime. Furthermore, more than half of all *Salmonella* isolates were susceptible to the complete range of antimicrobials tested.

- In food and animal isolates, the highest occurrence of resistance to ciprofloxacin was noted in *Salmonella* spp. isolates from fowl (*Gallus gallus*), broiler meat and turkeys (from 28.7 % to 50.4 % at the MS group level). The further sub-division of the *Gallus gallus* species into production types revealed higher overall resistance to ciprofloxacin in *Salmonella* spp. isolates from broilers (35.1 %) than in those from laying hens (12.7 %). In cattle, pigs and pig meat, low resistance levels were observed (from 1.7 % to 7.4 %).

- Resistance to cefotaxime (a third-generation cephalosporin) was observed in *Salmonella* spp. isolates from *Gallus gallus*, turkeys and pigs and in the meat derived from broilers and pigs, but at low or very low levels (0.4 % to 3.3 %), when all reporting MSs were considered. However, even low levels of resistance to this critically important antimicrobial are important, and increases in resistance to cefotaxime compared with 2010 data were observed in some MSs. Resistance to cefotaxime was not detected in *Salmonella* strains isolated from cattle in the reporting countries in 2011.

- Resistance to tetracyclines, ampicillin and sulfonamides was frequently reported among *Salmonella* spp. isolates from meat and animals (from 7.1 % to 60.5 % at MS group level). Resistance to these antimicrobials was higher in isolates from pigs, turkeys and cattle (29.1 % to 60.5 %) than in isolates from *Gallus gallus* (17.8 % to 25.3 %).

- Multi-resistance (reduced susceptibility to at least three antimicrobial classes according to epidemiological cut-off values) was high in *Salmonella* spp. isolates from animals in some countries reporting isolate-based data; however, co-resistance to the clinically important antimicrobials, ciprofloxacin and cefotaxime, was at very low to low levels.

- The resistance among ***Campylobacter*** spp. isolates from human cases was high to very high (between 30 % and 50 %) for ampicillin, ciprofloxacin, nalidixic acid and tetracyclines. Low resistance levels (average 3.5 %) were observed to the clinically important antimicrobial, erythromycin. Multi-resistance in human *Campylobacter* isolates was high or very high in some countries. Levels of co-resistance to the clinically important antimicrobials, ciprofloxacin and erythromycin, were on average low among *Campylobacter jejuni* (*C. jejuni*) isolates and moderate among *Campylobacter coli* (*C. coli*) isolates.

- Extremely high resistance to ciprofloxacin (a fluoroquinolone) was commonly observed in *C. coli* isolates from broilers (*Gallus gallus*) and broiler meat (76.6 % and 77.7 %, respectively), with somewhat lower levels in *C. jejuni* (57.2 % and 59.2 %, respectively). High levels were also reported for isolates from pigs and cattle (35.5 % to 38.8 %). Important differences were observed between animal species and MSs.

- Resistance to erythromycin was detected at low levels in *Campylobacter* isolates from broilers (*Gallus gallus*) and poultry meat (1.6 % to 9.8%), except for *C. coli* in broilers, in which moderate resistance was detected (15.5 %). The highest level of resistance to erythromycin at the reporting MS group level was observed in *C. coli* isolates from pigs (24.5 %), while the level of erythromycin resistance in isolates of *C. jejuni* from cattle across reporting MSs was very low (0.8 %).

- Resistance to nalidixic acid and tetracyclines was common among *Campylobacter* isolates from meat and animals (from 32.4 % to 74.6 %), whereas resistance to gentamicin was low (from 0.8 % to 7.2 %). As for *Salmonella,* levels of resistance to nalidixic acid followed closely those observed for ciprofloxacin.

- Multi-resistance (reduced susceptibility to at least three antimicrobial classes according to epidemiological cut-off values) was generally low in *C. jejuni* isolates from broilers and meat thereof, and co-resistance to the clinically important antimicrobials, ciprofloxacin and erythromycin, was, in the same isolates, either not detected or recorded at low levels. Multi-resistance and co-resistance levels were generally higher in *C. coli* isolates from broilers.

- Among **indicator (commensal) *E. coli*** isolates from animals, resistance to tetracyclines, ampicillin, streptomycin and sulfonamides was commonly reported in *Gallus gallus* and pigs (from 36.6 % to 57.0 %), moderate levels being reported in cattle (from to 13.3 % to 20.2 %). Resistance to ciprofloxacin and nalidixic acid was highest among *E. coli* isolates from *Gallus gallus* (40.5 % and 33.7 %, respectively), while levels were low in pigs and cattle (4.8 % to 8.3 %). Cefotaxime resistance was low in all species (0.9 % to 6.4 %), and highest in isolates from *Gallus gallus* (6.4 %), considering all reporting MSs. At the MS level, resistance to cefotaxime in indicator *E. coli* showed wider variation in some species or production types, for example between 0 % and 20.8 % in broilers. In general, resistance to third-generation cephalosporins in *E. coli* was higher than that observed in *Salmonella* spp. for the same species of animals, which is consistent with the hypothesis that *E. coli* may provide a reservoir of cephalosporin resistance genes for organisms such as *Salmonella*.

- Multi-resistance was high in **indicator (commensal) *E. coli*** isolates from animals in some countries reporting isolate-based data; however, co-resistance to the clinically important antimicrobials, ciprofloxacin and cefotaxime, was generally reported at very low to low levels.

- Among **indicator (commensal) enterococci**, resistance to tetracyclines and erythromycin remained common in isolates from broilers (*Gallus gallus*), pigs and cattle (from 22.9 % to 78.9 %), with the lowest levels of resistance occurring in isolates from cattle (22.9 % to 35.6 %). Vancomycin resistance continued to be detected in some animal species, but at very low levels (0.4 % to 0.7 %), although none of the meat samples tested yielded bacteria resistant to this antimicrobial.

- Several statistically significant national trends in resistance levels in isolates from animals and food were observed. Among *Salmonella* spp. isolates, more decreasing than increasing trends were found, whereas, in *Campylobacter* isolates, the statistically significant national trends were mostly increasing.

- More countries reported data for indicator (commensal) *E. coli* and enterococci in 2011 than in 2010.

2.2. Zoonotic and indicator agent-specific summaries

Salmonella

The *Salmonella* spp. data presented in this report comprise results for all reported *Salmonella* serovars which have been amalgamated to represent the overall occurrence of antimicrobial resistance in *Salmonella* within the various animal and food categories. The differences in the distribution and prevalence of particular serovars and phage types of *Salmonella* in different countries and in different animal species, and their associated patterns of resistance, may explain some of the differences in the levels of antimicrobial resistance observed as well as in those of multi-resistance. The spread of particularly resistant clones, and the occurrence of resistance genes within these clones, can be exacerbated by the use of antimicrobials in human and animal population and the selective pressure this exerts. Other factors, such as foreign travel by humans, animal movements, farming systems, animal husbandry and the pyramidal structure of some types of animal primary production can also influence the spread of resistant clones.

In addition to the amalgamated data for *Salmonella* spp., resistance data for the most important *Salmonella* serovars for public health, *Salmonella* Enteritidis (*S.* Enteritidis) and *S.* Typhimurium, were analysed separately. A selection of other serovars of public health importance were also analysed in a specific chapter of the report.

In humans

In 2011, 19 MSs and one non-MS provided information on antimicrobial resistance in *Salmonella* isolates from cases of salmonellosis in humans.

The reported data represented 26.6 % of the confirmed salmonellosis cases reported in the EU in 2011. Resistance in human *Salmonella* isolates was high for ampicillin (26.6 %), tetracyclines (27.1 %) and sulfonamides (21.5 %) and moderate for streptomycin (18.4 %) and nalidixic acid (15.3 %), and high levels of multi-resistance were observed in some countries (24.1 % overall). For these first four antimicrobials this was largely due to the high to extremely high resistance levels observed among *S.* Typhimurium and monophasic *S.* Typhimurium isolates. However, more than half of all isolates tested were susceptible to the complete range of antimicrobials in the human data collection. In addition, the resistance to the clinically important antimicrobials ciprofloxacin and cefotaxime was relatively low (9.1 % and 0.8 %, respectively), albeit reported level of resistance to ciprofloxacin were, as expected, markedly higher in countries using epidemiological cut-off values or similar values for interpretation of resistance results than in those using clinical breakpoints, with the exception of Italy. Co-resistance to ciprofloxacin and cefotaxime among isolates was very low (0.3 %). Resistance to quinolones (ciprofloxacin and nalidixic acid) was generally higher in *S.* Enteritidis isolates than in *S.* Typhimurium isolates.

Among other prevalent serovars, *S.* Kentucky isolates exhibited very high or extremely high resistance to all tested antimicrobials, when compared with all non-typhoidal *Salmonella* isolates, except for cefotaxime. There was notably higher resistance to ciprofloxacin, nalidixic acid, sulfonamides and tetracyclines in *S.* Infantis isolates than in all non-typhoidal *Salmonella* isolates. Conversely, *S.* Newport isolates had a comparatively low level of resistance to all antimicrobials. It is important to note that for some serovars, sufficient data for making separate country estimates was often available from only one or two countries. When assessed by geographical region, *Salmonella* spp. isolates acquired within the EU/EEA countries exhibited greater resistance to ampicillin and streptomycin, while the highest level of resistance to six of the antimicrobials tested was observed in isolates acquired from Asia.

In animals and food

In 2011, information on antimicrobial resistance in *Salmonella* isolates from animals and food was reported by 20 MSs and one non-MS.

Among *Salmonella* spp. isolates from *Gallus gallus*, the resistance level to tetracyclines, ampicillin and sulfonamides in all reporting MSs was at moderate level, 17.8 %, 18.9 % and 25.3 %, respectively. Resistance to ciprofloxacin and nalidixic acid was higher (28.7 % and 27.9 %, respectively), for all reporting MSs. In general, there were large variations in the levels of resistance to these antimicrobials between different reporting MSs. The occurrence of resistance to cefotaxime in all reporting MSs was low, at 1.5 %.

For the first year, data were presented at production type level, where possible, throughout the report. In 2011, 13 MSs reported quantitative data from broilers, and in general the levels of resistance in this production type were slightly higher than those reported when all *Gallus gallus* production types were considered. Twelve MSs reported quantitative data from laying hens in 2011, and in contrast to the data from broilers, the levels of resistance in this production type were lower than those reported when all *Gallus gallus* were considered.

Multi-resistance levels (reduced susceptibility to at least three different antimicrobial classes using epidemiological cut-off values) were generally high in *Salmonella* spp. isolates from broilers and low in those from laying hens. Co-resistance to ciprofloxacin and cefotaxime was very low, and not detected when using clinical breakpoints.

Some MSs showed statistically significant increasing trends in resistance among *Salmonella* spp. isolates from *Gallus gallus* over the years 2005–2011, whereas other MSs exhibited decreasing trends. Statistically significant decreasing trends were more frequently observed than significant increasing trends. Three MSs demonstrated a significant increasing trend for ciprofloxacin and nalidixic acid resistance and one a decreasing trend for both antimicrobials. In particular, resistance to cefotaxime remained generally low, very low or absent in reporting MSs between 2005 and 2011.

Resistance in *S.* Enteritidis was generally lower than in *Salmonella* spp. isolates from *Gallus gallus*, except to ciprofloxacin and nalidixic acid, for which resistance is at the same levels as for *Salmonella* spp. In *S.* Enteritidis the occurrence of resistance for all reporting MSs was 2.5 % for tetracyclines, 5.5 % for ampicillin and 4.8 % for sulfonamides, whereas the level of resistance to both ciprofloxacin and nalidixic acid was 30.8 %.

In *Salmonella* spp. isolates from broiler meat, resistance levels for all reporting MSs for tetracyclines and sulfonamides were high at 43.7 % and 44.8 %, respectively. Resistance to ciprofloxacin and nalidixic acid resistance was also very high, with overall resistance levels of 50.1 % and 48.8 %, respectively. The resistance level for cefotaxime was low, at 3.3 %.

Among *Salmonella* spp. isolates from turkeys, the level of resistance to tetracyclines, ampicillin and sulfonamides in all reporting MSs was high at 52.2 %, 43.6 % and 51.0 %, respectively. The levels of resistance to ciprofloxacin and nalidixic acid were also high, at 50.4 % and 36.9 %, respectively, for all reporting MSs. There were commonly large variations in the levels of resistance to these antimicrobials among the different reporting MSs. The occurrence of resistance to cefotaxime in all reporting MSs was very low, at 0.4 %. Multi-resistance was generally high in *Salmonella* spp. isolates from turkeys; however, co-resistance to ciprofloxacin and cefotaxime (interpreted using clinical breakpoints) was not detected.

For *Salmonella* spp. isolates from pigs, resistance levels in the reporting group of MSs were very high: 60.5 % for tetracyclines, 54.2 % for ampicillin and 60.5 % for sulfonamides. Ciprofloxacin and nalidixic acid resistance levels remained low, at 4.0 % and 3.4 % respectively, and the level of resistance to cefotaxime was also very low, at 1.0 % overall. Resistance to tetracyclines, ampicillin and sulfonamides was common in *Salmonella* spp. from pig meat, 52.8 %, 56.2 % and 54.5 %, respectively, considering all reporting MSs. Resistance to ciprofloxacin and nalidixic acid was at a low level (7.4 % and 6.1 %, respectively) and cefotaxime resistance was very low, at 0.9 %. The trends in resistance observed in *Salmonella* spp. isolates from pigs over the years 2005–2011 remained stable in some countries, while fluctuation was observed in others. Among the few statistically significant national trends, slightly more decreasing trends were observed than increasing ones. However, it is noteworthy that the level of resistance to cefotaxime remained generally low, very low or absent in reporting MSs over the period 2005 to 2011. Multi-resistance was generally high in *Salmonella* spp. isolates from pigs; however, co-resistance to ciprofloxacin and cefotaxime was very low and not detected when using clinical breakpoints.

Among *Salmonella* spp. isolates from cattle, the occurrence of resistance to tetracyclines, ampicillin and sulfonamides in all reporting MSs was high at 31.1%, 29.1 % and 33.4 %, respectively. The level of resistance to ciprofloxacin and nalidixic acid was low, 1.7 % and 1.4 % respectively, for all reporting MSs, while cefotaxime resistance was not observed among the reporting MSs. Although variation was observed between MSs in the level of resistance to some antimicrobials, overall trends in resistance between 2005 and 2011 were mainly decreasing ones among *Salmonella* spp. from cattle. Important variability was observed in multi-resistance levels in *Salmonella* spp. isolates from cattle; however, co-resistance to ciprofloxacin and cefotaxime was not detected. The few statistically significant trends observed in resistance levels among *Salmonella* isolates from cattle were all decreasing ones.

Campylobacter

In humans

Overall, 13 MSs and onr non-MS provided information on antimicrobial resistance in isolates from campylobacteriosis cases in humans for the year 2011.

Data from antimicrobial susceptibility testing represented 17.1 % of the total confirmed campylobacteriosis cases reported in the EU in 2011. Fewer countries reported results for *Campylobacter* than for *Salmonella.* The variety of methods and interpretative criteria used by MSs in antimicrobial susceptibility testing for *Campylobacter* was still large, even though some harmonisation towards the use of EUCAST clinical breakpoints could be observed. The launch of clinical breakpoints for disc diffusion by EUCAST in 2012 will most likely facilitate this harmonisation further, as many countries use disc diffusion for testing of human isolates. The resistance levels in human *Campylobacter* isolates were highest for nalidixic acid (47.8 %) and ciprofloxacin (44.4 %) followed by ampicillin (35.3 %) and tetracyclines (30.5 %), with high levels of multi-resistance observed in some countries. Resistance to the clinically important antimicrobial erythromycin was low overall (3.5 %), but moderately high in *C. coli* (10.3 %), although the number of isolates of this species tested was small.

Sufficient data were available for levels of resistance to be compared by geographical region for ciprofloxacin, erythromycin, nalidixic acid and tetracyclines. Isolates acquired in EU/EEA countries had the lowest frequency of resistance to all these antimicrobials, with resistance to erythromycin notably lower than in Asia and Africa. However, the number of isolates tested that originated from outside of the EU/EEA was very low.

In animals and food

In 2011, 17 MSs and two non-MSs reported quantitative MIC data for *Campylobacter* isolates from food and animals. Seven MSs additionally reported qualitative data where the method of testing was not specified; however these data are not presented in the report. When considering all host species, the highest levels of resistance were seen for the (fluoro)quinolones (ciprofloxacin and nalidixic acid) and tetracyclines. Resistance to erythromycin and gentamicin was comparatively low among *Campylobacter* isolates from food and animals. Resistance was generally higher in *C. coli* than in *C. jejuni* from the same host species (*Gallus gallus*).

For *C. jejuni* isolates from *Gallus gallus*, resistance ranged from high to very high for ciprofloxacin (57.2 %), nalidixic acid (55.5 %) and tetracyclines (40.6 %), while levels of resistance to erythromycin and gentamicin were low and very low at 1.6 % and 0.9 %, respectively. A similar pattern was seen for *C. coli* isolates from *Gallus gallus*; however, levels of resistance were higher overall. Levels of resistance to ciprofloxacin, nalidixic acid and tetracyclines were extremely high, at 76.6 %, 70.2 % and 74.6 %, respectively, while levels of resistance to erythromycin and gentamicin were moderate (15.5 %) and low (3.8 %), respectively. Multi-resistance (reduced susceptibility to at least three antimicrobial classes according to epidemiological cut-off values) was generally low in *C. jejuni* isolates from broilers, and co-resistance to the clinically important antimicrobials ciprofloxacin and erythromycin in the same isolates was either not detected or recorded at low levels in the reporting MSs.

Although resistance to tetracyclines, ciprofloxacin and nalidixic acid in *Gallus gallus* varied greatly among reporting MSs over the period 2005–2011, some statistically increasing trends in resistance to these antimicrobials were observed for several MSs. Resistance to erythromycin, however, remained absent to low in *C. jejuni* isolates over this period. The statistically significant trends observed among isolates from pigs were generally increasing trends.

For *C. jejuni* isolates from broiler meat, resistance ranged from high to very high for ciprofloxacin (59.2 %), nalidixic acid (56.9 %) and tetracyclines (46.9 %), while levels of resistance to erythromycin and gentamicin were low at 3.1 % and 1.7 %, respectively. A similar pattern was seen for *C. coli* isolates from broiler meat; however, levels of resistance were higher overall. Levels of resistance to ciprofloxacin, nalidixic acid and tetracyclines were extremely high, at 77.7 %, 72.2 % and 71.5 %, respectively, while levels of resistance to erythromycin and gentamicin were low at 9.8 % and 1.8 %, respectively.

C. coli isolates from pigs were isolated at the slaughterhouse. Resistance to ciprofloxacin, nalidixic acid and tetracyclines ranged from high to very high, at 35.5 %, 32.8 % and 64.8 %, respectively. Resistance to erythromycin was high (24.5 %) and to gentamicin was low (7.2 %).

C. jejuni isolates from cattle were also considered. Overall, resistance was high for ciprofloxacin (38.8 %), nalidixic acid (39.2 %) and tetracyclines (32.4 %), while resistance to erythromycin and gentamicin was very low at 0.8 % for both. Few statistically significant decreasing trends were observed in cattle, but resistance to erythromycin remained absent to low in *C. jejuni* isolates over the period 2005–2011.

Indicator (commensal) *Escherichia coli*

Twelve MSs and two non-MSs reported quantitative data on antimicrobial resistance in indicator *E. coli* isolates from animals and food in 2011. Most of the data related to isolates from *Gallus gallus*, pigs and cattle; three MSs reported results for meat derived from those species.

Most data on *Gallus gallus* referred to broilers, although two MSs provided data on *E. coli* from laying hens. Resistance levels were in general higher among *E. coli* from broilers than from laying hens. Regarding broilers, the highest overall resistance levels observed at the reporting MS group level were to ciprofloxacin (53.1 %), ampicillin (54.4 %), sulfonamides (50.8 %), streptomycin (47.2 %), tetracyclines (45.2 %) and nalidixic acid (42.6 %). The isolates from laying hens were also most commonly resistant to these antimicrobials but resistance levels were lower, ranging between 9.7 % and 18.1 %. Resistance to cefotaxime was low in both broilers (8.2 %) and layers (1.9 %). There was substantial variation in the level of resistance to these antimicrobials between reporting MSs. Countries mostly reported relatively stable resistance in *E. coli* isolates from *Gallus gallus* between 2005 and 2011. However, statistically significant trends in resistance to all of these antimicrobials, except cefotaxime, have been identified: these trends have more commonly been increasing ones than decreasing ones.

Concerning indicator *E. coli* from pigs, the highest overall resistance levels in the reporting group of MSs were observed for tetracyclines (57.0 %), streptomycin (53.1 %), sulfonamides (45.8 %) and ampicillin (37.1 %). Resistance to both ciprofloxacin and nalidixic acid was low at 8.3 % and 4.8 %, respectively, although resistance levels in the individual countries reached up to 30.6 %. Overall, only 1.7 % of isolates were resistant to cefotaxime. There were large differences in the occurrence of resistance between MSs. There were fewer statistically significant trends than in isolates from *Gallus gallus*. No significant trends were observed for cefotaxime, ciprofloxacin, nalidixic acid or streptomycin.

Multi-resistance levels (reduced susceptibility to at least three antimicrobial classes according to epidemiological cut-off values) were generally high in indicator *E. coli* isolates from broilers and pigs, and in a number of reporting countries. Co-resistance to the clinically important antimicrobials, ciprofloxacin and cefotaxime, was also detected in very few isolates from these species.

In the reporting group of MSs, resistance levels in indicator *E. coli* isolates from cattle were generally lower than among isolates from *Gallus galllus* and pigs. The highest resistance levels observed were to tetracyclines (20.2 %), sulfonamides (19.5 %), streptomycin (17.4 %) and ampicillin (13.3 %). Resistance to ciprofloxacin and nalidixic acid was low, at 6.0 % and 4.8 %, respectively. Overall, only very few isolates (0.9 %) expressed resistance to cefotaxime. The occurrence of resistance was variable between MSs for most of the antimicrobials. As for *Salmonella* some MSs presented data at production type level for cattle, although only four MSs did so. One of these MSs reported much higher resistance among younger animals, mainly fattening veal calves, compared to older cattle, mainly adult cows, but this was not observed in the other countries. There have been numerous statistically significant trends in resistance since 2005, always of a decreasing nature. The only antimicrobial for which no significant trends were observed was cefotaxime.

Indicator (commensal) enterococci

In 2011, 10 MSs and two non-MSs reported antimicrobial resistance data regarding enterococcal isolates from animals and food. Most of the data concerned isolates from broilers (*Gallus gallus*), pigs and cattle, although three MSs reported results for isolates from meat derived from those species.

There was substantial variation in the resistance levels observed in the different MSs. The highest resistance levels among *Enterococcus faecium* (*E. faecium*) and *Enterococcus faecalis* (*E. faecalis*) isolates from broilers (*Gallus gallus*) were observed for tetracyclines (59.7 % and 61.9 %, respectively) and erythromycin (54.6 % and 65.2 %, respectively). The isolates from pigs expressed greater resistance to tetracyclines (63.6 % in *E. faecium* and 78.9 % in *E. faecalis*) but lower resistance to erythromycin (34.8 % in *E. faecium* and 49.0 % in *E. faecalis*). Multi-resistance levels differed substantially between reporting MSs in *E. faecium* from pigs and *Gallus gallus*. Regarding the isolates from cattle, 34.2 % of *E. faecium* and 35.6 % of *E. faecalis* isolates were resistant to tetracyclines, while 30.5 % of *E. faecium* and 22.9 % of *E. faecalis* isolates were resistant to erythromycin. As in *E. coli,* one MS reported much higher resistance levels among younger animals, but this was not observed in the other country that reported data at production type level. Numerous statistically significant trends have been identified for these, and other, antimicrobials since 2005: those identified for isolates from pigs and cattle were predominantly decreasing trends.

Resistance levels in *E. faecium* to the combination of antimicrobials quinupristin/dalfopristin has been analysed in this report for the various animal species and was found to be at very high to extremely high levels (64.1 % to 86.5 %). This has however to be considered in relation to the very low levels of resistance to vancomycin observed in all animal species (maximum 0.7 %).

Owing to cross-resistance between avoparcin and the human antimicrobial vancomycin, the use of avoparcin as an antimicrobial growth promoter was banned in the EU in 1997. In 2011, vancomycin resistance was found in only 0.7 % of *E. faecium* isolates from broilers, 0.6 % of *E. faecalis* isolates from broilers, 0.4 % of *E. faecium* isolates from pigs and 0.4 % of *E. faecalis* isolates from cattle. Resistance was not detected in the *E. faecalis* isolates from pigs and *E. faecium* isolates from cattle tested.

Methicillin-resistant *Staphylococcus aureus*

As regards healthy food-producing animals, a number of MSs and one non-MS detected MRSA in broilers (3.3 %, respectively 29.2 %), fattening pigs (from 5.6 % to 84.1 %), beef cattle at slaughter (8.7 %), cattle at slaughter (83.0 %) and bulk milk from dairy cattle (1.5 %) in 2011. Where several countries had examined the same type of animal, the prevalence could differ markedly between reporting countries.

The most common type of MRSA detected was MRSA ST 398. However, some countries detected ST1 and ST49. Two countries reported longitudinal data on the occurrence of MRSA in pigs at slaughter in the years 2010 and 2011; an increase in the numbers of pigs testing positive from one year to another was observed in both countries.

Farm-to-fork analyses

The association between the observed resistance to certain antimicrobials in isolates of *S*. Typhimurium, *S*. Enteritidis and *Campylobacter* from humans, food and animals was analysed by using the same clinical breakpoints to determine resistance. It appeared that, when resistance to erythromycin and ciprofloxacin was observed in human isolates in a country, resistant isolates were also found in animals and food, mostly at the same levels. Resistance to ciprofloxacin in *S*. Typhimurium was rare in animal and food isolates when interpreted using clinical breakpoints, although some resistance was detected in human isolates. This could reflect other sources of human infection with these resistant isolates, such as infection through other alimentary sources than pork, chicken or beef, consumption of imported foods, infection associated with foreign travel or contact with pets.

3. ANTIMICROBIAL RESISTANCE IN *SALMONELLA*

3.1. Introduction

Salmonella is an important zoonotic pathogen of economic significance in both humans and animals. The genus *Salmonella* is divided into two species: *S. enterica* and *S. bongori*. There are six sub-species of *S. enterica* and most *Salmonella* belong to the sub-species *S. enterica* subsp. *enterica*. *Salmonella* are further sub-divided into serovars based on the serological reactions of their somatic O-antigens and flagellar H-antigens. Different serovars have often been named based on the location where the serovar was first isolated. In this report, the organisms are identified by genus followed by serovar, e.g. *S.* Typhimurium. There are more than 2,500 serovars of zoonotic *Salmonella* which have been recognised, and the prevalence of these different serovars can change over time. Within a given serovar, further sub-division of the isolates can be done, e.g. using bacteriophages (bacterial viruses). The pattern of lysis obtained with a standard panel of *Salmonella* bacteriophages (the lyso type) can be used to assign different phage types to a given serovar.

Human salmonellosis is usually characterised by the acute onset of fever, abdominal pain, nausea and sometimes vomiting. The majority of *Salmonella* infections result in mild, self-limiting, gastrointestinal illness and usually do not require antimicrobial treatment. In some patients the infection may be more serious and the associated dehydration can be life-threatening. Invasive disease, such as *Salmonella* bacteraemia or meningitis, can occur in a smaller subset of patients, with a higher risk in patients who are immuno-compromised. In cases of severe enteric disease, or when *Salmonella* invades and causes a bloodstream infection, effective antimicrobials are essential for treatment and can be life-saving. The treatment of choice for *Salmonella* infection is fluoroquinolones for adults and third-generation cephalosporins for children. Resistance in *Salmonella* to these first-line treatments, resulting in infections with antimicrobial-resistant strains, may cause treatment failure, which in turn can lead to more severe outcomes in patients. Salmonellosis has also been associated with long-term or chronic sequelae, e.g. reactive arthritis.

The common reservoir of non-typhoidal *Salmonella* strains is the intestinal tract of a wide range of domestic and wild animals. A wide variety of food stuffs of both animal and plant origin can be contaminated with *Salmonella,* which may cause infection in humans. Transmission usually occurs when the bacteria are introduced during food preparation or are allowed to multiply in food (for example because of inadequate storage temperature, inadequate cooking or cross-contamination of ready-to-eat food and uncooked food). *Salmonella* may also be transmitted through direct contact with infected animals or humans, or by contact with contaminated environments.

Overall, considering all *Salmonella* infections in the EU, *S.* Enteritidis and *S.* Typhimurium are the serovars most frequently associated with human illness. *S.* Enteritidis cases in humans are most commonly associated with the consumption of contaminated eggs and poultry meat, while *S.* Typhimurium cases are mostly associated with the consumption of contaminated pig, bovine and poultry meat.

In animals, particularly of certain species, sub-clinical infections or heathy carriage can be common. The organism may spread rapidly and easily between animals in a herd or flock without the animals showing any clinical signs in some cases and animals may become intermittent or persistent carriers. In other species, clinical disease may occur following *Salmonella* infection and, in particular, cattle may succumb to fever, diarrhoea and abortion following infection, particularly with some serovars, such as *S*. Dublin. In calves, *Salmonella* can cause outbreaks of diarrhoea with high mortality. Fever and diarrhoea are less common in pigs than in cattle and sheep and poultry may also show no signs of infection.

Salmonella spp. comprises the amalgamated results for all *Salmonella* serovars reported by a reporting MS. In the case of sampling in animals performed in accordance with EFSA's recommendations (EFSA, 2007) and related to National *Salmonella* Control Programmes, there is a defined method of selecting isolates for inclusion in the monitoring. The relative contribution of different serovars possessing a particular resistance should ideally be considered when interpreting the results, in order to evaluate the influence of clonal dissemination of serovars. If a MS has reported the susceptibility of particular serovars and excluded others, then this would introduce a source of bias in the susceptibility figures relating to *Salmonella* spp.

3.2. Overview of reported resistance data in *Salmonella* from humans, animals and food

Nineteen MSs and Iceland provided data for 2011 from *Salmonella* human cases isolates. Countries reported qualitative data, i.e. interpreted antibiotic susceptibillity testing (AST) results for tested isolates (susceptible (S), intermediate (I) or resistant (R)), but no minimum inhibitory concentration (MIC) values or inhibition zone diameters (IZDs). Twenty MSs and one non-MS (Norway) reported quantitative MIC data on the antimicrobial resistance of *Salmonella* isolates recovered from animals and food in 2011. Table SA1 presents an overview of the MSs reporting on antimicrobial resistance, either MIC or IZD data, on *Salmonella* spp. from humans and various animal and food categories in 2011.

Table SA1. Overview of countries reporting antimicrobial resistance data using MICs and disc inhibition zones on* Salmonella *spp. (all serovars) from humans and various animal and food categories in 2011

Method	Origin	Total number of MSs reporting	Countries
Diffusion	Human	12	**MSs:** AT, EE, GR, HU, IT, LT[4], LU, LV[4], RO, SK[4], SI, ES
			Non-MS: IS
	Gallus gallus (fowl)	6	**MSs:** AT[1], CY[2], LU[1], PL[2], RO, SI[3]
			Non-MS: IS[1]
	Turkeys	5	**MSs:** AT[1], CY[2], PL[2], RO, SI[3]
	Pigs	6	**MSs:** AT[1], IE[2], PL[2], PT[3], RO, SI[3]
			Non-MS: IS[1]
	Cattle (bovine animals)	3	**MSs:** AT[1], IE[2], LU[1]
	Meat from broilers (*Gallus gallus*)	8	**MSs:** AT[1], ES[2], HU[3], LT[3], LU[2], NL[3], PL[2], SI[3]
			Non-MS: IS[1]
	Meat from turkey	1	**MS:** HU[3]
	Meat from pig	8	**MSs:** AT[1], ES[2], HU[3], LT[3], LU[2], NL[3], PL[2], SI[3]
			Non-MS: IS[1]
	Meat from bovine animals	6	**MSs:** AT[1], ES[2], HU[3], LU[2], PL[2], SI[3]
Dilution	Human	12	**MSs:** DK, DE, EE, IE, IT, LT[4], LV[4], MT, NL, RO, SK[4], UK
	Gallus gallus (fowl)	19	**MSs:** AT, BE, DE, DK, EE, ES, FI, FR, GR, HU, IE, IT, LV, NL, PL, PT, SE, SK, UK
			Non-MS: NO
	Turkeys	13	**MSs:** AT, DE, DK, ES, FI, FR, HU, IE, IT, PL, PT, SK, UK
			Non-MS: NO
	Pigs	11	**MSs:** DE, DK, EE, ES, FI, HU, IE, IT, NL, SE, SK
			Non-MS: NO
	Cattle (bovine animals)	9	**MSs:** DE, EE, ES, FI, IE, IT, NL, SE, SK
			Non-MS: NO
	Meat from broilers (*Gallus gallus*)	11	**MSs:** BE, DE, GR, HU, IE, IT, LV, NL, PT, RO, SK
	Meat from turkey	9	**MSs:** DE, EE, FI, HU, IE, IT, NL, PL, RO
	Meat from pig	11	**MSs:** BE, DE, DK, EE, HU, IE, IT, NL, PT, RO, SK
	Meat from bovine animals	8	**MSs:** DE, EE, FI, IE, IT, NL, PT, RO

Note: Cyprus provided human data for only one isolate tested for one antimicrobial and no information was provided regarding interpretive criteria. Cyprus is therefore not represented in the table.

1. These data were submitted with no test method specified but are believed to have been tested by disc diffusion based on information in the National Zoonoses Reports.
2. These data were submitted with no test method specified and this information could not be obtained from the National Zoonoses Reports.
3. These data were submitted with the test method listed as dilution but no MIC distribution data were supplied.
4. Clinical breakpoints shown are from the 2010 report; clinical breakpoints for 2011 were not reported.

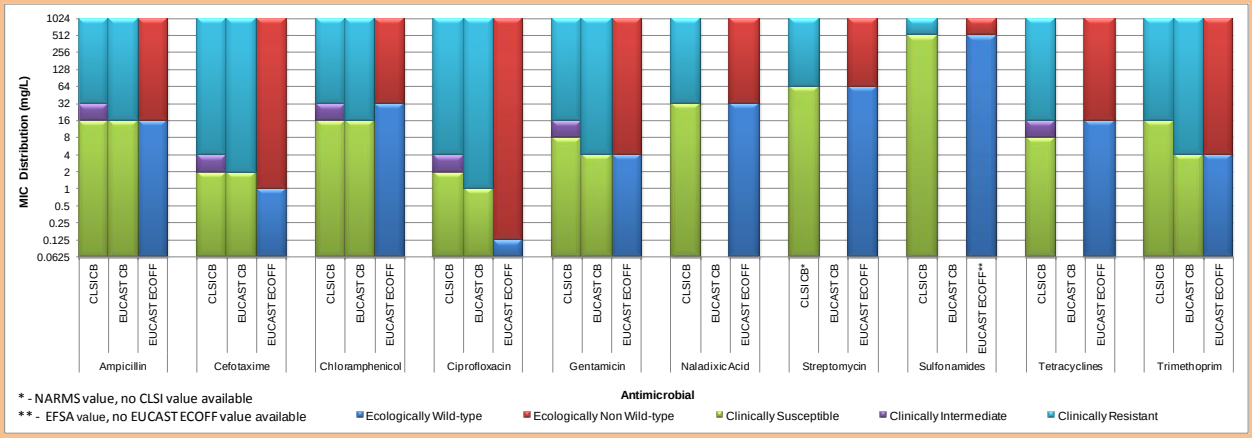
3.3. Antimicrobial resistance in *Salmonella* isolates from humans

METHODS AND INTERPRETATIVE THRESHOLDS OF RESISTANCE IN *SALMONELLA* IN HUMANS

The method of testing for antimicrobial susceptibility and the selection of the isolates to be tested varied between countries. In several countries, the reference laboratories perform antimicrobial susceptibility testing on only a subset of the isolates. The remainder may be subjected to susceptibility testing by hospitals or local laboratories and the methods used by these may not be reported. The methods and interpretative criteria used for antimicrobial susceptibility testing (AST) of Salmonella *are presented in Table MM1 in Materials and Methods. At present there is a lack of standardisation of AST methods and interpretive criteria both between and within countries. Most countries used clinical breakpoints for the interpretation of test results as provided by the Clinical and Laboratory Standards Institute (CLSI) or a combination of clinical breakpoints from CLSI and the European Committee on Antimicrobial Susceptibility Testing (EUCAST), depending on the antimicrobial. A few countries used other criteria such as epidemiological cut-off values (ECOFFs) provided by EUCAST.*

Of the 10 antimicrobials reported from both human and animal/food isolates, four MIC values or zone diameters differ markedly between the clinical breakpoints and the ECOFFs for four: cefotaxime, ciprofloxacin, gentamicin and trimethoprim. In particular, the ECOFF for ciprofloxacin is three dilution steps lower than the EUCAST clinical breakpoint and five dilution step lower than the CLSI clinical breakpoint (Figure SA1). The results for these four antimicrobials must therefore be interpreted with caution and no direct comparison between countries should be made. Where countries have used the same method over the time period covered by the report, the trends in occurrence of resistance are likely to be valid, although sensitivity may vary depending on the specific thresholds used.

Figure SA1. Comparison of clinical breakpoints and epidemiological cut-off values used to interpret MIC data reported for* Salmonella *spp. from humans, animals or food



Note: CLSI from 2011, EUCAST from 2011, EUCAST ECOFFS as utilised by EFSA in 2011.

3.3.1. Antimicrobial resistance in *Salmonella* spp.

Nineteen MSs and Iceland submitted antimicrobial resistance data from human non-typhoidal *Salmonella* isolates to ECDC for 2011. In total, 25,199 isolates were tested for resistance to one or more antimicrobials, representing 26.4 % (N=95,548) of the confirmed human salmonellosis cases reported in the EU in 2011 (EFSA and ECDC, 2013).

The highest level of resistance in all human *Salmonella* isolates from 2011 was observed for tetracyclines (27.1 %), closely followed by ampicillin (26.6 %) (Table SA2). However, as in previous years, wide variability in percentages of resistance to different antimicrobials was observed among the reporting countries. *Salmonella* Enteritidis and *S.* Typhimurium were, in 2011 as in previous years, the two most commonly reported *Salmonella* serovars, representing 44.4 % and 24.9 % respectively of all confirmed human cases for which serover information was provided (EFSA and ECDC, 2013). Furthermore, harmonisation of reporting of monophasic *S.* Typhimurium 1,4,[5],12:i:- in 2010 resulted in this serotype becoming the third most commonly reported serovar, representing 4.7 % of all confirmed reported cases in 2011.

Multi-drug resistance of human *Salmonella* spp. to 10 antimicrobials are presented. The 10 antimicrobials included were ampicillin, cefotaxime, chloramphenicol, ciprofloxacin/nalidixic acid, gentamicin, kanamycin, streptomycin, sulfonamides, tetracyclines and trimethoprim. Of these, only kanamycin is not on the list of antimicrobials tested for in food and animal isolates. Multi-drug resistance of an isolate is defined as non-susceptibility to at least three different antimicrobial classes (Magiorakos et al., 2012). Co-resistance to ciprofloxacin and cefotaxime was also estimated as these two antimicrobials are considered the most important for treatment of severe salmonellosis (EFSA, 2009d).

The AST results for a total of 14 serovars (the top 10 serovars in humans and some additional serovars of importance in animals) are presented in a separate chapter. In order to assess whether there were any differences in resistance levels between human *Salmonella* infections aquired within the EU/EEA and those aquired when travelling outside of the EU/EEA, resistance data are presented by region based on most likely country of infection. Multi-drug resistance and co-resistance of human *Salmonella* spp. are also presented.

Table SA2. Antimicrobial resistance in* Salmonella *spp. (all non-typhoidal serovars) from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Kanamycin	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	2,235	12.7	2,235	0.7	2,235	4.0	2,235	0.7	2,235	0.9	2,235	0.6
Cyprus	1	NA	-	-	-	-	-	-	-	-	-	-
Denmark[1]	1,149	25.8	1,149	1.6	1,149	6.6	1,149	14.6	1,149	3.7	1,149	1.2
Estonia	286	15.7	266	1.1	222	1.8	359	1.1	220	0.9	219	0.5
Germany	1,933	38.6	1,933	1.1	-	-	1,933	1.1	1,933	2.2	1,933	1.7
Greece	273	13.2	53	0	214	3.3	270	0	58	86.2	214	4.2
Hungary	697	55.4	697	0.1	697	12.2	697	0.1	697	0.3	697	0.9
Ireland	305	31.5	304	3.0	305	19.0	304	1.0	304	3.6	304	2.3
Italy	1,563	59.2	1,287	1.8	353	9.6	1,522	11.3	1,163	45.7	225	4.4
Latvia	126	0	18	NA	3	NA	105	0	1	NA	-	-
Lithuania	2,265	17.7	1,922	0.2	1,049	0.9	1,800	0.7	1,044	0.2	944	0
Luxembourg	123	38.2	123	0	123	4.9	123	4.1	123	1.6	122	0
Malta	120	30.8	-	-	-	-	120	9.2	120	58.3	-	-
Netherlands[1]	1,115	37.9	1,115	0.4	1,115	8.4	1,115	10.2	1,115	1.3	-	-
Romania	281	27.8	281	0.4	281	8.2	281	0.7	281	1.4	281	1.1
Slovakia	600	10.8	230	3.0	110	1.8	249	3.2	195	93.8	-	-
Slovenia	400	15.3	400	0	400	3.8	400	0.3	400	0.8	400	0.8
Spain	2,112	38.1	2,111	0.6	2,111	7.7	2,110	0.7	2,111	1.6	2,109	1.1
United Kingdom	9,320	20.3	9,239	0.9	9,284	5.6	9,354	17.6	9,295	2.6	9,243	1.9
Total (19 MSs)	**24,904**	**26.6**	**23,363**	**0.8**	**19,651**	**6.0**	**24,126**	**9.1**	**22,444**	**5.6**	**20,075**	**1.5**
Iceland	44	22.7	1	NA	44	4.5	44	4.5	1	NA	-	-

Table continued overleaf.

N = number of isolates tested.

% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable: if fewer than 20 isolates were tested resistance was not calculated.

1. ECOFFs were used for interpretation.

Table SA2 (continued). Antimicrobial resistance in* Salmonella spp. *(all non-typhoidal serovars) from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Nalidixic acid		Streptomycin		Sulfonamides		Tetracyclines		Trimethoprim	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	2,235	11.1	2,235	13.1	2,235	13.5	2,235	14.8	2,235	2.8
Cyprus	-	-	-	-	-	-	-	-	-	-
Denmark[1]	1,149	11.5	1,149	29.5	1,149	27.9	1,149	29.7	1,148	5.7
Estonia	217	6.9	215	5.6	221	6.8	220	5.0	294	3.1
Germany	1,933	6.9	1,933	42.9	-	-	-	-	1,931	5.3
Greece	257	2.7	214	15.4	-	-	215	14.9	44	11.4
Hungary	697	26.8	697	49.2	697	63.8	697	54.8	697	6.9
Ireland	304	11.8	305	28.5	305	32.5	305	36.4	304	10.5
Italy	351	7.4	232	51.3	208	51.9	473	61.9	1,379	8.3
Latvia	-	-	-	-	-	-	1	NA	107	0
Lithuania	968	12.2	946	7.7	943	9.4	942	9.3	2,256	7.5
Luxembourg	123	5.7	123	33.3	123	36.6	123	32.5	123	7.3
Malta	-	-	-	-	-	-	-	-	120	10.8
Netherlands[1]	1,115	8.9	1,115	37.8	1,115	37.3	1,115	39.1	-	-
Romania	281	16.4	281	23.5	281	45.6	281	27.8	281	15.7
Slovakia	4	NA	11	NA	33	9.1	373	10.5	-	-
Slovenia	400	10.0	400	13.3	400	15.3	400	12.5	400	1.0
Spain	2,110	21.7	2,112	29.1	2,110	0.3	2,110	36.9	2,110	0.1
United Kingdom	9,309	18.5	9,284	6.3	9,240	22.3	9,240	25.7	9,344	10.1
Total (19 MSs)	**21,453**	**15.3**	**21,252**	**18.4**	**19,060**	**21.5**	**19,879**	**27.1**	**22,773**	**7.2**
Iceland	44	13.6	-	-	-	-	-	-	44	2.3

N = number of isolates tested.

% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable: if fewer than 20 isolates were tested resistance was not calculated.

1. ECOFFs were used for interpretation.

3.3.2. Antimicrobial resistance in *S.* Enteritidis

As in previous years, *S.* Enteritidis was the most common *Salmonella* serovar isolated in Europe in 2011, with 34,385 cases (EFSA and ECDC, 2013). Data on antimicrobial resistance of *S.* Enteritidis isolates were submitted by 19 MSs and Iceland for 2011.

The highest levels of resistance among *S.* Enteritidis isolates were observed for nalidixic acid (23.2 %; N=6,811), and ciprofloxacin (12.7 %; N=7,965) (Table SA3). Both of these antimicrobials belong to the quinolones, a family of synthetic broad-spectrum antimicrobials. Whereas nalidixic acid is a first-generation quinolone (and not normally used for the treatment of salmonellosis), ciprofloxacin belongs to the second-generation of fluoroquinolones and is today the antimicrobial of choice for treatment of severe or invasive *Salmonella* infections in humans (EFSA, 2009d). As in 2009 and 2010, the highest resistance to ciprofloxacin was found in the United Kingdom (33.7 %; N=2,596) and Denmark (23.6 %; N=288), which both used more sensitive breakpoints. Italy reported the third highest resistance to ciprofloxacin in 2011 (15.5 %; N=148) which was a substantial increase compared with 2010 (1.4 %; N=207). This unexpected result, and those that follow, may be due to a lack of standardisation in AST methods and interpretive criteria. The United Kingdom reported a marked increase in ciprofloxacin resistance among *S.* Enteritidis from the 19.0 % (N=2,784) observed in 2010, reflecting a return to the levels of resistance observed in 2009. A high level of resistance among *S.* Enteritidis to nalidixic acid was observed in the United Kingdom (34.4 %; N=2,587), Ireland (25.9 %; N=58) and Denmark (22.2 %; N=288) with very high resistance observed in Spain (56.4 %; N=612) (Table SA3).

For the country-specific five-year trends for ciprofloxacin resistance over the 2007–2011 period, the countries were presented individually owing to wide diversity of AST methods and breakpoints/cut-off values used for interpreting resistance data (Figure SA2). The more sensitive breakpoints (ECOFFs or similar) were used in the United Kingdom, Denmark, the Netherlands and, since 2011, Estonia. Most of the countries using CLSI breakpoints reported very low to low levels of resistance, with the exception of Italy.

The second most clinically important group of antimicrobials for the treatment of human salmonellosis are the cephalosporins, especially for treatment of severe infections in children (EFSA, 2009d). In the panel of antimicrobials tested, this group of antimicrobials is represented by cefotaxime, a third-generation cephalosporin. As in previous years, resistance to cefotaxime was generally very low in the reporting MSs, 0.3 % (N=7,700) in 2011. The highest resistance was observed in Slovakia (3.0 %; N=169) followed by Italy (1.7 %; N=120) (Table SA3). The five-year 2007–2011 trends in cefotaxime resistance were generally at a very low level in reporting MSs (Figure SA3). The fact that CLSI changed the breakpoint for cefotaxime from ≥64 mg/L to ≥4 mg/L in 2010 did not result in any visible increases in resistance in the countries adapting to this change in either 2010 or 2011.

Other noteworthy observations are the extremely high resistance to gentamicin among *S.* Enteritidis in Slovakia (94.8 %; N=135) and Greece (83.3 %; N=42), while Malta reported a rise from 0 % (N=72) in 2010 to 55.3 % (N=47) in 2011, although this can be attributed to the use of a more sensitive breakpoint in 2011 (Table SA3).

Table SA3. Antimicrobial resistance in S. Enteritidis from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Kanamycin	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	1,266	1.6	1,266	0.2	1,266	0.2	1,266	0.1	1,266	0	1,266	0
Cyprus	1	NA	-	-	-	-	-	-	-	-	-	-
Denmark[1]	288	7.6	288	0.7	288	0	288	23.6	288	0	288	0
Estonia	206	13.6	185	1.1	153	0.7	217	1.4	151	0	150	0.7
Germany	191	1.0	191	0	-	-	191	0	191	0	191	0.5
Greece	112	5.4	39	0	70	0	111	0	42	83.3	70	0
Hungary	20	65.0	20	0	20	25.0	20	0	20	0	20	0
Ireland	58	5.2	58	0	58	0	58	0	58	0	58	0
Italy	147	8.8	120	1.7	28	0	148	15.5	124	37.9	23	0
Latvia	116	0	12	NA	1	NA	97	0	-	-	-	-
Lithuania	1,759	12.1	1,496	0.2	894	0.2	1,464	0.6	879	0	812	0
Luxembourg	30	3.3	30	0	30	0	30	3.3	30	0	29	0
Malta	47	10.6	-	-	-	-	47	6.4	47	55.3	-	-
Netherlands[1]	317	3.5	317	0	317	0.3	317	9.1	317	0	-	-
Romania	120	7.5	120	0	120	2.5	120	0	120	0	120	0
Slovakia	460	3.3	169	3.0	68	0	172	1.7	135	94.8	-	-
Slovenia	210	3.3	210	0	210	0	210	0	210	0	210	0
Spain	614	9.3	613	0.2	614	0.2	613	0.2	614	0.2	613	0
United Kingdom	2,589	3.2	2,566	0.3	2,575	0.3	2,596	33.7	2,577	0.2	2,566	0
Total (19 MSs)	**8,551**	**5.9**	**7,700**	**0.3**	**6,712**	**0.4**	**7,965**	**12.7**	**7,069**	**3.4**	**6,416**	**0**
Iceland	19	NA	-	-	19	NA	19	NA	-	-	-	-

Table continued overleaf.

N = number of isolates tested.

% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable: if fewer than 20 isolates were tested resistance was not calculated.

1. ECOFFs were used for interpretation.

***Table SA3 (continued). Antimicrobial resistance* in *S. Enteritidis* from humans per country in 2011, using clinical breakpoints, with some exceptions[1]**

Country	Nalidixic acid		Streptomycin		Sulfonamides		Tetracyclines		Trimethoprim	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	1,266	4.9	1,266	0.6	1,266	0.8	1,266	1.1	1,266	0.4
Cyprus	-	-	-	-	-	-	-	-	-	-
Denmark[1]	288	22.2	288	2.1	288	3.1	288	5.2	288	1.7
Estonia	150	8.0	146	0	149	0.7	151	1.3	210	0.5
Germany	191	3.7	191	0.5	-	-	-	-	191	0
Greece	108	1.9	70	1.4	-	-	71	1.4	26	7.7
Hungary	20	5.0	20	50.0	20	50.0	20	50.0	20	10.0
Ireland	58	25.9	58	0	58	1.7	58	13.8	58	1.7
Italy	38	5.3	23	0	21	0	43	9.3	113	4.4
Latvia	-	-	-	-	-	-	-	-	99	0
Lithuania	812	13.1	813	0.2	810	0.6	811	1.8	1,761	6.3
Luxembourg	30	13.3	30	3.3	30	3.3	30	6.7	30	0
Malta	-	-	-	-	-	-	-	-	47	6.4
Netherlands[1]	317	9.1	317	0.6	317	1.6	317	2.5	-	-
Romania	120	20.0	120	3.3	120	20.0	120	2.5	120	4.2
Slovakia	4	NA	4	NA	24	0	289	4.2	-	-
Slovenia	210	6.7	210	1.9	210	4.3	210	0	210	0
Spain	612	56.4	614	1.0	613	0	613	2.6	614	0
United Kingdom	2,587	34.4	2,575	0.5	2,566	1.8	2,566	3.0	2,594	0.8
Total (19 MSs)	**6,811**	**23.2**	**6,745**	**0.8**	**6,492**	**1.9**	**6,853**	**2.7**	**7,647**	**2.1**
Iceland	19	NA	-	-	-	-	-	-	19	NA

N = number of isolates tested.

% Res = percentage of resistant isolates.

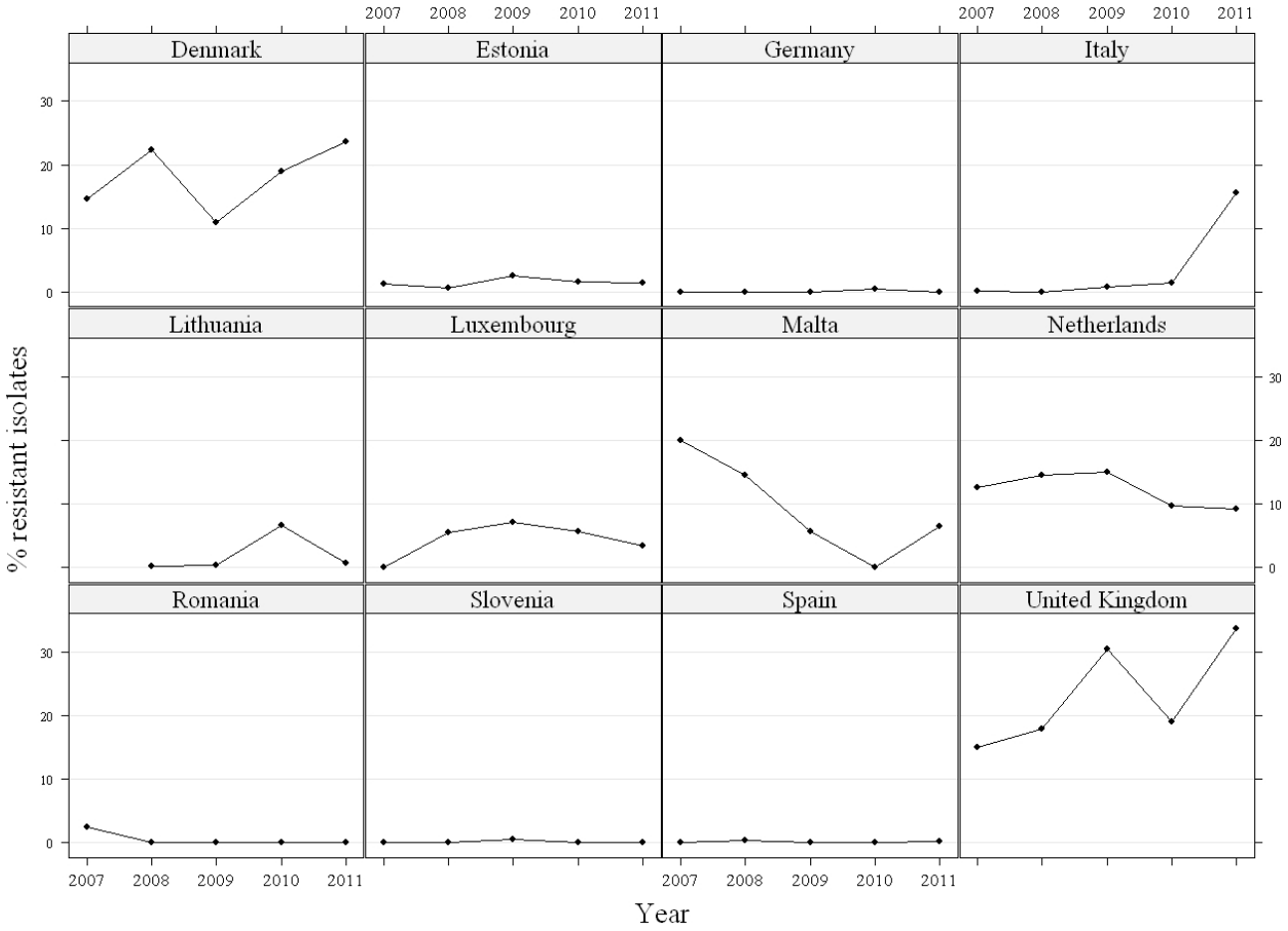
– = no data reported.

NA = not applicable: if fewer than 20 isolates were tested resistance was not calculated.

1. ECOFFs were used for interpretation.

Figure SA2. Resistance to ciprofloxacin in S. Enteritidis in humans in reporting MSs, 2007-2011, using clinical breakpoints, with some exceptions[1]

Direct comparisons between countries should be avoided owing to use of different interpretive criteria[2]

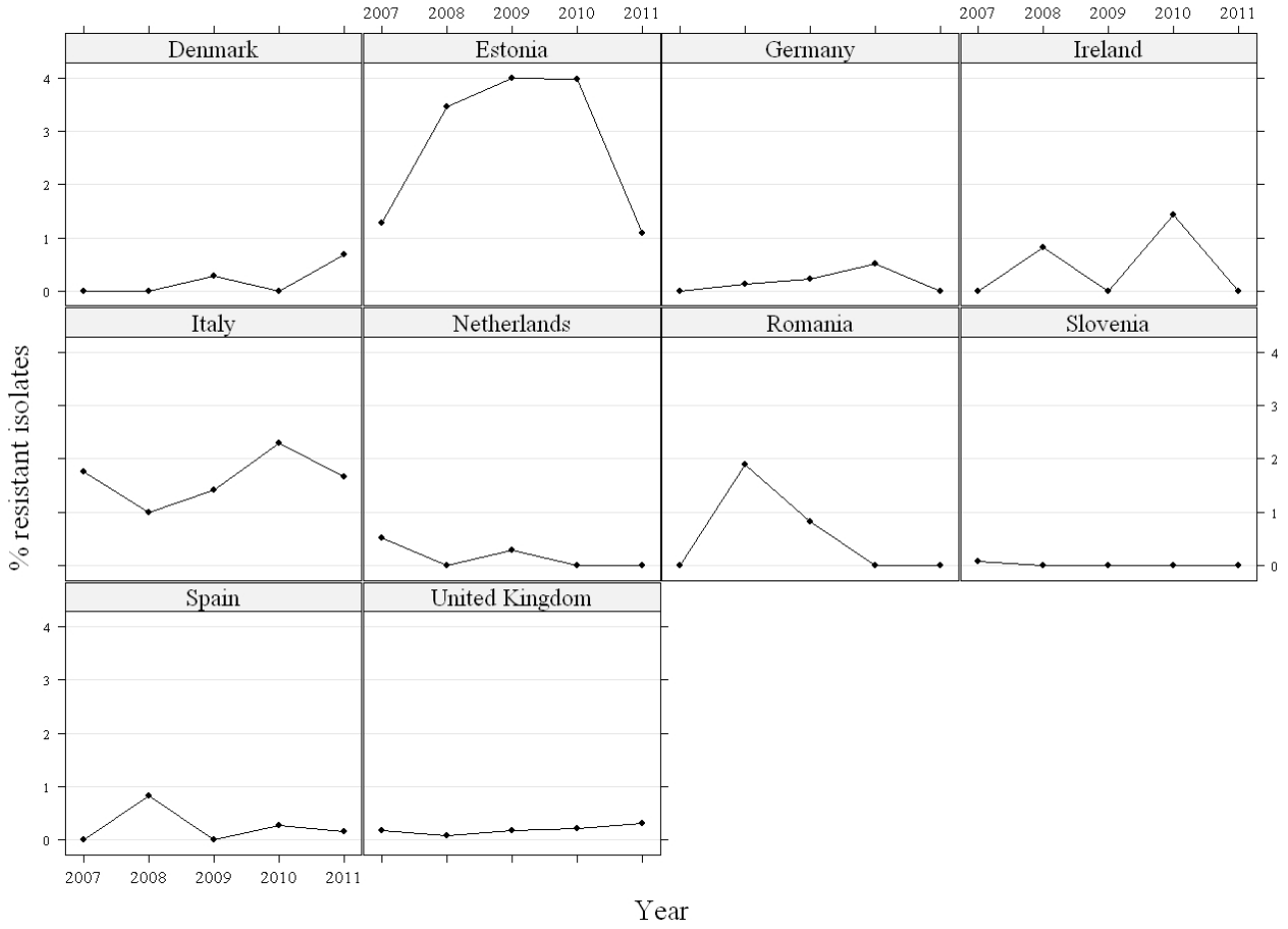


Note: Data for at least four years from 2007 to 2011 were also available for Ireland, but are not shown as no resistant cases were observed in this period.

1. ECOFFs were used for interpretation in Denmark and the Netherlands.
2. Guidelines used for AST: Denmark (Danmap), Estonia (EUCAST), Germany (DIN), Italy (CLSI), Lithuania (CLSI), Luxembourg (CLSI), Malta (EUCAST), the Netherlands (EUCAST), Romania (CLSI), Slovenia (CLSI), Spain (CLSI), UK (HPA). See also Table MM1.

Figure SA3. Resistance to cefotaxime in S. Enteritidis in humans in reporting MSs, 2007-2011, using clinical breakpoints, with some exceptions[1]

Direct comparisons between countries should be avoided owing to use of different interpretive criteria[2]



Note: Data for at least four years from 2007 to 2011 were also available for Lithuania and Luxembourg, but are not shown as few resistant cases were observed in this period in these countries.

1. ECOFFs were used for interpretation in Denmark and the Netherlands.
2. Guidelines used for AST: Denmark (Danmap), Estonia (EUCAST), Germany (DIN), Ireland (EUCAST) Italy (CLSI), the Netherlands (EUCAST), Romania (CLSI), Slovenia (CLSI), Spain (CLSI), UK (HPA). See also Table MM1.

3.3.3. Antimicrobial resistance in *S.* Typhimurium

Antimicrobial resistance in *S.* Typhimurium isolates reported for 2011 differed from that in *S.* Enteritidis. *S.* Typhimurium was the second most common *Salmonella* serovar isolated in 2011, with 19,250 cases (excluding monophasic *S.* Typhimurium which is presented in Section 4.2.1) (EFSA and ECDC, 2013). Data were reported by 18 MSs and Iceland. The highest resistance in *S.* Typhimurium was observed for ampicillin (61.5 %; N=5,617), tetracyclines (59.5 %; N=4,241), sulfonamides (53.9 %; N=4,031) and streptomycin (38.0 %; N=4,921) (Table SA4). The occurrence of resistance to these antimicrobials was generally high to extremely high in the majority of reporting MSs. In 2011, resistance observed in *S.* Typhimurium isolates to the two clinically most important antimicrobials was 4.8 % (N=5,562) for ciprofloxacin and 1.0 % (N=5,337) for cefotaxime. The percentage of resistance to ciprofloxacin increased from 0.8 % (N=824) in 2010 to 13.0 % (N=486) in Italy in 2011, but decreased from 20.1 % (N=388) in 2010 to 12.7 % (N=314) in the Netherlands. The highest levels of resistance to cefotaxime were observed in Slovakia (4.8 %; N=21) and Italy (2.7 %; N=412) (Table SA4).

The five-year trend (2007–2011) in resistance to ciprofloxacin by country showed that most reporting countries using CLSI clinical breakpoints reported consistently low levels of resistance to ciprofloxacin, with the exception of Italy. Countries using ECOFFs or similar interpretative criteria (Denmark, the Netherlands and the United Kingdom) generally reported higher levels of resistance over the five-year period, even though the trend in the Netherlands was notably inconsistent (Figure SA4). For the five-year trends for cefotaxime resistance over 2007 to 2011, resistance was low overall in reporting MSs independent of the breakpoints used. The highest resistance (13.8 %; N=87) was observed in Romania in 2007, followed by a considerable decline to 2011 (1.1 %; N=94) (Figure SA5).

Other noteworthy observations were the high resistance in *S.* Typhimurium to gentamicin in Italy (49.1 %, N=377) and extremely high resistance in Slovakia (82.6 %; N=23), while Malta reported a rise from 0 % (N=37) in 2010 to 60.0 % (N=25) in 2011, although this can be attributed to the use of a more sensitive breakpoint in 2011 and a small sample size (Table SA4).

Table SA4. Antimicrobial resistance in S. Typhimurium from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Kanamycin	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	302	46.0	302	1.3	302	22.5	302	0	302	0.3	302	0
Denmark[1]	244	32.4	244	0.4	244	17.2	244	4.9	244	0.4	244	0.8
Estonia	37	27.0	38	0	29	10.3	39	0	29	3.4	29	0
Germany	811	79.0	811	1.1	-	-	811	0.4	811	1.6	811	2.6
Greece	55	23.6	9	NA	44	9.1	54	0	10	NA	44	2.3
Hungary	320	68.8	320	0	320	21.9	320	0	320	0.3	320	1.3
Ireland	88	56.8	87	0	88	51.1	87	0	87	1.1	87	1.1
Italy	507	76.7	412	2.7	115	24.3	486	13.0	377	49.1	47	2.1
Latvia	7	NA	3	NA	-	-	7	NA	-	-	-	-
Lithuania	215	63.7	174	0	104	6.7	194	0	99	0	92	0
Luxembourg	31	51.6	31	0	31	16.1	31	3.2	31	0	31	0
Malta	25	64.0	-	-	-	-	25	4.0	25	60.0	-	-
Netherlands[1]	314	55.1	314	0	314	24.5	314	12.7	314	0.6	-	-
Romania	94	55.3	94	1.1	94	20.2	94	0	94	1.1	94	3.2
Slovakia	62	50.0	21	4.8	25	8.0	29	10.3	23	82.6	-	-
Slovenia	56	51.8	56	0	56	26.8	56	0	56	3.6	56	1.8
Spain	274	82.5	274	0.7	273	26.4	273	0	273	1.8	273	3.3
United Kingdom	2,175	56.7	2,147	1.2	2,169	14.8	2,196	6.6	2,171	2.2	2,150	1.6
Total (18 MSs)	**5,617**	**61.5**	**5,337**	**1.0**	**4,208**	**18.5**	**5,562**	**4.8**	**5,266**	**5.8**	**4,580**	**1.7**
Iceland	9	NA	1	NA	9	NA	9	NA	1	NA	-	-

Table continued overleaf.

N = number of isolates tested.

% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable: if fewer than 20 isolates were tested, resistance was not calculated.

1. ECOFFs were used for interpretation.

Table SA4 (continued). Antimicrobial resistance in S. Typhimurium from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Nalidixic acid		Streptomycin		Sulfonamides		Tetracyclines		Trimethoprim	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	302	4.6	302	42.4	302	49.0	302	48.3	302	9.3
Denmark[1]	244	3.3	244	38.1	244	39.8	244	41.0	244	4.9
Estonia	29	3.4	29	17.2	29	24.1	29	13.8	39	12.8
Germany	811	4.8	811	78.2	-	-	-	-	809	7.3
Greece	48	2.1	44	25.0	-	-	44	43.2	9	NA
Hungary	320	1.9	320	43.8	320	51.3	320	44.4	320	13.4
Ireland	87	8.0	88	59.1	88	62.5	88	63.6	87	12.6
Italy	110	8.2	47	63.8	36	61.1	171	76.6	454	7.3
Latvia	-	-	-	-	-	-	-	-	7	NA
Lithuania	92	5.4	92	65.2	92	83.7	91	74.7	211	22.7
Luxembourg	31	3.2	31	38.7	31	48.4	31	35.5	31	12.9
Malta	-	-	-	-	-	-	-	-	25	0
Netherlands[1]	314	11.8	314	51.3	314	52.9	314	55.4	-	-
Romania	94	5.3	94	43.6	94	73.4	94	50.0	94	26.6
Slovakia	-	-	6	NA	5	NA	37	27.0	-	-
Slovenia	56	19.6	56	53.6	56	48.2	56	46.4	56	3.6
Spain	274	10.6	274	59.1	273	0	273	83.2	272	0
United Kingdom	2,178	6.2	2,169	14.2	2,147	61.6	2,147	63.4	2,195	12.8
Total (18 MSs)	**4,990**	**6.2**	**4,921**	**38.0**	**4,031**	**53.9**	**4,241**	**59.5**	**5,155**	**10.7**
Iceland	9	NA	-	-	-	-	-	-	9	NA

N = number of isolates tested.

% Res = percentage of resistant isolates.

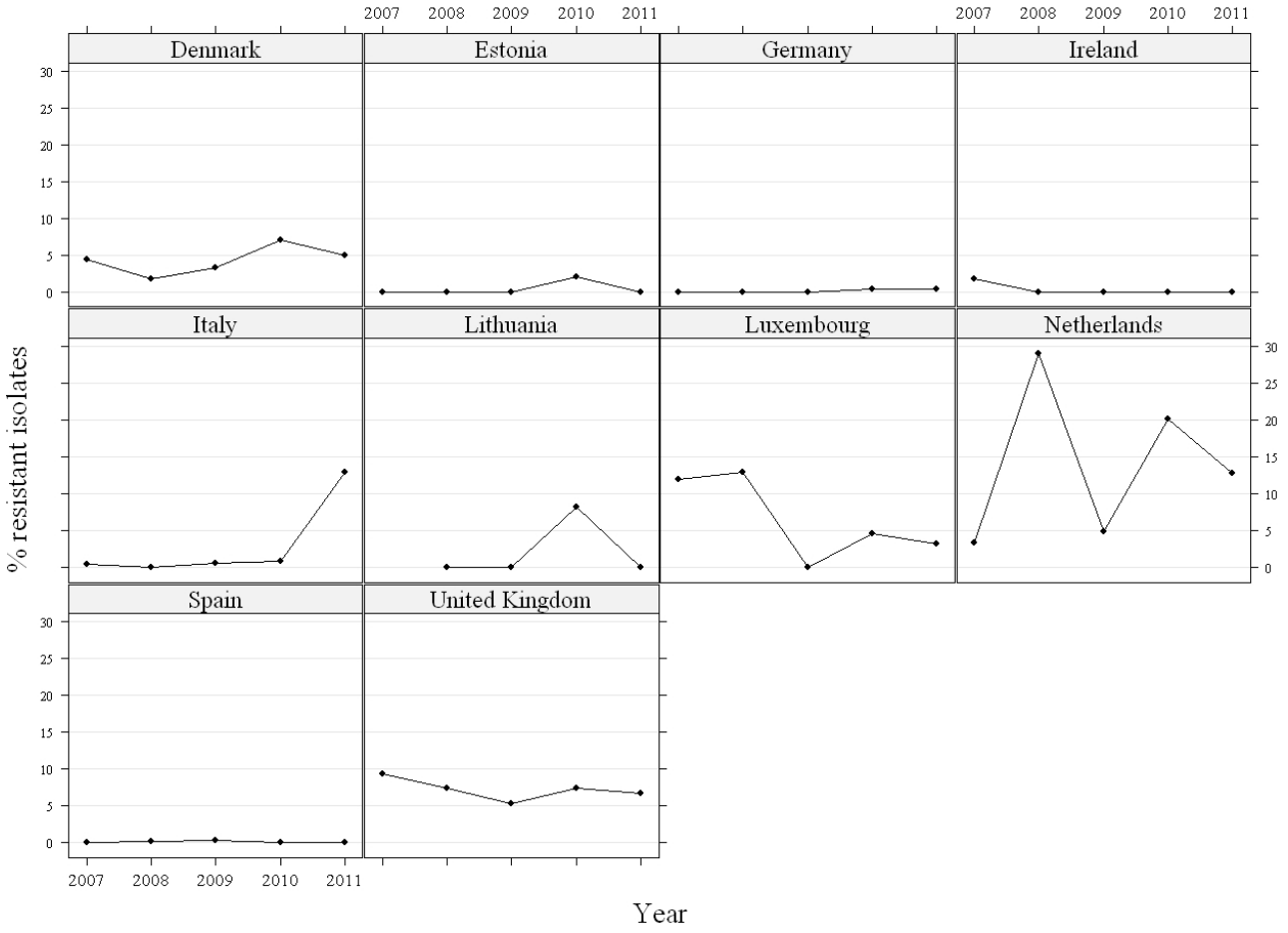
– = no data reported.

NA = not applicable; if fewer than 20 isolates were tested, resistance was not calculated.

1. ECOFFs were used for interpretation.

Figure SA4. Resistance to ciprofloxacin in S. Typhimurium in humans in reporting MSs, 2007–2011, using clinical breakpoints, with some exceptions[1]

Direct comparisons between countries should be avoided owing to use of different interpretive criteria[2]

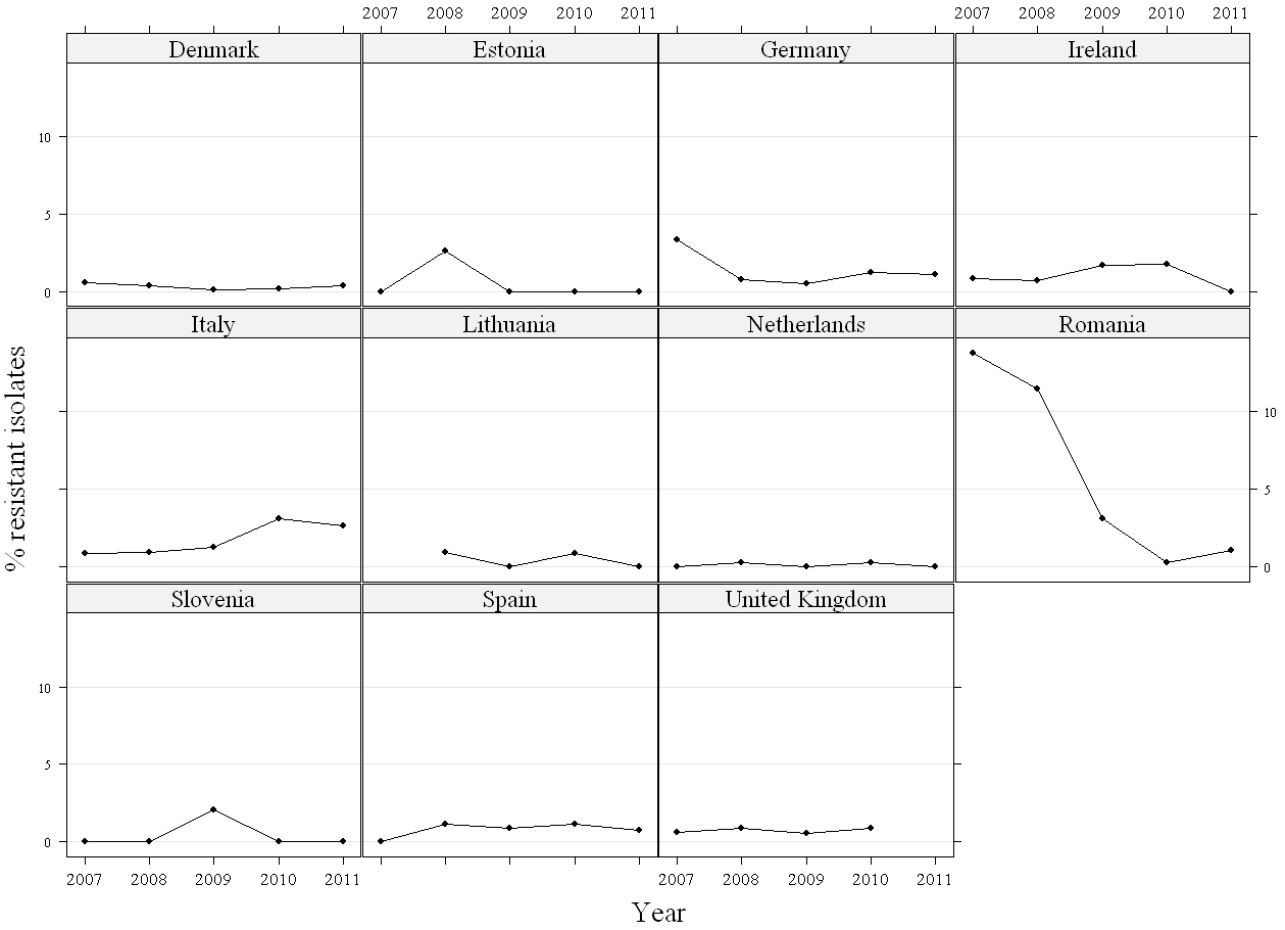


Note: Data for at least four years from 2007 to2011 were also available for Malta, Romania and Slovenia, but are not shown as few, if any, resistant cases were observed in this period in these countries.

1. ECOFFs were used for interpretation in Denmark and the Netherlands.
2. Guidelines used for AST: Denmark (Danmap), Estonia (EUCAST), Germany (DIN), Ireland (EUCAST), Italy (CLSI), Lithuania (CLSI), Luxembourg (CLSI), the Netherlands (EUCAST), Spain (CLSI), UK (HPA). See also Table MM1.

Figure SA5. Resistance to cefotaxime in S. Typhimurium in humans in reporting MSs, 2007-2011, using clinical breakpoints, with some exceptions[1]

Direct comparisons between countries should be avoided owing to use of different interpretive criteria[2]



1. ECOFFs were used for interpretation in Denmark and the Netherlands.
2. Guidelines used for AST: Denmark (Danmap), Estonia (EUCAST), Germany (DIN), Ireland (EUCAST), Italy (CLSI), Lithuania (CLSI), the Netherlands (EUCAST), Romania (CLSI), Slovenia (CLSI), Spain (CLSI), UK (HPA). See also Table MM1.

3.3.4. Multi-drug resistance in *Salmonella* isolates from humans

Twelve MSs had tested isolates for the full range of antimicrobials included in the human data collection for *Salmonella* spp., and these isolates were included in the multi-drug resistance analysis. About half of the human *Salmonella* spp. isolates in the 12 MSs were susceptible to all 10 antimicrobials (55.6 %; N=17,833), varying from 17.1 % (N=697) in Hungary to 79.0 % (N=209) in Estonia (Table SA5). Multi-drug resistance was high (24.1 %; N=17,833; country average 28.2 %) at the EU level, with the highest levels reported from Hungary (60.7 %; N=697) and Italy (54.6 %; N=183) (Table SA5). The proportions of isolates susceptible to all and resistant (or non-susceptible) to any one up to 10 antimicrobials are presented by MSs in Figure SA6. The proportions differed substantially between countries. Isolates resistant to as many as seven or eight antimicrobials were reported from all 12 MSs, and four MSs (Austria, Denmark, Italy and the United Kingdom) even reported a few isolates resistant to nine or all 10 antimicrobials. The serotypes of those isolates resistant to nine or ten antimicrobials included *S.* Bovismorbificans, *S.* Concord, *S.* Haifa, *S.* Kentucky, *S.* Newport, *S.* Typhimurium, monophasic *S*. Typhimurium and *S*. Virchow.

Few isolates exhibited co-resistance to both ciprofloxacin and cefotaxime at the EU level (0.3 %; N=17,833) (Table SA6). The highest co-resistance was observed in isolates from Denmark (1.3 %; N=1,148). It should be noted however that Denmark used ECOFFs as interpretive criteria, which are more sensitive, in particular for ciprofloxacin (see Figure SA1).

Table SA5. Complete susceptibility, multi-resistance and co-resistance (non-susceptibility) to ciprofloxacin and cefotaxime as determined by clinical breakpoints[1] in* Salmonella *spp. from humans by MS, 2011

Country	Susceptible to all (%)	Multi-resistant (%)	Co-resistant to CIP and CTX (%)
Austria (N=2,235)	73.0	14.4	0.1
Denmark[1] (N=1,148)	52.7	26.9	1.3
Estonia (N=209)	78.9	6.2	0
Hungary (N=697)	17.1	60.7	0
Ireland (N=304)	53.6	31.9	0
Italy (N=183)	42.1	54.6	0.5
Lithuania (N=914)	70.5	9.3	0
Luxembourg (N=122)	48.4	35.2	0
Romania (N=281)	27.8	35.9	0
Slovenia (N=400)	70.5	12.0	0
Spain (N=2,102)	35.0	32.7	0
United Kingdom (N=9,238)	58.0	22.4	0.4
Total (12 MSs) (N=17,833)	**55.6**	**24.1**	**0.3**

N = total number of isolates tested for susceptibility against the whole common antimicrobial set for *Salmonella*.

CIP = ciprofloxacin; CTX = cefotaxime.

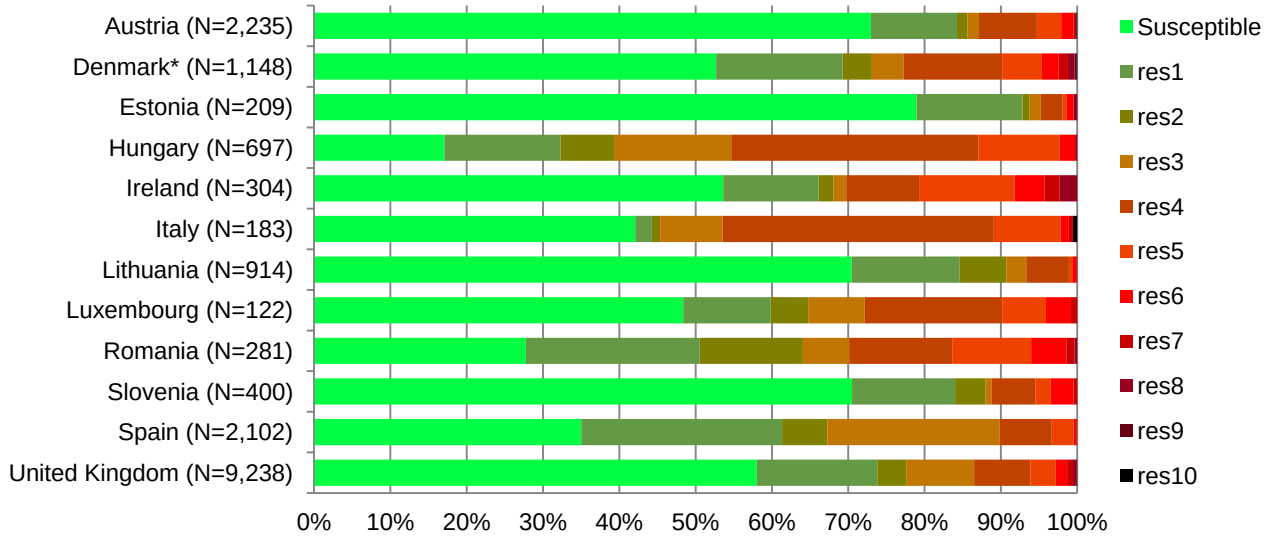
Susceptible to all = proportion of isolates clinically susceptible to all antimicrobial substances of the ECDC common set for *Salmonella*.

Multi-resistant = proportion of isolates clinically non-susceptible (resistant and intermediate) to at least three different antimicrobial substances belonging to any three antimicrobial families from the ECDC common antimicrobial set for *Salmonella.*

Co-resistant to CIP and CTX = proportion of isolates clinically non-susceptible to both ciprofloxacin and cefotaxime.

1. Denmark used ECOFFs for interpreting AST results.

Figure SA6. Frequency distribution of* Salmonella *spp. isolates completely susceptible or resistant to 1 to 10 antimicrobials, as determined by clinical breakpoints,* from humans by MS, 2011



N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances for *Salmonella*.

Susceptible = total number of isolates susceptible to all antimicrobial substances of the common set for *Salmonella*.

res1/res10 = total number of isolates non-suscpetible (resistant and intermediate) to between 1 and 10 antimicrobial substances of the common set for *Salmonella*.

* Denmark used ECOFFs for interpreting AST results.

3.3.5. Antimicrobial resistance in *Salmonella* isolates from humans by geographical region

In 2011, overall, the proportion of isolates tested for any antimicrobial among salmonellosis cases reported as imported (from other EU/EEA countries or outside of EU/EEA) was higher than in cases reported as domestically acquired (62.5 % versus 20.9 % in reporting countries, unknown importation status excluded). Varying levels of resistance were observed among *Salmonella* spp. infections acquired from different geographical regions around the world.[12] Data were submitted on ≥10 isolates from infections acquired in six geographical regions (EU/EEA, non-EU/EEA, Africa, Asia, Northern and Central America, and Southern America). Only for infections acquired in Oceania were an insufficient number of isolates tested (Table SA6).

For all antimicrobials, isolates acquired in Europe contributed to at least 75 % of the isolates tested. Isolates acquired within EU/EEA countries had a much greater level of resistance to both streptomycin (24.6 %; N=11,523) and ampicillin (27.8 %; N=12,619) than isolates acquired in other regions (Table SA15). Isolates acquired from Asia exhibited the highest level of resistance to six antimicrobials, most notably to ciprofloxacin (31.1 %; N=913), nalidixic acid (30.0 %; N=908) and tetracyclines (33.2 %; N=889). Infections acquired in South America exhibited the highest level of resistance to cefotaxime (4.3 %; N=23), although only a few isolates were tested (Table SA6).

[12] Regional classification from United Nations Statistical Division http://unstats.un.org/unsd/methods/m49/m49regin.htm

Table SA6. Antimicrobial resistance in* Salmonella *spp. (all non-typhoidal serovars) from humans by geographical region in 2011, using clinical breakpoints, with some exceptions[1]

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Kanamycin	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Europe (EU/EEA countries)	12,619	27.8	11,739	0.8	9,757	6.2	12,342	5.0	11,805	4.2	10,462	1.2
Europe (non-EU/EEA countries)	33	21.2	29	0	29	0	33	12.1	28	0	28	0
Africa	1,028	12.4	1,013	0.9	1,009	4.7	1,034	19.1	1,017	5.6	948	1.2
Asia	910	20.1	904	2.3	897	7.1	913	31.1	906	7.1	875	5.9
North and Central America	158	3.8	157	1.9	156	3.8	158	11.4	157	0.6	155	1.3
South America	23	8.7	23	4.3	21	4.8	23	17.4	23	8.7	20	20.0
Oceania	7	NA	6	NA	6	NA	6	NA	6	NA	5	NA

Country	Nalidixic acid		Streptomycin		Sulfonamides		Tetracyclines		Trimethoprim	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Europe (EU/EEA countries)	11,611	13.2	11,523	24.6	9,416	20.7	9,985	27.4	10,766	4.0
Europe (non-EU/EEA countries)	31	16.1	29	13.8	26	7.7	29	10.3	27	0
Africa	1,021	19.8	1,011	5.4	999	14.9	1,001	17.5	974	7.5
Asia	908	30.0	904	5.4	889	29.6	889	33.2	887	17.5
North and Central America	157	11.5	157	1.9	156	7.7	156	10.9	156	3.8
South America	23	26.1	23	4.3	21	28.6	21	28.6	20	10.0
Oceania	6	NA	6	NA	6	NA	6	NA	5	NA

N = number of isolates tested.

% Res = percentage of resistant isolates.

NA = not applicable, if less than 10 isolates were tested resistance was not calculated.

1. ECOFFs were used for interpretation in the Netherlands and Denmark.

3.4. Antimicrobial resistance in *Salmonella* isolates from animals and food

Twenty MSs and one non-MS (Norway) reported quantitative MIC data on the antimicrobial resistance of *Salmonella* isolates recovered from animals and food in 2011. The MSs reporting either MIC or IZD data, for each animal or food category, are listed in Tables SA1, SA7 and SA8. The results of 97,602 MIC susceptibility tests performed on the *Salmonella* isolates were included in the analyses, as well as those of 11,441 disc diffusion tests. As quantitative IZD data constitute a relatively small percentage (12 %) of the total data available, these data have therefore been analysed as qualitative data only. The susceptibility test results for *Salmonella* isolates reported as qualitative data are presented in Appendix 1.

The antimicrobials selected by the different MSs and non-MSs for susceptibility testing of *Salmonella* are shown in Chapter 11, Materials and Methods, Table MM4. In this chapter, resistance to ampicillin, cefotaxime, ciprofloxacin, chloramphenicol, gentamicin, nalidixic acid, streptomycin, sulfonamides and tetracyclines has been analysed in detail in line with the antimicrobials listed in the EFSA monitoring and reporting specifications for antimicrobial resistance in *Salmonella* (EFSA, 2007).

In this report, antimicrobial resistance data for all reported *Salmonella* isolates were collated to generate a figure for *Salmonella* spp. (covering all reported serovars) for each country, year and animal/food category. In addition, the *Salmonella* serovars that are most prevalent and significant for public health, *S.* Enteritidis and *S.* Typhimurium, were reported separately when sufficient quantitative data were available from the various animal/food categories.

Table SA7. Overview of countries reporting antimicrobial resistance data using MIC and disc inhibition zones on* Salmonella *Typhimurium from various animal and food categories in 2011

Method	Origin	Total number of MSs reporting	Countries
Diffusion	*Gallus gallus* (fowl)	4	**MSs:** AT[1], PL[2], RO, SI[3]
	Turkeys	1	**MS:** PL[2]
	Pigs	2	**MSs:** AT[1], RO
	Meat from pig	1	**MS:** ES
	Cattle (bovine animals)	3	**MSs:** AT[1], IE[2], LU[1]
	Meat from pig	5	**MSs:** AT[1], ES[2], LT[3], NL[3], PL[2]
	Meat from bovine animals	5	**MSs:** AT[1], ES[2], HU[3], LU[2], PL[2]
Dilution	*Gallus gallus* (fowl)	15	**MSs:** AT, DE, DK, ES, FR, GR, HU, IT, LV, NL, PL, PT, SE, SK, UK
			Non-MS: NO
	Turkeys	9	**MSs:** DE, DK, ES, FI, FR, HU, IE, SK, UK
	Pigs	11	**MSs:** DE, DK, EE, ES, FI, HU, IE, IT, NL, SE, SK
			Non-MS: NO
	Cattle (bovine animals)	9	**MSs:** DE, EE, ES, FI, IE, IT, NL, SE, SK
			Non-MS: NO
	Meat from broilers (*Gallus gallus*)	6	**MSs:** BE, DE, GR, IE, LV, PT
	Meat from turkey	2	**MSs:** DE, FI
	Meat from pig	10	**MSs:** BE, DE, DK, EE, HU, IE, IT, PT, RO, SK
	Meat from bovine animals	5	**MSs:** DE, EE, FI, IE, RO

1. These data were submitted with no test method specified but are believed to have been tested by disc diffusion based on information in the National Zoonoses Reports.
2. These data were submitted with no test method specified and this information could not be obtained from the National Zoonoses Reports.
3. These data were submitted with the test method listed as dilution but no MIC distribution data were supplied.

Table SA8. Overview of countries reporting antimicrobial resistance data using MIC and disc inhibition zones on* Salmonella *Enteritidis from various animal and food categories in 2011

Method	Origin	Total number of MSs reporting	Countries
Diffusion	*Gallus gallus* (fowl)	5	**MSs:** AT[1], CY[2], PL[2], RO, SI[3]
	Turkeys	2	**MSs:** AT[1], PL[2]
	Pigs	1	**MS:** RO
	Cattle (bovine animals)	1	**MS:** IE[2]
	Meat from pig	3	**MSs:** HU[3], NL[3], PL[2]
			Non-MS: IS[1]
	Meat from bovine animals	1	**MS:** SI[3]
Dilution	*Gallus gallus* (fowl)	16	**MSs:** AT, DE, DK, EE, ES, FI, FR, GR, HU, IT, LV, NL, PL, PT, SK, UK
	Turkeys	5	**MSs:** AT, DE, FR, HU, PT
	Pigs	6	**MSs:** DE, DK, EE, ES, HU, IT
	Cattle (bovine animals)	3	**MSs:** DE, IE, IT
	Meat from broilers (*Gallus gallus*)	4	**MSs:** BE, DE, LV, RO
	Meat from pig	2	**MSs:** IT, RO
	Meat from bovine animals	1	**MS:** DE

1. These data were submitted with no test method specified but are believed to have been tested by disc diffusion based on information in the National Zoonoses Reports.
2. These data were submitted with no test method specified and this information could not be obtained from the National Zoonoses Reports.
3. These data were submitted with the test method listed as dilution but no MIC distribution data were supplied.

Whenever a country subjected fewer than 10 isolates to susceptibility testing for a given animal or food category then these data were not included in any further analyses in this report. In addition, tables were generated and analysis performed only if four or more countries tested and reported quantitative data for a given *Salmonella* category and sampling origin.

Where the minimum criteria for detailed analysis were met, temporal trend graphs were generated showing resistance to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, nalidixic acid and tetracyclines for *Salmonella* isolates from animals and food over the 2005–2011 period, by plotting the level of resistance against the year of sampling. Only countries which had reported data for four or more years in the 2005–2011 period were included. Data from 2004 were excluded from the temporal trends graphs because of the relative scarcity of data compared with the 2005–2011 period. Statistical analysis of the trend within individual countries was performed using logistic regression when data were available for five or more years.

The spatial distributions of ampicillin, nalidixic acid and tetracycline resistance rates in *Salmonella* spp. from *Gallus gallus,* turkeys, pigs and cattle are presented. For countries where resistance level figures for 2011 were not available, 2010 figures were used.

Where the minimum criteria for detailed analysis were met, multi-resistance was analysed in isolate-based data on *Salmonella* isolates tested for the full hamonised set of antimicrobials (nine substances) belonging to different classes. Multi-resistance was defined as the non-susceptibility to at least three different antimicrobial classes. The proportions of isolates susceptible to all and resistant (non-susceptible) to any one up to nine antimicrobials were presented. Co-resistance to cefotaxime and ciprofloxacin was estimated as these two antimicrobials are of particular interest in human medicine in the case of treatment of severe salmonellosis. Co-resistance was addressed using both ECOFFs (CTX >0.5 mg/L and CIP >0.06 mg/L) and clinical breakpoints (CTX >2 mg/L and CIP >1 mg/L).

For further information on reported MIC distributions and number of resistant isolates for apramycin, ceftazidime, ceftiofur, colistin, florfenicol, kanamycin, neomycin, spectinomycin, streptomycin and trimethoprim, refer to the Level 3 tables published on the EFSA website.

3.4.1. Antimicrobial resistance in *Salmonella* isolates from food

This section describes the MIC data for isolates of *Salmonella* spp. and *S.* Enteritidis from meat from broilers, and *Salmonella* spp. and *S.* Typhimurium from meat from pigs. Additionally, eight MSs reported data on meat from bovine animals in 2011. However, as only three MSs tested more than 10 isolates, the corresponding data have not been included in the report.

3.4.1.1. Meat from broilers (*Gallus gallus*)

Quantitative MIC susceptibility data for isolates of *Salmonella* spp. from broiler meat from eight MSs in 2011 are included in the following analysis. Data for *S.* Typhimurium isolates are not presented separately for meat from broilers as only one MS tested more than 10 isolates. Details of the sampling scheme used for testing isolates from meat from broilers were submitted by some MSs. Belgium and Germany implement monitoring programmes at slaughterhouses, cutting plants, meat processing plants and at retail. Romania tests all *Salmonella* spp. strains isolated in foodstuffs derived from products of animal origin. The types of samples tested by MSs include neck skin, minced meat and meat preparations.

Resistance levels in *Salmonella* spp.

Table SA9 describes the occurrence of resistance to selected antimicrobials in *Salmonella* spp. isolated from broiler meat in MSs in 2011.

Considering data from the eight reporting MSs, resistance levels to ampicillin, sulfonamides and tetracyclines were high at 20.6 %, 44.8 % and 43.7 % respectively. There was a substantial increase in the levels of resistance to sulfonamides and tetracyclines when compared with the levels reported by a similar group of MSs in 2010 (27 % and 20 % respectively). In 2011, resistance to these antimicrobials was highly variable across the reporting MSs, ranging from 5.0 % to 48.9 % for ampicillin, from 5.0 % to 77.3 % for sulfonamides and from 0 % to 81.2 % for tetracyclines. Resistance to chloramphenicol and gentamicin at the reporting MS group level was 5.4 % and 1.6 % respectively. Resistance levels ranged from 0 % to 20.3 % for chloramphenicol and from 0 % to 10.0 % for gentamicin, with a number of MSs observing no resistance to one or both of these antimicrobials.

Resistance to ciprofloxacin and nalidixic acid among reporting MSs was 50.1 % and 48.8 % respectively, and was a considerable increase on the levels reported in 2010 (24 % for both antimicrobials). As in previous years, the occurrence of resistance to each of these compounds was similar within MSs, and between countries levels ranged from 0 % to 98.8 %. The overall level of resistance to cefotaxime across the reporting MSs remained low in 2011 at 3.3 %. No resistance was observed in Greece, Hungary or Latvia, although Greece and Latvia tested only a limited number of isolates. The Netherlands reported a high level of resistance to cefotaxime of 31.9 %, which was an increase from the level of 11 % reported in 2010.

Resistance levels in *Salmonella* Enteritidis

Resistance among *S.* Enteritidis isolates from broiler meat in reporting MSs was generally lower than that reported in *Salmonella* spp. As low numbers of isolates of *S.* Enteritidis (fewer than 10) were recovered from meat from broilers in Romania, this country has been excluded from the detailed analysis, leaving only Belgium, Germany and Latvia contributing to the analysis; thus, there are insufficient data to present a specific table.

Belgium detected no resistance to gentamicin, chloramphenicol, nalidixic acid and cefotaxime. Resistance to ampicillin, sulfonamides, tetracyclines and ciprofloxacin (1.8 % for each compound) was observed in a single isolate of *S.* Enteritidis in meat from broilers. In both Germany and Latvia, no resistance was detected to ampicillin, cefotaxime, chloramphenicol, gentamicin, sulfonamides or tetracyclines. Resistance was detected against ciprofloxacin and nalidixic acid in both countries. Four isolates (25.0 %) were resistant to both antimicrobials in Germany, whilst three isolates (15.8 %) were resistant to both antimicrobials in Latvia.

Multi-resistance among *Salmonella* isolates from meat from broilers

As fewer than four MSs reported isolate-based resistance data on more than 10 isolates of *Salmonella* spp. in meat from broilers, multi-resistance analysis was not presented.

Table SA9. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *spp. from meat from broilers in MSs reporting MIC data in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Belgium	253	28.1	256	1.6	256	0	254	11.0	256	0	256	10.9	256	33.6	256	15.2
Germany	145	13.8	145	2.8	145	4.1	145	31.0	145	2.1	145	30.3	145	27.6	145	22.1
Greece	10	10.0	10	0	10	0	10	0	10	10.0	10	0	10	10.0	10	0
Hungary	170	9.4	170	0	170	1.2	170	98.2	170	1.8	170	98.8	37	75.7	170	81.2
Ireland	47	17.0	47	8.5	47	0	47	12.8	47	0	47	12.8	47	23.4	47	23.4
Latvia	20	5.0	20	0	20	5.0	20	20.0	20	0	20	20.0	20	5.0	20	5.0
Netherlands	47	48.9	47	31.9	47	6.4	47	70.2	47	0	47	66.0	47	61.7	47	46.8
Romania	172	22.1	172	1.2	172	20.3	172	87.2	172	4.1	172	82.6	172	77.3	172	79.1
Total (8 MSs)	**864**	**20.6**	**867**	**3.3**	**867**	**5.4**	**865**	**50.1**	**867**	**1.6**	**867**	**48.8**	**734**	**44.8**	**867**	**43.7**

N = number of isolates tested.

% Res = percentage of resistant isolates.

3.4.1.2. Meat from pigs

Ten MSs reported quantitative MIC data for *Salmonella* spp. from pig meat in 2011. Data for *S.* Enteritidis isolates are not presented separately for meat from pigs as none of the MSs reporting data tested more than 10 isolates. Tables SA10 and SA11 present the level of resistance to selected antimicrobials for *Salmonella* spp. and *S*. Typhimurium isolates. Monitoring and surveillance programmes for *Salmonella* spp. in meat from pigs at slaughter are in place in Belgium, Denmark and Estonia, while passive surveillance of diagnostic submissions takes place in Germany and Italy. Sample types collected by MSs at slaughterhouses consisted of carcass swabs. Belgium and Estonia tested minced meat and other meat preparations (e.g. ham, sausages and paté) at meat processing plants and at retail.

Resistance levels in *Salmonella* spp.

Among the 10 reporting MSs, *Salmonella* spp. isolated from pig meat displayed very high levels of resistance to ampicillin, sulfonamides and tetracyclines (56.2 %, 54.5 % and 52.8 %, respectively). Within the reporting group, the occurrence of resistance to ampicillin and sulfonamides ranged from high to extremely high across the MSs, varying from 22.7 % to 82.4 % and from 25.0 % to 71.4 %, respectively. Six of the 10 reporting MSs reported resistance to tetracyclines in at least 60.0 % of isolates. Chloramphenicol resistance remained moderate, at 13.7 %, for all reporting MSs, and ranged from 4.3 % to 26.7 % across the reporting MSs. Overall, gentamicin resistance was 1.4 % in the reporting group of MSs; it was not detected in five MSs and ranged between 1.1 % and 8.3 % in the other five reporting MSs.

The proportion of *Salmonella* spp. isolates resistant to ciprofloxacin and nalidixic acid among the reporting MSs was similar to that reported in 2011–7.4 % and 6.1 % respectively compared with 5 % and 4 % in 2010. Once again, Denmark and Estonia reported no resistance to either ciprofloxacin or nalidixic acid. Hungary reported no resistance to nalidixic acid but a low level of resistance to ciprofloxacin. Among countries that did observe resistance to these two antimicrobials the level of resistance ranged from low to high, at 2.5 % to 21.8 %. The occurrence of resistance to cefotaxime among all reporting MSs was very low, at 0.9 %. Four of the 10 reporting MSs reported resistance to cefotaxime in *Salmonella* spp. isolates from pig meat at levels ranging from 0.4 % to 8.3 %.

Resistance levels in *Salmonella* Typhimurium

Seven MSs reported quantitative MIC data for *S*. Typhimurium isolates from pig meat in 2011. For most antimicrobials, resistance levels were higher than the levels reported in *Salmonella* spp. isolates from pig meat. The level of resistance to ampicillin was extremely high across all reporting MSs, at 74.4 %, ranging from 58.3 % in Italy to 90.0 % in Germany. Resistance to sulfonamides, tetracyclines and chloramphenicol were high, at 62.4 %, 59.2 % and 24.0 %, respectively. Fairly wide ranges in the level of resistance in individual reporting MSs were observed for sulfonamides and tetracyclines (from 53.4 % to 85.0 % and from 41.7 % to 82.5 % respectively). Overall resistance to gentamicin was very low in the reporting MS group (0.8 %) and, as in 2010, reporting MSs did not detect resistance to cefotaxime.

Similar levels of resistance to ciprofloxacin and nalidixic acid were observed among isolates within individual MSs. Among all reporting MSs, the occurrence of resistance to ciprofloxacin was 8.0 % and to nalidixic acid was 6.4 %. The levels of resistance to these compounds varied from 1.9 % to 33.3 % among reporting MSs. For the fifth consecutive year, Denmark reported no resistance to ciprofloxacin or nalidixic acid. Among *Salmonella* spp. isolates from pig meat, Hungary reported no resistance to nalidixic acid.

Table SA10. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *spp. isolates from meat from pigs in MSs reporting MIC data in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Belgium	244	67.6	244	0.4	244	11.5	244	4.1	244	0	244	2.5	244	48.0	244	36.1
Denmark	49	71.4	49	0	49	10.2	49	0	49	0	49	0	49	67.3	49	65.3
Estonia	22	22.7	22	0	22	4.3	22	0	22	0	22	0	22	27.3	22	27.3
Germany	115	56.5	115	2.6	115	12.2	115	6.1	115	2.6	115	5.2	115	63.5	115	59.1
Hungary	17	82.4	17	0	17	23.5	17	5.9	17	0	17	0	14	71.4	17	64.7
Ireland	139	48.9	139	0	139	18.7	139	4.3	139	1.4	139	2.9	139	64.0	139	64.7
Italy	67	40.3	67	3.0	67	9.0	67	14.9	67	6.0	67	16.4	67	44.8	67	61.2
Netherlands	15	53.3	15	0	15	26.7	15	20.0	15	0	15	20.0	15	53.3	15	60.0
Portugal	12	50.0	12	8.3	12	25.0	12	8.3	12	8.3	12	8.3	12	25.0	12	66.7
Romania	87	43.7	87	0	87	16.1	87	21.8	88	1.1	87	18.4	86	54.7	87	59.8
Total (10 MSs)	**767**	**56.2**	**767**	**0.9**	**767**	**13.7**	**767**	**7.4**	**768**	**1.4**	**767**	**6.1**	**763**	**54.5**	**767**	**52.8**

N = number of isolates tested.

% Res = percentage of resistant isolates.

Table SA11. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Typhimurium isolates from meat from pigs in MSs reporting MIC data in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Belgium	103	78.6	103	0	103	13.6	103	3.9	103	0	103	1.9	103	53.4	103	41.7
Denmark	28	60.7	28	0	28	17.9	28	0	28	0	28	0	28	60.7	28	50.0
Germany	20	90.0	20	0	20	40.0	20	10.0	20	0	20	10.0	20	85.0	20	75.0
Hungary	12	75.0	12	0	12	33.3	12	8.3	12	0	12	0	-	-	12	58.3
Ireland	57	70.2	57	0	57	38.6	57	7.0	57	1.8	57	7.0	57	82.5	57	82.5
Italy	12	58.3	12	0	12	16.7	12	25.0	12	8.3	12	33.3	12	58.3	12	75.0
Romania	18	77.8	18	0	18	27.8	18	33.3	18	0	18	22.2	18	72.2	18	72.2
Total (7 MSs)	**250**	**74.4**	**250**	**0**	**250**	**24.0**	**250**	**8.0**	**250**	**0.8**	**250**	**6.4**	**250**	**62.4**	**250**	**59.2**

N = number of isolates tested.

% Res = percentage of resistant isolates.

– = no data reported.

Multi-resistance among *Salmonella* spp. isolates from meat from pigs

In 2011, five MSs provided isolate-based data concerning resistance in *Salmonella* spp. in meat from pigs. Among the reporting MSs, isolates exhibiting complete susceptibility accounted for about 20 % to 25 % of the isolates tested and this figure reached above 70 % in Estonia, although, in this case, the complete susceptibility level was assessed on an isolate sample of small size. The multi-resistance levels ranged between 27.3 % in Estonia and 65.3 % in Denmark (Table SA12).The frequency distributions (Figure SA7) showed similarities among the multi-resistance recorded in three reporting MSs, with some isolates showing reduced susceptibility to up to eight different substances, while Denmark and Estonia recorded multi-resistance to five classes at a maximum. Very few isolates were resistant to both ciprofloxacin and cefotaxime.

Table SA12. Complete susceptibility, multi-resistance and index of diversity in* Salmonella *spp. from meat from pigs in MSs reporting isolate-based data, 2011

Country	Susceptible to all		Multi-resistant		Index of diversity	Co-resistant to CIP and CTX	
	n	%	n	%		n	%
Denmark (N=49)	9	18.4	32	65.3	0.372	0 (0)	0 (0)
Estonia (N=22)	16	72.7	6	27.3	0.259	0 (0)	0 (0)
Germany (N=115)	29	25.2	71	61.7	0.451	0 (0)	0 (0)
Ireland (N=139)	37	26.6	83	59.7	0.552	0 (0)	0 (0)
Italy (N=67)	18	26.9	30	44.8	0.525	2 (0)	3.0 (0)

N = total number of isolates tested for susceptibility against the whole EFSA antimicrobial set for *Salmonella*.

n = number of isolates per category of complete susceptibility or multiple resistance.

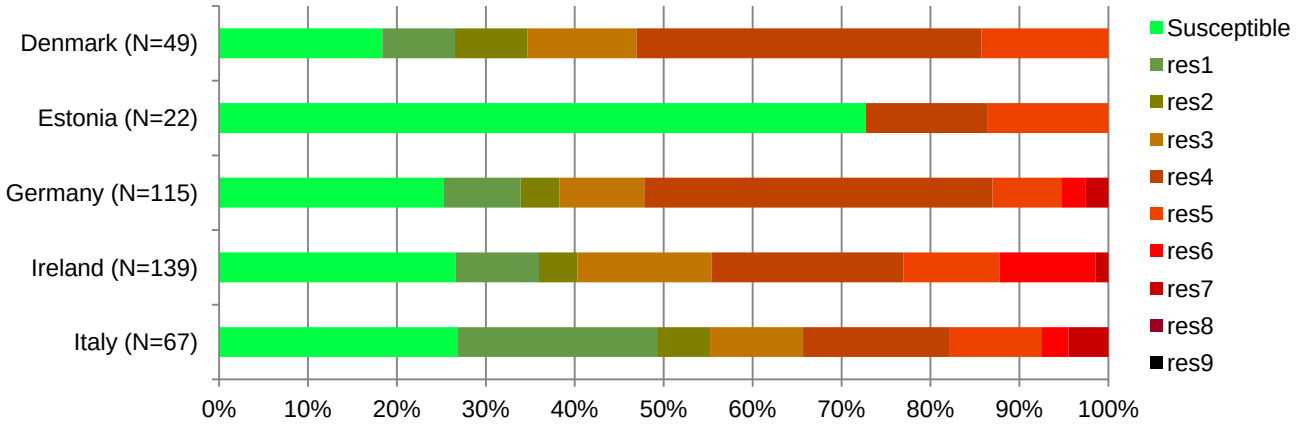
Susceptible to all = isolate susceptible to all antimicrobial substances of the EFSA common set for *Salmonella*.

Multi-resistant = resistant to at least three different antimicrobial substances, belonging to any three classes from the common set.

Index of diversity = see definition in Section 11.4.2.1 of Materials and Methods.

Co-resistant to ciprofloxacin (CIP) and cefotaxime (CTX) = the frequencies and percentages of *Salmonella* isolates not susceptible to concentrations greater than ECOFFs (CTX: >0.5 mg/L and CIP: >0.06 mg/L). Figures in parentheses indicate the occurrence of resistance determined using EUCAST clinical breakpoints (CTX: >2 mg/L and CIP: >1 mg/L).

Figure SA7. Frequency distribution of* Salmonella *spp. in meat from pigs completely susceptible or resistant to one to nine antimicrobials, in in MSs reporting isolate-based data, 2011



N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances.

Susceptible = susceptible to all antimicrobial substances of the common set.

res1/res9 = resistance to one antimicrobial substance/resistance to nine antimicrobial substances of the common set.

3.4.2. Antimicrobial resistance in *Salmonella* isolates from animals

3.4.2.1. Fowl (*Gallus gallus*)

A new feature of this section in 2011 is that data from broiler flocks and laying hens have been presented separately. As in previous years, an overview of all data including breeding, laying hen and broiler flocks, as well as unspecified flocks of *Gallus gallus,* is also presented. In 2011, 16 MSs submitted quantitative antimicrobial susceptibility data for *Salmonella* spp. from *Gallus gallus.* In the majority of MSs, isolates for antimicrobial resistance testing are obtained from national control programmes carried out according to EC regulations. In Greece no official national programme is in force and isolates are obtained from faecal samples from broilers before slaughter and laying hens during rearing, and from eggshells from breeding flocks at the hatchery. In Latvia isolates were obtained from faecal samples from broilers before slaughter and from laying hens at farm.

Resistance levels in *Salmonella* spp.

Table SA13 shows the level of resistance to antimicrobials among isolates of *Salmonella* spp. from *Gallus gallus* in 2011. There was moderate resistance to ampicillin and tetracyclines in the reporting MS group (18.9 % and 17.8 %, respectively) and the reported levels varied between 2.6 % and 39.5 % for ampicillin and 2.4 % and 57.4 % for tetracyclines across the 16 reporting countries. Sulfonamide resistance was high at 25.3 % and ranged from 4.6 % to 55.8 % across the 16 reporting MSs. A low level of resistance to chloramphenicol was reported at MS group level (2.3 %) and reported levels ranged from 0 % to 6.6 % between countries. Considering the reporting MS group, the occurrence of resistance to ciprofloxacin was 28.7 % and to nalidixic acid was 27.9 %. The level of resistance to both antimicrobials within individual MSs ranged widely, from 0 % to 63.5 %. As previously observed, there was considerable disparity in resistance to ciprofloxacin and nalidixic acid among *Salmonella* isolates from different MSs, which may reflect the variability of serovars of *Salmonella* spp. included in the analyses of the different MSs. Gentamicin resistance was detected at a low level of 0.3 % to 4.5 % across the reporting MSs, and not detected at all by Denmark, France, Greece and Latvia. The overall occurrence of resistance considering all reporting MSs was 1.5 %. Cefotaxime resistance was reported by 9 of the 15 reporting MSs and varied from at 0.7 % to 10.0 %, with an overall resistance at MS group level of 1.5 %. The highest level of resistance to cefotaxime was reported by the Netherlands (10.0 %), which saw a return to a similar level to that reported in 2009 (12 %) following a decrease to 5 % in 2010.

Resistance among isolates of *Salmonella* spp. from broiler flocks is presented in Table SA14. Thirteen MSs reported quantitative data from broilers in 2011, and in general the levels of resistance at this production level were slightly higher than those reported when all *Gallus gallus* were considered. There was moderate resistance to ampicillin at the MS group level (18.0 %) and the levels reported by individual MSs ranged from 4.8 % to 42.7 %. Resistance to sulfonamides and tetracyclines was high at 38.0 % and 31.0 % respectively, and ranged from 4.8 % to 73.4 % for sulfonamides and from 3.2 % to 70.4 % for tetracyclines. Low levels of resistance were reported for chloramphenicol (2.7 %) and gentamicin (1.6 %) and these ranged from 0 % to 7.4 %, and from 0 % to 10.0 % respectively. The occurrence of resistance to ciprofloxacin and nalidixic acid was high at the MS group level (35.1 % and 33.4 % respectively). Denmark observed no resistance to both compounds, while, in the remaining 12 MSs, resistance to both compounds ranged from 1.6 % to 82.8 %. Cefotaxime resistance was observed by 9 of the 13 reporting MSs with an overall level of 2.8 %. The Netherlands reported the highest level of resistance (16.5 %) with the remaining reported levels ranging from 0.6 % to 5.6 %.

Table SA15 describes the resistance among isolates of *Salmonella* spp. from laying hens. Twelve MSs reported quantitative data from laying hens in 2011, and in contrast to the data from broilers, the levels of resistance at this production level were lower than those reported when all *Gallus gallus* were considered. Low levels of resistance to ampicillin and sulfonamides were reported at the MS group level (7.1 % and 9.1 % respectively) and the levels reported by individual MSs ranged from 0 % to 21.6 % for ampicillin, and from 0 % to 27.5 % for sulfonamides. Moderate resistance to tetracyclines was observed across all reporting MSs (11.6 %), and this ranged from 0 % to 29.4 %. Low levels of resistance to chloramphenicol (1.8 %) and gentamicin (1.1 %) were reported at the MS group level, and ranged from 0 % to 7.8 % and from 0 % to 5.0 %, respectively. Moderate resistance to ciprofloxacin and nalidixic acid was reported at the MS group level (12.7 % and 12.4 % respectively). France, Latvia, Slovakia and the United Kingdom observed no resistance to both compounds, while in the remaining eight MSs resistance to both compounds ranged from 3.9 % to 26.5 %. Cefotaxime resistance was observed only by Hungary, Italy and the United Kingdom making the overall resistance at MS group level 0.4 %.

Table SA13. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *spp. isolates from* Gallus gallus *in MSs reporting MIC data in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	176	10.8	176	1.1	176	0	176	26.7	176	0.6	176	26.1	176	21.6	176	28.4
Belgium	755	39.5	-	-	756	3.2	755	33.4	756	2.0	755	33.4	722	36.8	756	15.5
Denmark	48	14.6	48	0	48	0	48	0	48	0	48	0	48	12.5	48	12.5
France	326	13.8	326	0	326	2.1	326	2.1	326	0	326	2.1	326	20.2	326	15.6
Germany	291	12.0	291	0.7	291	2.4	291	7.9	291	0.7	291	8.2	291	17.2	291	8.9
Greece	38	2.6	48	2.1	48	0	48	22.9	48	0	48	12.5	48	8.3	46	6.5
Hungary	249	5.6	249	2.0	249	4.8	249	63.5	249	2.0	249	61.8	249	55.8	249	53.4
Ireland	65	4.6	65	1.5	65	0	65	1.5	65	1.5	65	1.5	65	4.6	65	3.1
Italy	198	26.3	199	3.5	198	6.6	199	24.1	198	4.5	198	23.7	198	16.7	198	23.2
Latvia	12	8.3	12	0	12	0	12	0	12	0	12	0	12	16.7	12	8.3
Netherlands	180	26.7	180	10.0	180	0.6	180	25.6	180	1.1	180	25.0	180	32.8	180	16.7
Poland	340	10.9	340	0	333	0.3	340	51.2	340	0.3	339	49.3	340	8.2	340	2.4
Portugal	170	13.5	170	1.2	170	1.2	170	46.5	170	1.2	170	43.5	170	11.8	170	8.8
Slovakia	54	11.1	54	0	54	0	54	55.6	54	3.7	54	55.6	54	53.7	54	57.4
Spain	220	10.0	220	0	220	0.9	220	35.0	220	2.7	220	33.2	220	9.1	220	10.9
United Kingdom	221	9.0	221	0.9	221	3.6	221	4.5	221	1.4	221	4.1	221	35.3	221	24.9
Total (16 MSs)	**3,343**	**18.9**	**2,599**	**1.5**	**3,347**	**2.3**	**3,354**	**28.7**	**3,354**	**1.5**	**3,352**	**27.9**	**3,320**	**25.3**	**3,352**	**17.8**

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

Table SA14. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *spp. isolates from broilers in MSs reporting MIC data in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	90	18.9	90	2.2	90	0	90	46.7	90	0	90	46.7	90	40.0	90	51.1
Denmark	43	14.0	43	0	43	0	43	0	43	0	43	0	43	9.3	43	11.6
France	160	21.3	160	0	160	2.5	160	4.4	160	0	160	4.4	160	33.8	160	18.8
Germany	39	23.1	39	2.6	39	5.1	39	17.9	39	0	39	17.9	39	28.2	39	12.8
Greece	15	6.7	25	4.0	25	0	25	24.0	25	0	25	12.0	25	8.0	24	4.2
Hungary	169	7.1	169	1.8	169	6.5	169	82.8	169	0.6	169	79.9	169	73.4	169	70.4
Ireland	63	4.8	63	1.6	63	0	63	1.6	63	1.6	63	1.6	63	4.8	63	3.2
Italy	54	31.5	54	5.6	54	7.4	54	27.8	54	5.6	54	25.9	54	20.4	54	35.2
Netherlands	103	42.7	103	16.5	103	1.0	103	37.9	103	1.9	103	36.9	103	51.5	103	25.2
Portugal	100	23.0	100	2.0	100	2.0	100	62.0	100	2.0	100	57.0	100	18.0	100	11.0
Slovakia	44	11.4	44	0	44	0	44	68.2	44	4.5	44	68.2	44	65.9	44	68.2
Spain	40	32.5	40	0	40	5.0	40	67.5	40	10.0	40	60.0	40	22.5	40	17.5
United Kingdom	170	7.1	170	0.6	170	2.4	170	5.9	170	1.8	170	5.3	170	37.6	170	23.5
Total (13 MSs)	**1,090**	**18.0**	**1,100**	**2.8**	**1,100**	**2.7**	**1,100**	**35.1**	**1,100**	**1.6**	**1,100**	**33.4**	**1,100**	**38.0**	**1,099**	**31.0**

N = number of isolates tested.

% Res = percentage of resistant isolates.

Table SA15. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *spp. isolates from laying hens in MSs reporting MIC data in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	86	2.3	86	0	86	0	86	5.8	86	1.2	86	4.7	86	2.3	86	4.7
France	166	6.6	166	0	166	1.8	166	0	166	0	166	0	166	7.2	166	12.7
Germany	103	9.7	103	0	103	1.9	103	3.9	103	1.0	103	3.9	103	10.7	103	9.7
Greece	18	0	18	0	18	0	18	22.2	18	0	18	16.7	18	11.1	17	11.8
Hungary	80	2.5	80	2.5	80	1.3	80	22.5	80	5.0	80	23.8	80	18.8	80	17.5
Italy	88	21.6	89	1.1	88	6.8	89	22.5	88	3.4	88	21.6	88	13.6	88	19.3
Latvia	10	0	10	0	10	0	10	0	10	0	10	0	10	0	10	0
Netherlands	67	4.5	67	0	67	0	67	7.5	67	0	67	7.5	67	6.0	67	4.5
Portugal	64	0	64	0	64	0	64	23.4	64	0	64	23.4	64	3.1	64	6.3
Slovakia	10	10.0	10	0	10	0	10	0	10	0	10	0	10	0	10	10.0
Spain	170	5.3	170	0	170	0	170	26.5	170	0.6	170	25.9	170	5.3	170	8.8
United Kingdom	51	15.7	51	2.0	51	7.8	51	0	51	0	51	0	51	27.5	51	29.4
Total (12 MSs)	**913**	**7.1**	**914**	**0.4**	**913**	**1.8**	**914**	**12.7**	**913**	**1.1**	**913**	**12.4**	**913**	**9.1**	**912**	**11.6**

N = number of isolates tested.

% Res = percentage of resistant isolates.

Resistance levels in *Salmonella* Enteritidis

Susceptibility data on *S.* Enteritidis isolates from *Gallus gallus* were reported by 11 MSs in 2011 (Table SA16). The levels of resistance in the reporting MS group to ampicillin, sulfonamides and tetracyclines were low at 5.5 %, 4.8 % and 2.5 % respectively. The occurrence of resistance to ampicillin ranged from 3.1 % to 20.0 % among reporting MS, and no resistance to this antimicrobial was observed by France, Germany, the Netherlands and Slovakia. A similar observation was made for sulfonamides, resistance to which ranged from 0 % to 26.8 % across the reporting countries. Six countries did not detect resistance to tetracyclines and among those that did, reported resistance ranged from 0.4 % to 26.8 %. As in 2010, resistance to chloramphenicol in 2011 was relatively rare among *S.* Enteritidis isolates in the reporting MS group (0.3 %) and was detected only in isolates from Hungary and Poland. Hungary was the only country to report gentamicin resistance, at a low level (3.1 %). In contrast to the other antimicrobials tested, the occurrence of ciprofloxacin and nalidixic acid resistance in the reporting MSs was high at 30.8 % for both compounds. This continues the overall increasing trend in resistance to these compounds observed in recent years among isolates of *S.* Enteritidis from *Gallus gallus*. Once again, the levels of ciprofloxacin and nalidixic acid resistance within each MS were generally very similar, as would be expected. The levels of resistance to both antimicrobials varied from 0 % to 90.2 % among reporting MSs. In a similar pattern to the data reported in 2010, the highest occurrence of ciprofloxacin and nalidixic acid resistance was reported by Portugal (90.2 %), followed by Spain (65.7 %) and then Poland (47.4 % for ciprofloxacin and 46.9 % for nalidixic acid). Resistance to cefotaxime in *S.* Enteritidis was reported only by Austria and Hungary in 2011, making the overall resistance at MS group level very low at 0.6 %. Hungary was also the only country to report resistance to gentamicin at a low level of 3.1 %. Germany and Slovakia did not observe resistance to any of the antimicrobials tested.

Four MSs reported quantitative data on isolates of *S.* Enteritidis from broiler flocks in 2011 (Table SA16). In the case of almost all antimicrobials tested, the levels of resistance among isolates were higher when considering only broiler flocks than considering all *Gallus gallus,* although the overall number of isolates tested was considerably lower. Germany and Slovakia did not observe resistance to any of the antimicrobials tested, however they each tested only 10 isolates from broiler flocks. Among the four reporting MSs, the overall resistance to ampicillin was low, at 9.4 %, and was only reported by Austria (26.7 %) and Portugal (6.9 %). Within these two countries the level of resistance to sulfonamides and tetracyclines was the same, with the overall level of resistance to each compound being 15.6 %. Portugal was the only country to report resistance to ciprofloxacin and nalidixic acid among isolates of *S.* Enteritidis from broiler flocks. In both cases, it observed an extremely high level of resistance (93.1 %). Austria was the only country to observe resistance to cefotaxime, at the moderate level of 13.3 %. None of the reporting MSs observed resistance to chloramphenicol or gentamicin.

Quantitative data on isolates of *S.* Enteritidis from laying hens were reported by seven MSs in 2011 (Table SA16). As for *Salmonella* spp., the levels of resistance among isolates from laying hens were generally lower than those observed in broiler flocks, or when all *Gallus gallus* were considered together. France and Germany did not observe resistance to any of the antimicrobials tested. The occurrence of resistance to ampicillin, sulfonamides and tetracyclines was low across the reporting MSs (2.2 %, 1.9 % and 1.9 % respectively). Only three MSs observed resistance to ampicillin and sulfonamides with values varying from 3.3 % to 21.4 %, and from 3.3 % to 14.3 % respectively. Tetracycline resistance was observed in isolates from laying hens only in Italy (21.4 %) and Spain (3.4 %). Moderate levels of resistance to ciprofloxacin and nalidixic acid were observed at the MSs group level (16.2 % and 16.7 % respectively). As usually observed, the levels of resistance within each MS were generally very similar for the two compounds. For both antimicrobials, reported resistance levels reported ranged from 0 % to 61.0 %. Hungary was the only country to observe resistance to chloramphenicol (3.3 %), gentamicin (3.3 %) and cefotaxime (6.7 %).

Table SA16. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Enteritidis isolates from* Gallus gallus *in MSs reporting MIC data in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
All *Gallus gallus*																
Austria	53	7.5	53	3.8	53	0	53	5.7	53	0	53	5.7	53	1.9	53	1.9
France	41	0	41	0	41	0	41	2.4	41	0	41	2.4	41	0	41	0
Germany	133	0	133	0	133	0	133	0	133	0	133	0	133	0	133	0
Greece	-	-	17	0	17	0	17	11.8	17	0	17	11.8	17	0	17	0
Hungary	32	3.1	32	6.3	32	3.1	32	9.4	32	3.1	32	12.5	32	3.1	32	0
Italy	15	20.0	16	0	15	0	16	6.3	15	0	15	6.7	15	13.3	15	20.0
Netherlands	31	0	31	0	31	0	31	6.5	31	0	31	6.5	31	3.2	31	0
Poland	274	9.5	274	0	274	0.4	274	47.4	274	0	273	46.9	274	6.2	274	0.4
Portugal	41	4.9	41	0	41	0	41	90.2	41	0	41	90.2	41	26.8	41	26.8
Slovakia	18	0	18	0	18	0	18	0	18	0	18	0	18	0	18	0
Spain	67	4.5	67	0	67	0	67	65.7	67	0	67	65.7	67	3.0	67	3.0
Total (11 MSs)	**705**	**5.5**	**723**	**0.6**	**722**	**0.3**	**723**	**30.8**	**722**	**0.1**	**721**	**30.8**	**722**	**4.8**	**722**	**2.5**
Broiler flocks																
Austria	15	26.7	15	13.3	15	0	15	0	15	0	15	0	15	6.7	15	6.7
Germany	10	0	10	0	10	0	10	0	10	0	10	0	10	0	10	0
Portugal	29	6.9	29	0	29	0	29	93.1	29	0	29	93.1	29	31.0	29	31.0
Slovakia	10	0	10	0	10	0	10	0	10	0	10	0	10	0	10	0
Total (4 MSs)	**64**	**9.4**	**64**	**3.1**	**64**	**0**	**64**	**42.2**	**64**	**0**	**64**	**42.2**	**64**	**15.6**	**64**	**15.6**
Laying hens																
Austria	38	0	38	0	38	0	38	7.9	38	0	38	7.9	38	0	38	0
France	39	0	39	0	39	0	39	0	39	0	39	0	39	0	39	0
Germany	64	0	64	0	64	0	64	0	64	0	64	0	64	0	64	0
Hungary	30	3.3	30	6.7	30	3.3	30	10.0	30	3.3	30	13.3	30	3.3	30	0
Italy	14	21.4	15	0	14	0	15	6.7	14	0	14	7.1	14	14.3	14	21.4
Netherlands	26	0	26	0	26	0	26	3.8	26	0	26	3.8	26	0	26	0
Spain	59	3.4	59	0	59	0	59	61.0	59	0	59	61.0	59	3.4	59	3.4
Total (7 MSs)	**270**	**2.2**	**271**	**0.7**	**270**	**0.4**	**271**	**16.2**	**270**	**0.4**	**270**	**16.7**	**270**	**1.9**	**270**	**1.9**

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

Note: Data reported under 'All *Gallus gallus*' include that data which have been reported by production level.

Resistance levels in *Salmonella* Typhimurium

Six MSs reported quantitative MIC antimicrobial susceptibility data for *S.* Typhimurium isolates from *Gallus gallus* in 2011 (Table SA17). Only two MSs provided production level information with these data and this has been indicated in the table footnotes. The overall level of resistance to ampicillin, sulfonamides and tetracyclines in the reporting MS group was higher among *S.* Typhimurium isolates from *Gallus gallus* (26.8 %, 33.9 % and 27.7 %, respectively), than in *S.* Enteritidis isolates and all *Salmonella* spp. isolates as a whole. All MSs except Hungary reported resistance to ampicillin, and the prevalence ranged from 13.3 % to 53.3 %. Overall resistance to sulfonamides and tetracyclines ranged from 10.0 % to 53.3 % and from 13.3 % to 46.7 %, respectively. At the reporting MS group level, the occurrence of resistance to ciprofloxacin and nalidixic acid was 10.7 % and 9.8 %, respectively. Among individual MSs, the level of ciprofloxacin resistance varied from 0 % in France, Germany, the Netherlands and the United Kingdom, to 73.3 % in Poland. Similarly, the level of resistance to nalidixic acid among individual MSs varied from 0 % in France, the Netherlands and the United Kingdom, to 53.3 % in Poland. Neither cefotaxime nor gentamicin resistance was detected in *S.* Typhimurium isolates from any reporting MSs.

Table SA17. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Typhimurium isolates from* Gallus gallus *in MSs reporting MIC data in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
France[1]	33	36.4	33	0	33	15.2	33	0	33	0	33	0	33	39.4	33	36.4
Germany	29	17.2	29	0	29	13.8	29	0	29	0	29	6.9	29	34.5	29	13.8
Hungary	10	0	10	0	10	0	10	10.0	10	0	10	10.0	10	10.0	10	30.0
Netherlands[2]	15	13.3	15	0	15	6.7	15	0	15	0	15	0	15	20.0	15	13.3
Poland	15	53.3	15	0	0	0	15	73.3	15	0	15	53.3	15	53.3	15	46.7
United Kingdom	10	30.0	10	0	10	10.0	10	0	10	0	10	0	10	30.0	10	30.0
Total (6 MSs)	**112**	**26.8**	**112**	**0**	**97**	**11.3**	**112**	**10.7**	**112**	**0**	**112**	**9.8**	**112**	**33.9**	**112**	**27.7**

N = number of isolates tested.

% Res = percentage of resistant isolates.

1. Twenty-eight of the isolates tested by France were from laying hens.

2. Eleven of the isolates tested by the Netherlands were from broiler chickens.

Temporal trends in resistance among *Salmonella* spp. isolates from *Gallus gallus*

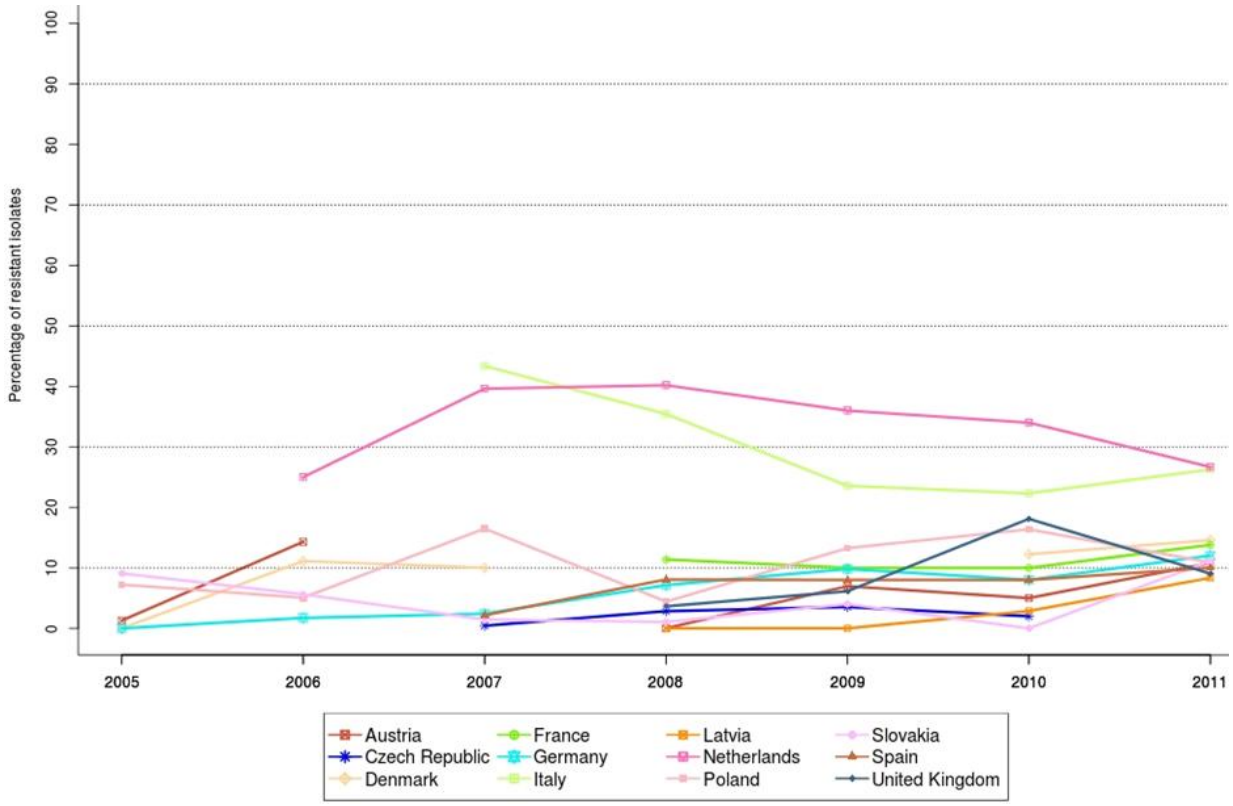
Figures SA8–SA11 indicate how the level of resistance to selected antimicrobials in *Salmonella* spp. isolates from *Gallus gallus* has changed over the period 2005–2011 in the MSs and non-MSs. It is important to note that because some antimicrobial resistance is associated with particular serovars or clones within serovars, fluctuations in the occurrence of resistance in *Salmonella* spp. isolates within a country may result from changes in the proportions of different *Salmonella* serovars which contribute to the total numbers of *Salmonella* spp. isolates tested.

For the majority of MSs, resistance to ampicillin increased slightly between 2010 and 2011, although decreases were observed in the Netherlands, Poland and the United Kingdom. Across the seven years of data, statistically significant increasing trends were observed in Austria, Germany and Poland, while decreasing trends were observed in Italy and the Netherlands. Regarding tetracyclines, increasing trends were observed in Austria and Germany for five or more years, and decreasing trends were observed in Italy, the Netherlands and Spain.

The level of resistance to cefotaxime in *Salmonella* spp. was generally low, very low or absent in reporting MSs between 2005 and 2011. A statistically significant decreasing trend for five or more years was observed in Italy and Spain. Statistically significant increasing trends in resistance to ciprofloxacin and nalidixic acid were registered in three MSs for five or more years over the 2005–2011 period. Spain observed a statistically significant decreasing trend in resistance to both antimicrobials, while Italy and the Netherlands observed a significant decrease in resistance to ciprofloxacin only.

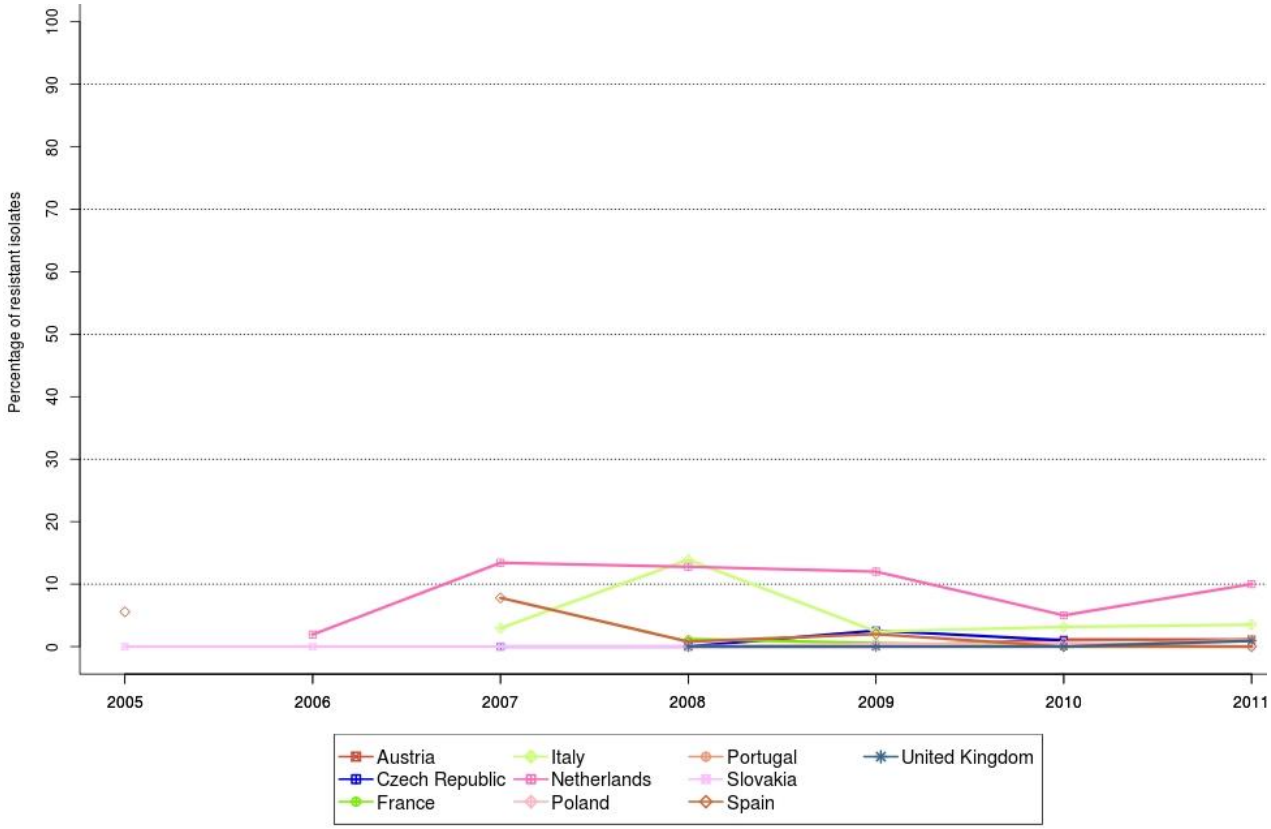
All reporting MSs observed a similarity in their trends in resistance to ciprofloxacin and nalidixic acid among isolates of *S.* Enteritidis from *Gallus gallus*. In most MSs there was little change in the trends reported in the 2005-2011 period. Statistically significant decreasing trends were observed in Germany and the Netherlands for both substances, while a significant increasing trend was observed in Poland, also for both substances.

Figure SA8. Trends in ampicillin resistance in tested* Salmonella *spp. isolates from* Gallus gallus *in reporting MSs, 2005-2011, quantitative data



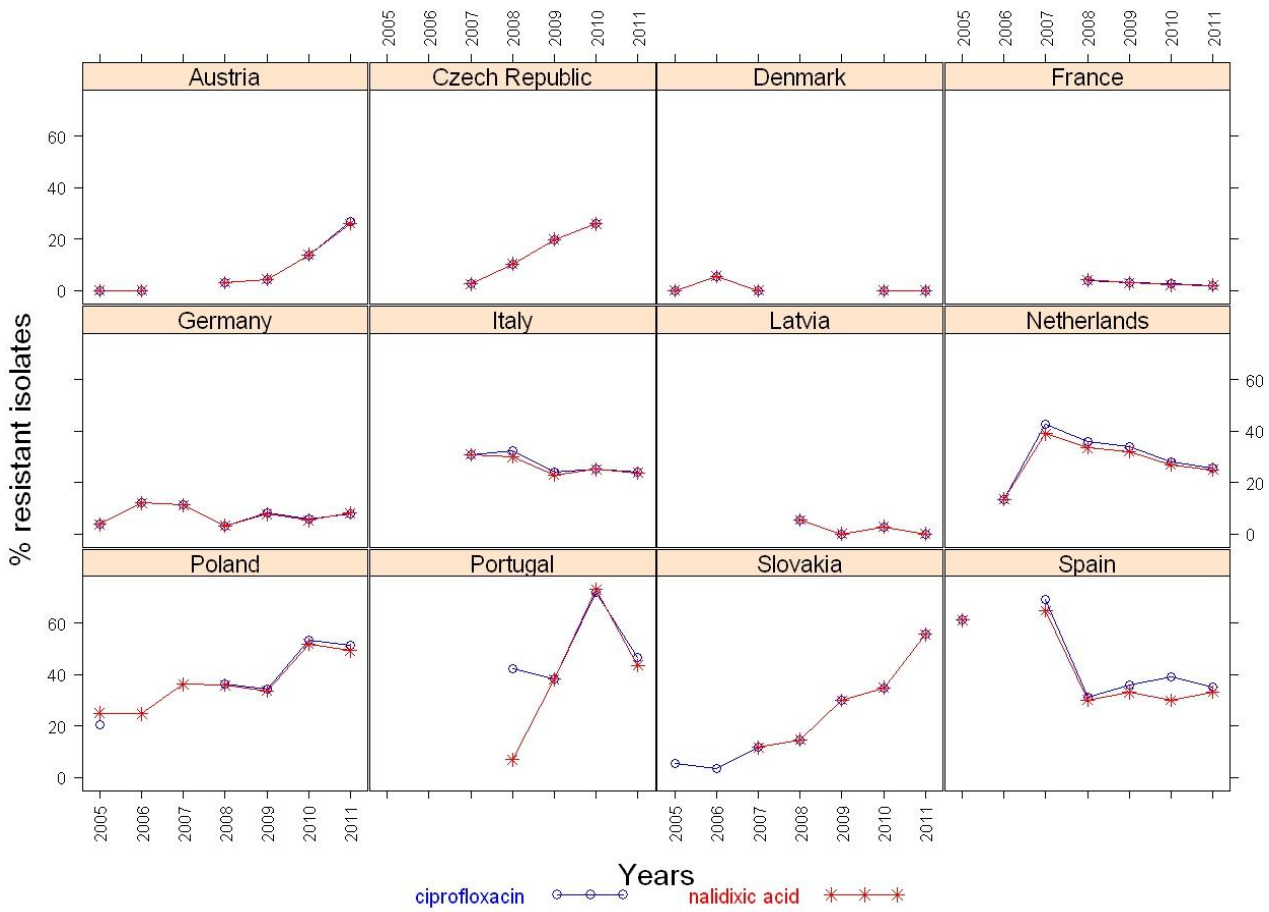
Note: Statistically significant increasing or decreasing trends for five or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Austria (↑), Germany (↑), Italy (↓), the Netherlands (↓) and Poland (↑).

Figure SA9. Trends in cefotaxime resistance in tested* Salmonella *spp. isolates from* Gallus gallus *in reporting MSs, 2005-2011, quantitative data



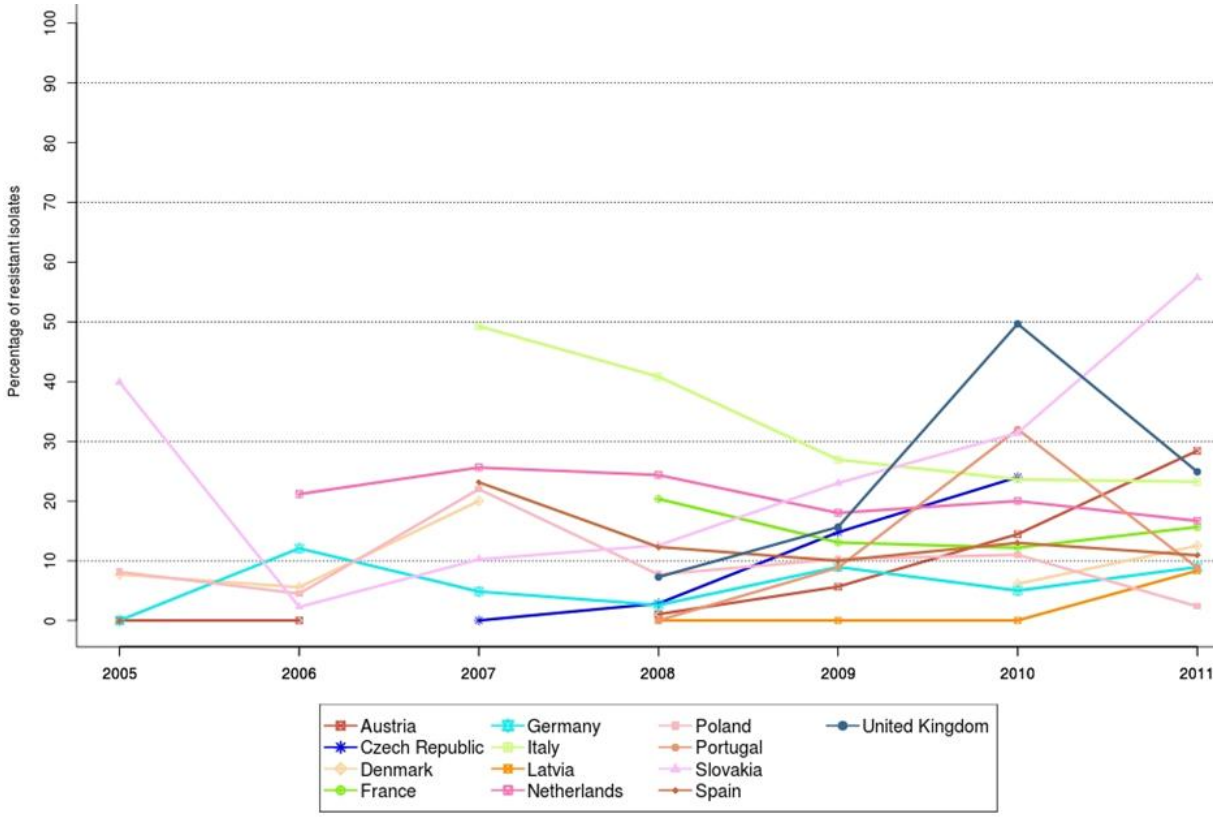
Note: A statistically significant decreasing trend for five or more years, as tested by logistic regression model ($p \leq 0.05$), was observed for Italy (↓) and Spain (↓).

Figure SA10. Trends in ciprofloxacin and nalidixic acid resistance in tested* Salmonella *spp. isolates from* Gallus gallus *in reporting MSs, 2005-2011, quantitative data



Note: A statistically significant increasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Austria (↑), Poland (↑) and Slovakia (↑) for both ciprofloxacin and nalidixic acid. A statistically significant decreasing trend was observed for ciprofloxacin in Italy (↓) and the Netherlands (↓), and for both ciprofloxacin and nalidixic acid in Spain (↓).

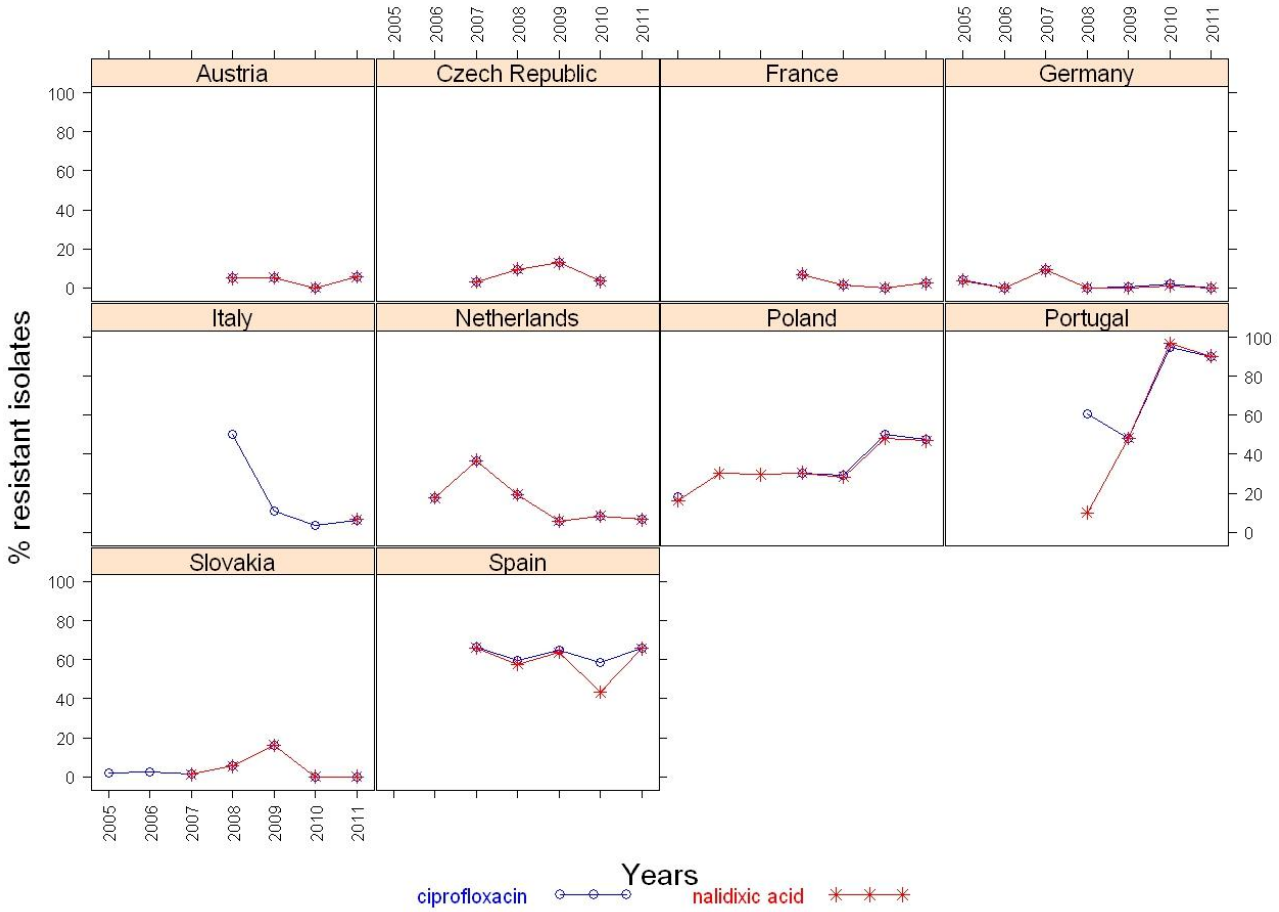
Figure SA11. Trends in tetracycline resistance in tested* Salmonella *spp. isolates from* Gallus gallus *in reporting MSs, 2005-2011, quantitative data



Note: Statistically significant increasing or decreasing trends for five or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Austria (↑), Germany (↑), Italy (↓), the Netherlands (↓) and Spain (↓).

Temporal trends in resistance among *S.* Enteritidis isolates from *Gallus gallus*

Figure SA12. Trends in ciprofloxacin and nalidixic acid resistance in tested* Salmonella *Enteritidis isolates from* Gallus gallus *in reporting MSs, 2005-2011, quantitative data

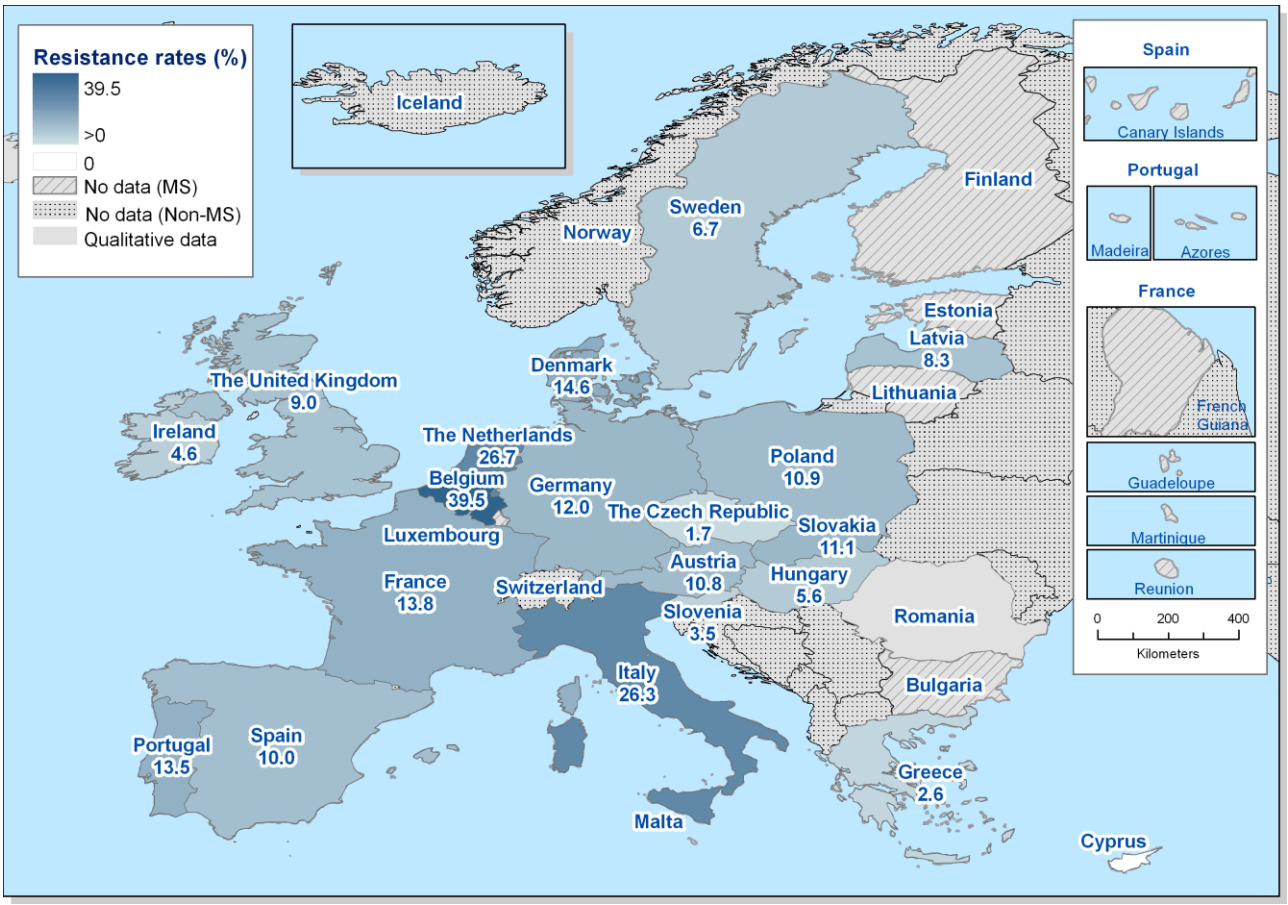


Note: A statistically significant decreasing trend for five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Germany (↓) and the Netherlands (↓) for both ciprofloxacin and nalidixic acid. A statistically significant increasing trend was observed in Poland (↑) for both ciprofloxacin and nalidixic acid.

Spatial distribution of resistance among *Salmonella*

Figures SA13-SA15 show the spatial distributions of ampicillin, nalidixic acid and tetracycline resistance in *Salmonella* spp. isolated from *Gallus gallus* in 2011. Figures SA13 and SA15 illustrate the variability in levels of ampicillin and tetracycline resistance in *Salmonella* spp. across the EU and the absence of a clear spatial distribution. Figure SA14 illustrates the continued absence, or low prevalence, of resistance to nalidixic acid in *Salmonella* spp. in northern Europe, but high levels of resistance in southern and Eastern Europe.

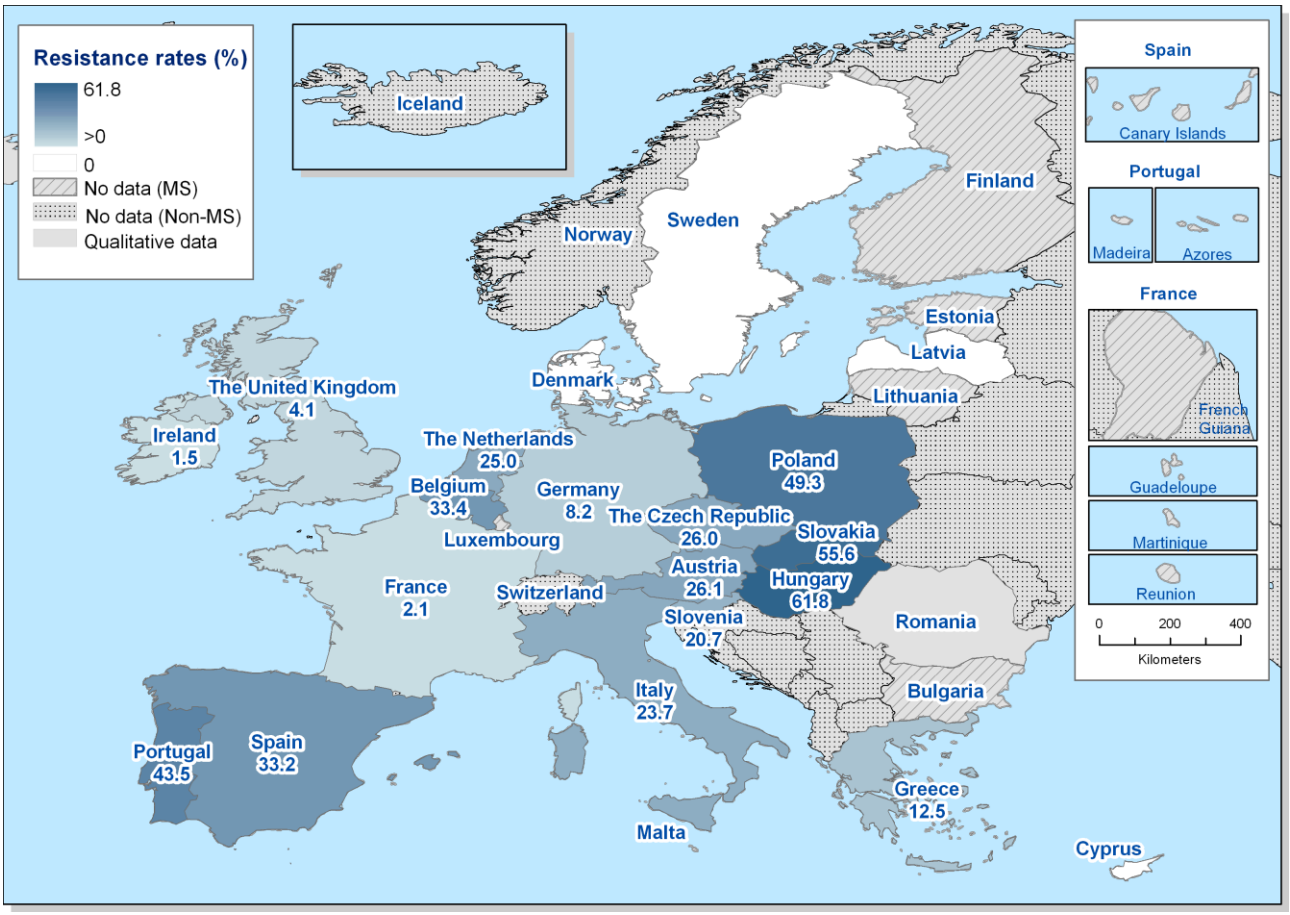
Figure SA13. Spatial distribution of ampicillin resistance among* Salmonella *spp. from* Gallus gallus *in countries reporting MIC data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data have been used instead. The countries labelled as 'qualitative data' therefore include those reporting either IZD data, MIC data for fewer than 10 isolates, or purely qualitative data (as proportion of resistant isolates).

1. For the Czech Republic, Slovenia and Sweden, 2010 data were used.

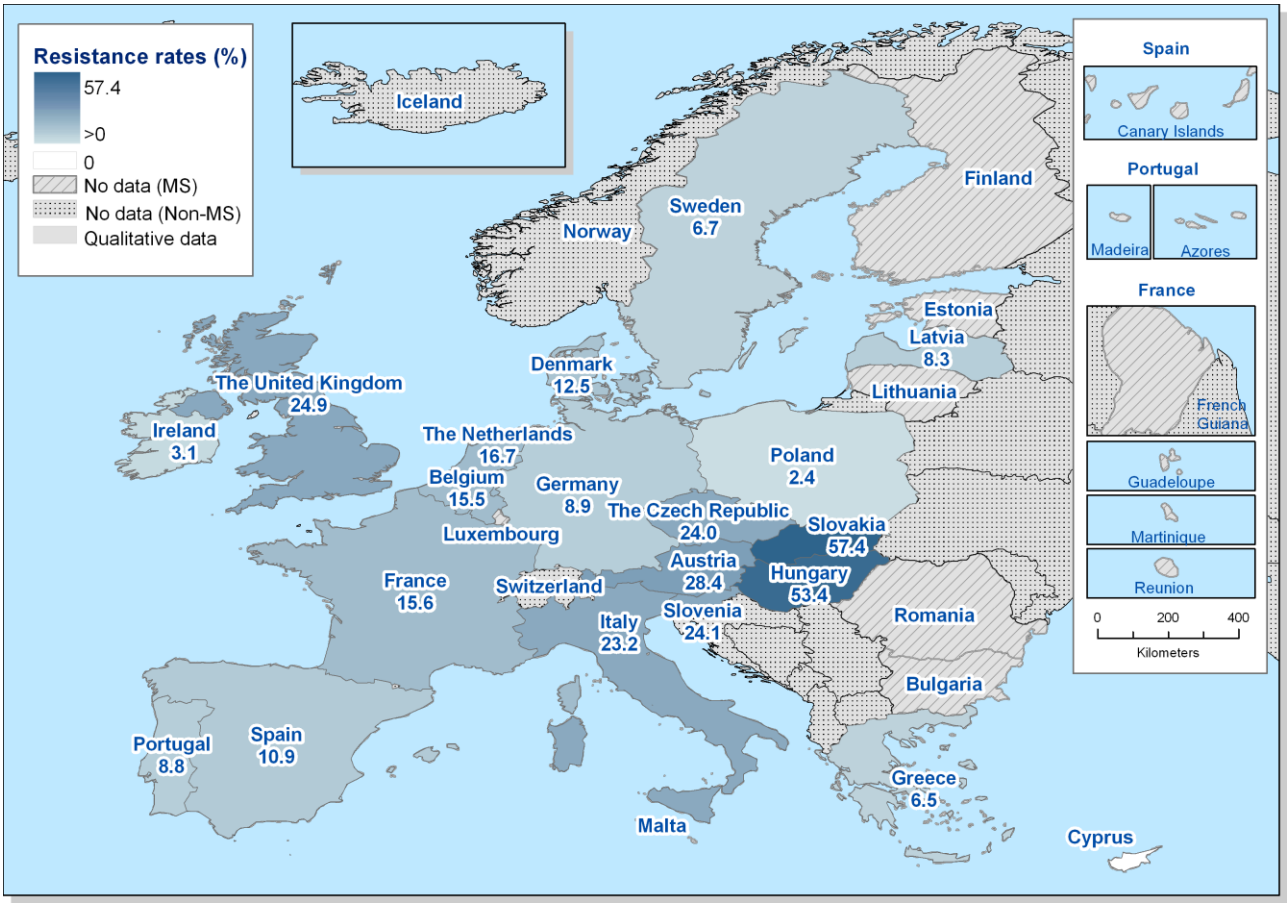
***Figure SA14. Spatial distribution of nalidixic acid resistance among* Salmonella *spp. from* Gallus gallus *in countries reporting MIC data in 2011*[1]**



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data have been used instead. The countries labelled as 'qualitative data' therefore include those reporting either IZD data, MIC data for fewer than 10 isolates, or purely qualitative data (as proportion of resistant isolates).

1. For the Czech Republic, Slovenia and Sweden, 2010 data were used.

***Figure SA15. Spatial distribution of tetracycline resistance among* Salmonella *spp. from* Gallus gallus *in countries reporting MIC data in 2011*[1]**



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data have been used instead.

1. For the Czech Republic, Slovenia and Sweden, 2010 data were used.

Multi-resistance among *Salmonella* spp. isolates from broilers of *Gallus gallus*

In 2011, eight MSs reported isolate-based data on resistance in *Salmonella* spp. from broiler flocks. Among the reporting MSs, more than 40 % of the isolates tested were susceptible to all nine antimicrobials; complete susceptibility varied from 43.3 % in Austria to 90.5 % in Ireland. The only exception was Spain, which reported a level of complete susceptibility of 20 %. Multi-resistance levels were low in Ireland (3.2 %) and Denmark (7.0 %), while in the remaining reporting MSs they were high reaching 37 % in Italy and 50 % in Austria (Table SA18). Similarities among the multi-resistance distributions (Figure SA16) were observed in France and Germany with some isolates showing reduced susceptibility to up to six and seven different substances, respectively. Although Austria and Italy reported similar levels of complete-susceptibility, Austria recorded higher proportions of isolates exhibiting reduced susceptibility to one or two classes, while Italy detected isolates showing reduced susceptibility to eight different substances. These differences in frequency distributions results in values of the index of diversity (weighted entropy) of 0.319 and 0.487 in Austria and Italy, respectively (Table SA18). Diversity in the structure of the frequency distributions of resistant isolates is also summarised in Table SA18. Very few isolates were resistant to both ciprofloxacin and cefotaxime.

Table SA18. Complete susceptibility, multi-resistance and index of diversity in Salmonella *spp. from broilers in MSs reporting isolate-based data, 2011*

Country	Susceptible to all		Multi-resistant		Index of diversity	Co-resistant to CIP and CTX	
	n	%	n	%		n	%
Austria (N=90)	39	43.3	45	50.0	0.319	0 (0)	0 (0)
Denmark (N=43)	34	79.1	3	7.0	0.280	0 (0)	0 (0)
France (N=156)	94	60.3	35	22.4	0.328	0 (0)	0 (0)
Germany (N=39)	24	61.5	10	25.6	0.440	1 (0)	2.6 (0)
Ireland (N=63)	57	90.5	2	3.2	0.351	0 (0)	0 (0)
Italy (N=54)	24	44.4	20	37.0	0.487	2 (0)	3.7 (0)
Spain (N=40)	8	20.0	11	27.5	0.322	0 (0)	0 (0)
United Kingdom (N=23)	12	52.2	3	13.0	0.318	NA	NA

N = total number of isolates tested for susceptibility against the whole common antimicrobial set for *Salmonella* spp.

n = number of isolates per category of complete susceptibility or multiple resistance.

NA = Not available.

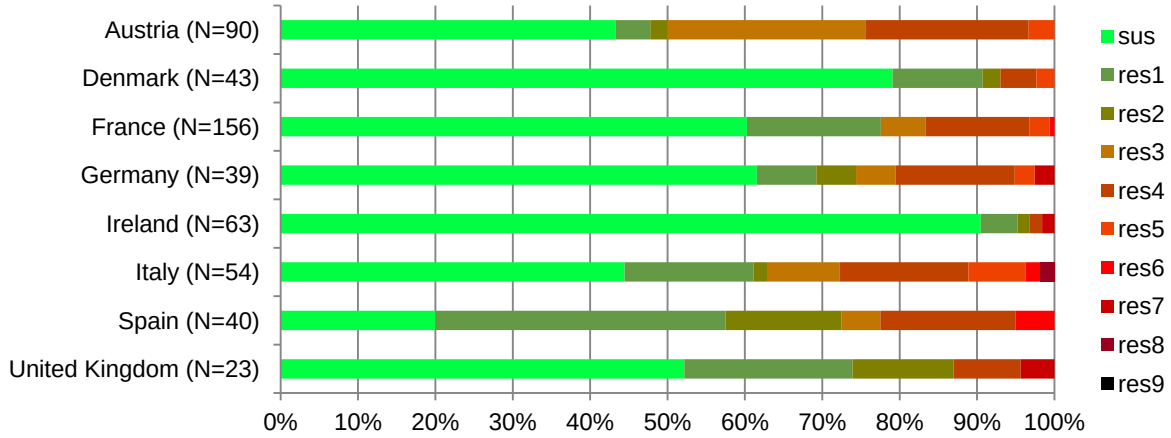
Susceptible to all = isolate susceptible to all antimicrobial substances of the EFSA common set for *Salmonella* spp.

Multi-resistant = resistant to at least three different antimicrobial substances, belonging to any three antimicrobial families from the common antimicrobial set.

Index of diversity = see definition in Section 11.4.2.1 of Materials and Methods.

Co-resistant to ciprofloxacin (CIP) and cefotaxime (CTX) = the frequencies and percentages of *Salmonella* isolates not susceptible to concentrations greater than ECOFFs (CTX: >0.5 mg/L and CIP: >0.06 mg/L). Figures in parentheses indicate the occurrence of resistance determined using EUCAST clinical breakpoints (CTX: >2 mg/L and CIP: >1 mg/L).

Figure SA16. Frequency distribution of Salmonella *spp. isolates from broilers completely susceptible or resistant to one to nine antimicrobials in MSs reporting isolate based data, 2011*



N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances.

sus = susceptible to all antimicrobial substances of the common set.

res1/res9 = resistance to one antimicrobial substance/resistance to nine antimicrobial substances of the common set.

Multi-resistance among *Salmonella* spp. isolates from laying hens of *Gallus gallus*

In 2011, six MSs provided isolate-based data concerning resistance in *Salmonella* spp. from laying hen flocks. Analysis of multi-resistance showed that, among the reporting MSs, isolates exhibiting complete susceptibility accounted for a very high level of more than 85 % in Austria, France and Germany, 65.9 % in Spain, 58.3 % in the United Kingdom and 53.4 % in Italy. Multi-resistance levels were low in most reporting MSs, ranging between 2.3 % in Austria and 9.7 % in Germany (Table SA19), while Italy and the United Kingdom recorded multi-resistance levels of 20.5 % and 33.3 %, respectively. The frequency distributions (Figure SA17) showed low frequencies of isolates showing reduced susceptibility to important numbers of different substances with Germany, for example, recording isolates with reduced susceptibility to up to eight different substances. The corresponding values of the indices of diversity are presented in Table SA19. Very few isolates were resistant to both ciprofloxacin and cefotaxime.

Table SA19. Complete susceptibility, multi-resistance and index of diversity in Salmonella *spp. from laying hens in MSs reporting isolate-based data, 2011*

Country	Susceptible to all		Multi-resistant		Index of diversity	Co-resistant to CIP and CTX	
	n	%	n	%		n	%
Austria (N=86)	77	89.5	2	2.3	0.199	0 (0)	0 (0)
France (N=165)	141	85.5	11	6.7	0.339	0 (0)	0 (0)
Germany (N=103)	89	86.4	10	9.7	0.425	0 (0)	0 (0)
Italy (N=88)	47	53.4	18	20.5	0.402	1 (0)	1.1 (0)
Spain (N=170)	112	65.9	9	5.3	0.210	0 (0)	0 (0)
United Kingdom (N=12)	7	58.3	4	33.3	0.240	NA	NA

N = total number of isolates tested for susceptibility against the whole common antimicrobial set for *Salmonella* spp.

n = number of isolates per category of complete susceptibility or multiple resistance.

NA = Not available.

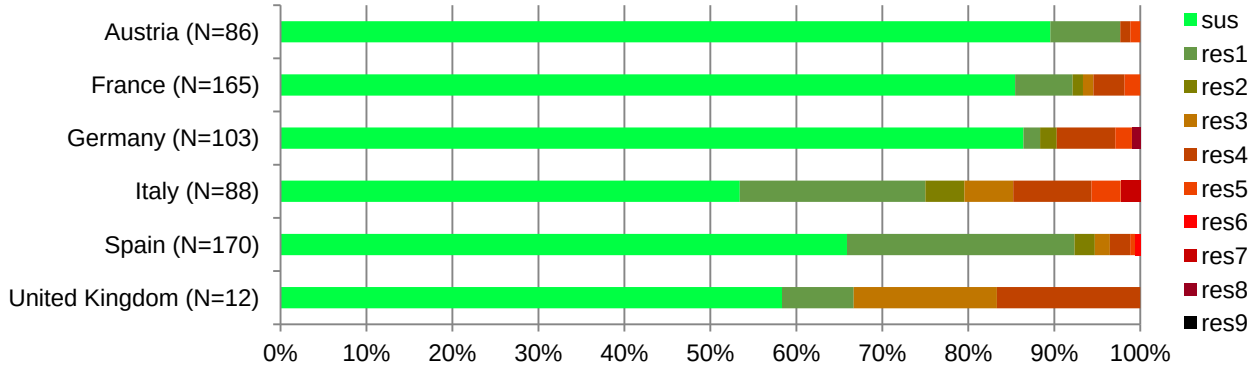
Susceptible to all = isolate susceptible to all antimicrobial substances of the EFSA common set for *Salmonella* spp.

Multi-resistant = resistant to at least three different antimicrobial substances, belonging to any three antimicrobial families from the common antimicrobial set.

Index of diversity = see definition in section 11.4.2.1 of Materials and Methods.

Co-resistant to ciprofloxacin (CIP) and cefotaxime (CTX) = the frequencies and percentages of *Salmonella* isolates not susceptible to concentrations greater than ECOFFs (CTX: >0.5 mg/L and CIP: >0.06 mg/L). Figures in parentheses indicate the occurrence of resistance determined using EUCAST clinical breakpoints (CTX: >2 mg/L and CIP: >1 mg/L).

Figure SA17. Frequency distribution of Salmonella *spp. isolates from laying hens completely susceptible or resistant to one to nine antimicrobials in MSs reporting isolate-based data, 2011*



N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances.

sus = susceptible to all antimicrobial substances of the common set.

res1/res9 = resistance to one antimicrobial substance/resistance to nine antimicrobial substances of the common set.

Multi-resistance among *S.* Enteritidis and *S.* Typhimurium isolates from *Gallus gallus*

Multi-resistance data on *S.* Typhimurium isolates from either broilers or laying hens and on *S.* Enteritidis from broilers are not presented in this report because the inclusion criteria (more than four reporting countries providing data on more than 10 isolates per production type) were not met. Generally, the isolates of *S.* Enteritidis and *S.* Typhimurium in these production types were very rare in the isolate-based dataset of the reporting countries. The same observation is true with respect to monophasic *S.* Typhimurium from broilers and laying hens.

3.4.2.2. Turkeys

In 2011, 10 MSs submitted quantitative antimicrobial susceptibility data for *Salmonella* spp. from turkeys, in accordance with the EU legislation. This section includes data from meat production flocks and mixed flocks of turkeys. Nine MSs reported data on *S.* Typhimurium in turkeys; however, no countries submitted sufficient data to warrant inclusion. Austria, Germany, Italy, Spain and the United Kingdom tested isolates obtained as part of their national control programmes in accordance to EU regulations. No information on the sampling scheme used was provided by France, Hungary, Ireland, Poland and Portugal.

Resistance levels in *Salmonella* spp.

Data on antimicrobial resistance among *Salmonella* spp. in turkeys were reported by 10 MSs in 2011 (Table SA20). The occurrence of resistance to ampicillin in the reporting MS group was high at 43.6 % and ranged widely from 14.3 % to 90.9 % across the reporting countries. Resistance to sulfonamides and tetracyclines in the reporting MS group was very high at 51.0 % and 52.2 %, respectively, and ranged from 20.0 % to 91.6 % and from 0 % to 77.9 %, respectively, across the reporting MSs. For chloramphenicol, the level of resistance in the reporting MS group increased from 7 % in 2010 to 13.0 % in 2011, and ranged from 0 % to 61.7 % between countries. Reported levels of resistance to gentamicin varied among MSs, ranging from 0 % to 33.3 % across the group; the occurrence of resistance considering all reporting MSs was 9.4 %.

At the reporting MS group level, resistance to ciprofloxacin was 50.4 % and to nalidixic acid was 36.9 %, and for both antimicrobials the resistance levels ranged from 4.8 % to 80.0 %. Cefotaxime resistance was very low in the reporting group of 10 MSs at 0.4 %, with only France, Hungary and Spain reporting any cefotaxime-resistant isolates, at low proportions of 0.6 %, 0.4 % and 1.3 %, respectively.

Ten MSs reported resistance among *Salmonella* spp. isolates from both fowl (*Gallus gallus*) and turkeys, and as was also observed in 2010, the levels of resistance recorded were generally much higher in turkeys than in *Gallus gallus*, in particular for ampicillin, chloramphenicol, gentamicin, sulfonamides and tetracyclines. Resistance levels to ciprofloxacin and nalidixic acid were also considerably higher in turkeys than in *Gallus gallus*. Once again, more reporting MSs detected no resistance to cefotaxime in isolates from turkeys than in isolates from *Gallus gallus* and, among the nine MSs overall, resistance was lower (0.4 %) in turkeys than in *Gallus gallus* (1.5 %). However, the difference in resistance levels between the two species needs to be interpreted with caution because, other than in Hungary, estimated resistance levels among *Salmonella* spp. isolates from turkeys are based on low numbers of isolates compared with *Gallus gallus*.

Table SA20. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *spp. isolates from turkeys in MSs reporting MIC data in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	22	18.2	22	0	22	0	22	68.2	22	0	22	63.6	22	36.4	22	40.9
France	176	29.5	176	0.6	174	7.5	174	24.1	174	5.7	174	21.8	174	39.7	174	41.4
Germany	78	41.0	78	0	78	7.7	78	52.6	78	10.3	78	34.6	78	51.3	78	53.8
Hungary	258	38.8	258	0.4	258	1.2	258	77.1	258	17.8	258	74.8	258	29.8	258	46.9
Ireland	14	14.3	14	0	14	14.3	14	14.3	14	0	14	7.1	14	28.6	14	28.6
Italy	27	59.3	27	0	27	0	27	25.9	27	33.3	27	25.9	27	51.9	27	77.8
Poland	41	61.0	41	0	41	0	41	61.0	41	31.7	41	51.2	41	34.1	41	0
Portugal	10	20.0	10	0	10	0	10	80.0	10	0	10	80.0	10	20.0	10	20.0
Spain	154	90.9	154	1.3	154	61.7	154	77.3	154	0.6	154	16.2	154	91.6	154	77.9
United Kingdom	145	20.7	145	0	145	0.7	145	4.8	145	0	145	4.8	145	70.3	145	62.8
Total (10 MSs)	**925**	**43.6**	**925**	**0.4**	**923**	**13.0**	**923**	**50.4**	**923**	**9.4**	**923**	**36.9**	**923**	**51.0**	**923**	**52.2**

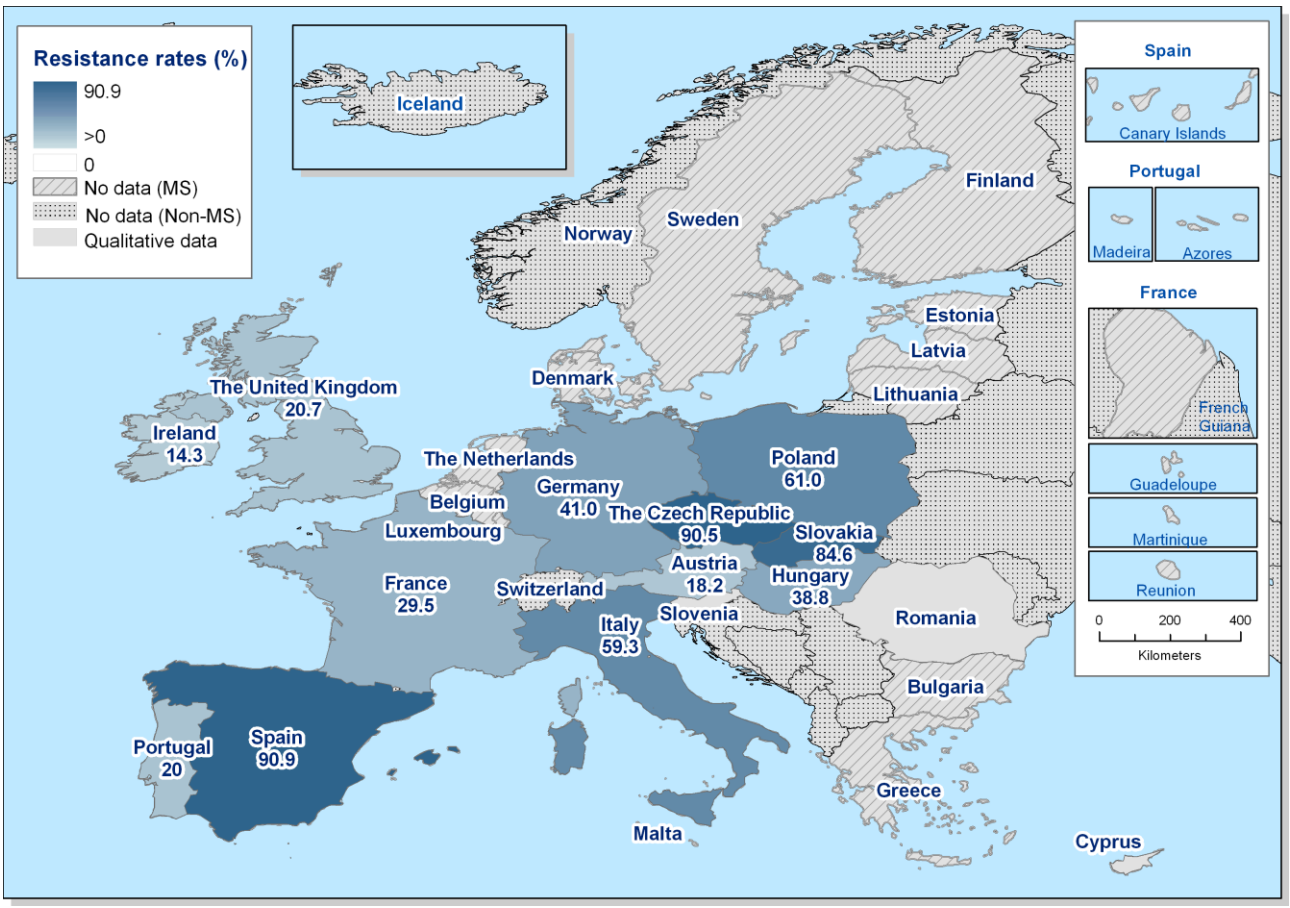
N = number of isolates tested.

% Res = percentage of resistant isolates.

Spatial distribution of resistance among *Salmonella*

Figures SA18-SA20 show the spatial distributions of ampicillin, nalidixic acid and tetracycline, resistance in *Salmonella* spp. isolated from turkeys in 2011. They illustrate the variability in levels of tetracycline and ampicillin resistance in *Salmonella* spp. across the EU and the absence of a clear spatial distribution.

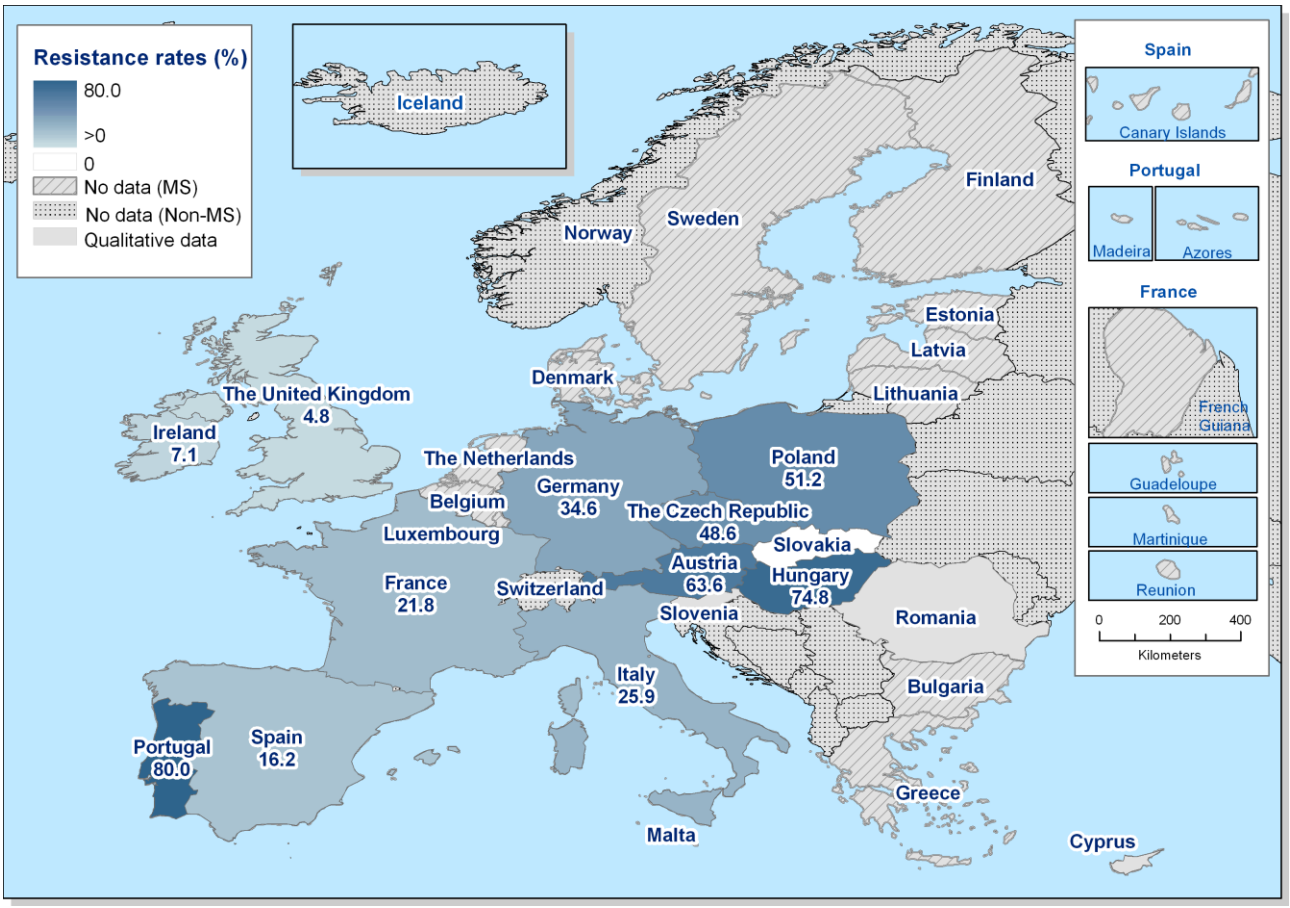
Figure SA18. Spatial distribution of ampicillin resistance among* Salmonella *spp. from turkeys in countries reporting MIC data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data have been used instead. The countries labelled as 'qualitative data' therefore include those reporting either IZD data, MIC data for fewer than 10 isolates, or purely qualitative data (as proportion of resistant isolates).

1. For the Czech Republic and Slovakia, 2010 data were used.

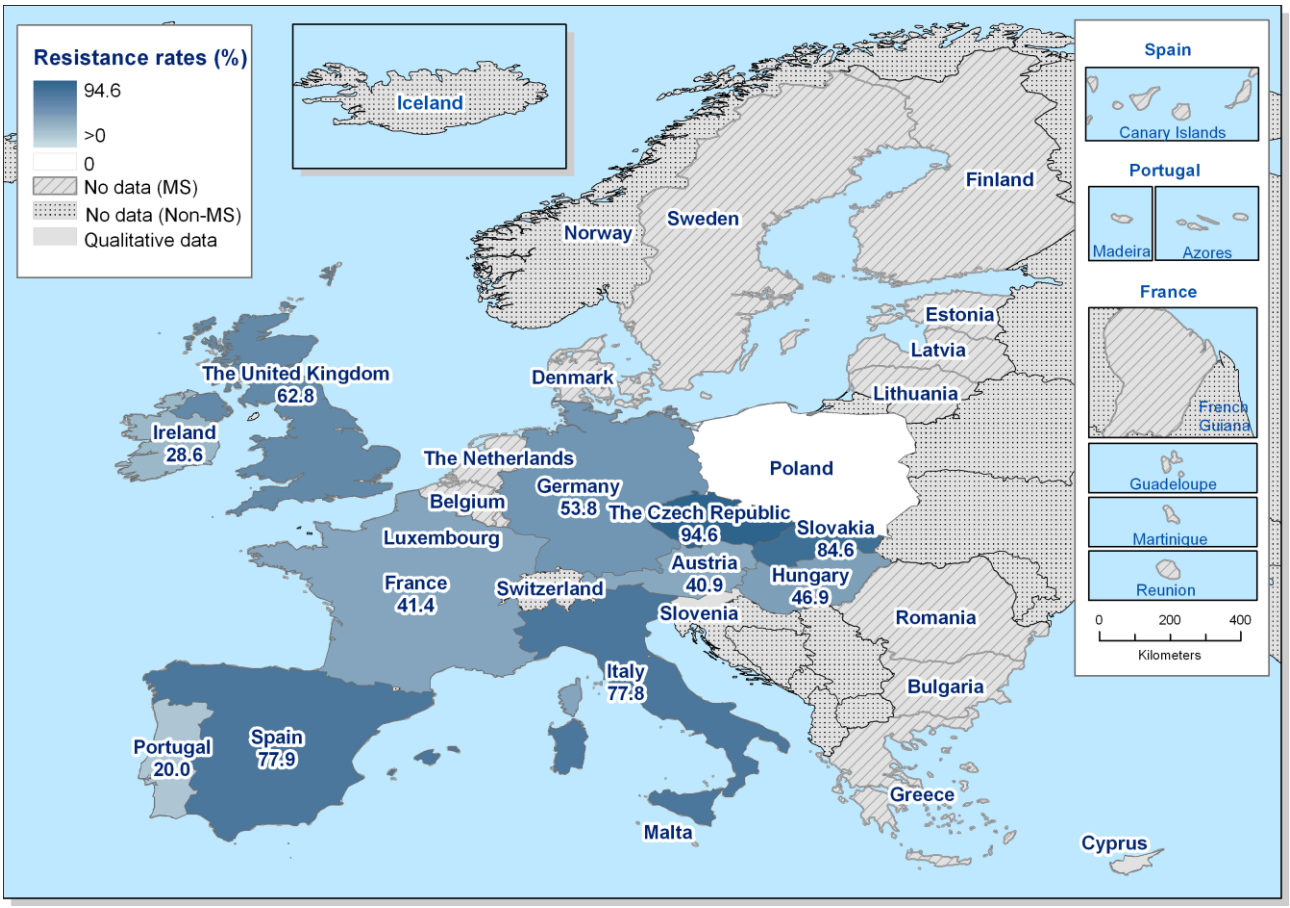
Figure SA19. Spatial distribution of nalidixic acid resistance among* Salmonella *spp. from turkeys in countries reporting MIC data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data have been used instead. The countries labelled as 'qualitative data' therefore include those reporting either IZD data, MIC data for fewer than 10 isolates, or purely qualitative data (as proportion of resistant isolates).

1. For the Czech Republic and Slovakia, 2010 data were used.

Figure SA20. Spatial distribution of tetracycline resistance among* Salmonella *spp. from turkeys in countries reporting MIC data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data have been used instead.

1. For the Czech Republic and Slovakia, 2010 data were used.

Multi-resistance among *Salmonella* spp. isolates from turkeys

In 2011, six MSs provided isolate-based data concerning resistance in *Salmonella* spp. from turkeys. Analysis of multi-resistance showed that, among the reporting MSs, complete susceptibility was exhibited by about fewer than one-third of the isolates tested, with the exception of Ireland, which reported a level of complete susceptibility of 57.1 %. Multi-resistance levels were high in all reporting MSs and varied importantly between 28.6 % in Ireland and 94.8 % in Spain (Table SA21). The frequency distributions (Figure SA21) showed similarities among the multi-resistance recorded in Austria, France and Germany with some isolates showing reduced susceptibility to as many as six different substances, while Italy and Spain reported fewer completely susceptible isolates and isolates showing reduced susceptibility to seven or eight different substances. Ireland recorded multi-resistance to five classes of antimicrobials at a maximum. The difference in the structure of the frequency distributions of resistant isolates is summarised in Table SA21. Very few isolates were resistant to both ciprofloxacin and cefotaxime.

Table SA21. Complete susceptibility, multi-resistance and index of diversity in Salmonella *spp. from turkeys in MSs reporting isolate-based data, 2011*

Country	Susceptible to all		Multi-resistant		Index of diversity	Co-resistant to CIP and CTX	
	n	%	n	%		n	%
Austria (N=22)	6	27.3	8	36.4	0.438	0 (0)	0 (0)
France (N=174)	64	36.8	66	37.9	0.434	0 (0)	0 (0)
Germany (N=78)	24	30.8	46	59.0	0.469	0 (0)	0 (0)
Ireland (N=14)	8	57.1	4	28.6	0.274	0 (0)	0 (0)
Italy (N=27)	5	18.5	18	66.7	0.595	0 (0)	0 (0)
Spain (N=154)	4	2.6	146	94.8	0.593	2 (0)	1.3 (0)

N = total number of isolates tested for susceptibility against the whole common antimicrobial set for *Salmonella* spp.

n = number of isolates per category of complete susceptibility or multiple resistance.

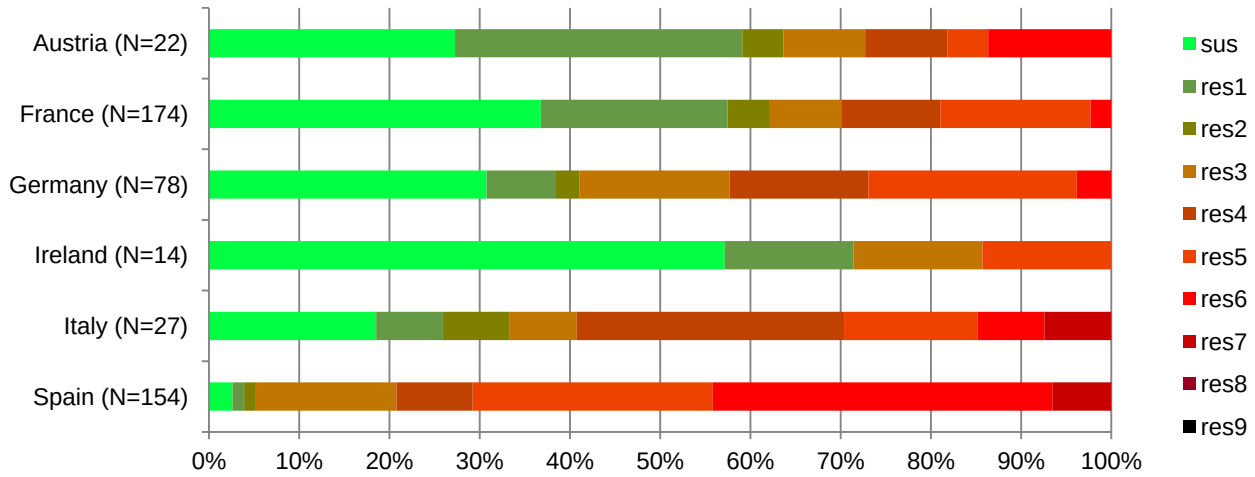
Susceptible to all = isolate susceptible to all antimicrobial substances of the EFSA common set for *Salmonella* spp.

Multi-resistant = resistant to at least three different antimicrobial substances, belonging to any three antimicrobial families from the common antimicrobial set.

Index of diversity = see definition in section 11.4.2.1 of Materials and Methods.

Co-resistant to ciprofloxacin (CIP) and cefotaxime (CTX) = the frequencies and percentages of *Salmonella* isolates not susceptible to concentrations greater than ECOFFs (CTX: >0.5 mg/L and CIP: >0.06 mg/L). Figures in parentheses indicate the occurrence of resistance determined using EUCAST clinical breakpoints (CTX: >2 mg/L and CIP: >1 mg/L).

Figure SA21. Frequency distribution of Salmonella *spp. isolates from turkeys completely susceptible or resistant to one to nine antimicrobials in MSs reporting isolate based data, 2011*



N = Total number of isolates tested for susceptibility against the whole common set of antimicrobial substances.

sus = susceptible to all antimicrobial substances of the common set.

res1/res9 = resistance to one antimicrobial substance/resistance to nine antimicrobial substances of the common set.

Multi-resistance among *S.* Enteritidis and *S.* Typhimurium isolates from turkeys

Generally, the *S.* Enteritidis and *S.* Typhimurium isolates from turkey flocks were very rare in the isolate-based dataset of the reporting countries. Data in multi-resistance in these serovars from turkeys are therefore not presented in this report, as the inclusion criteria (more than four reporting countries providing data on more than 10 isolates per production type) were not met. The same observation is true with respect to monophasic *S.* Typhimurium from broilers and laying hens.

3.4.2.3. Pigs

Quantitative MIC data for *Salmonella* spp. isolated from pigs from eight MSs in 2011 are included in the following analyses. Isolates from Estonia and Spain were collected as part of monitoring plans, whereas Germany and Italy tested isolates obtained through passive surveillance via diagnostic submissions. Denmark collected isolates from sub-clinical infections detected via the serological surveillance programme, from healthy pigs at slaughter and from herds with clinical salmonellosis. Sample types collected by MSs were generally faecal, while Estonia and Spain also tested ileocaecal lymph nodes at slaughter.

Resistance levels in *Salmonella* spp.

Data describing the occurrence of resistance to selected antimicrobials in isolates of *Salmonella* spp. from pigs are presented in Table SA22. Isolates tested by Denmark and Germany made up over 78 % of the total isolates tested in 2011 so the results from these two countries will have influenced the overall levels reported at MS group level. A similar level of resistance to ampicillin at MS group level was reported in 2011 (54.2 %) compared with 2010 (55 %). The levels of resistance among MSs ranged from 11.8 % to 73.6 % in 2011. Overall resistance to sulfonamides and tetracyclines was very high at 60.5 %, among the reporting MS group. The level of resistance to sulfonamides in *Salmonella* spp. from pigs ranged from 0.3 % to 88.6 % among the reporting MSs. A similar range was observed in the occurrence of resistance to tetracyclines (0.4–76.8 %). There was moderate resistance to chloramphenicol at MS group level (15.6 %), and among the MSs the levels ranged from 0 % to 33.3 %. Resistance to gentamicin in the reporting MS group was low, at 3.7 %, and ranged from 0 % to 10.3 %.

The levels of resistance for ciprofloxacin and nalidixic acid in the reporting MS group were similar to those reported in 2010 (4.0 % and 3.4 % respectively in 2011 compared with 3 % and 2 % in 2010). Three MSs detected no resistance to either compound in *Salmonella* spp. isolates from pigs. Among the MSs that did detect resistance, the occurrence of ciprofloxacin and nalidixic acid resistance was low to moderate (range 2.8–17.1 %). The overall level of resistance to cefotaxime was 1.0 %, with three MSs not detecting any cefotaxime resistance in *Salmonella* spp. isolates from pigs. Among those MSs reporting resistance, levels ranged from 0.3 % to 2.9 %.

Resistance levels in *Salmonella* Typhimurium

Quantitative MIC antimicrobial susceptibility results for *Salmonella* Typhimurium isolates from pigs were reported by four MSs in 2011 (Table SA23). As for *Salmonella* spp., the majority of isolates tested were from Denmark and Germany so the results from these two countries will have more bearing on the overall levels. The occurrence of resistance to ampicillin, chloramphenicol and sulfonamides among *S*. Typhimurium isolates from pigs was higher than that reported in *Salmonella* spp., with the overall level of resistance in the reporting MS group being 71.5 % for ampicillin, 30.0 % for chloramphenicol and 74.5 % for sulfonamides. Among the individual reporting MSs, resistance to ampicillin ranged from 36.6 % to 89.5 %, resistance to chloramphenicol ranged from 7.6 % to 76.5 % and resistance to sulfonamides ranged from 41.2 % to 90.7 %. Resistance to tetracyclines was fairly similar in *S.* Typhimurium and *Salmonella* spp. (69.1 % vs. 60.5 %) and among MSs the reported levels ranged from 37.4 % to 94.1 %. A low level of resistance to gentamicin (5.9 %) was reported by the MS group. In a similar pattern to that observed in 2010, Denmark, Germany and Spain reported low levels of resistance (range 1.5 %–7.2 %), while in Ireland the figure was higher, at 23.5 %.

Low levels of resistance to ciprofloxacin and nalidixic acid were reported at MS group level (4.5 % and 3.7 %, respectively). Denmark reported no resistance to either compound, and Germany reported low levels of resistance to both. Moderate to high levels of resistance were reported by Ireland and Spain, ranging from 17.6 % to 26.3 %. In the reporting MS group, cefotaxime resistance was detected only in *S*. Typhimurium isolates from Spain, and at a low level (5.3 %).

Table SA22. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *spp. isolates from pigs in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Denmark[1]	371	30.2	371	0.3	371	5.7	371	0	371	1.6	371	0	371	36.6	371	43.6
Denmark[2]	23	0.3	23	0	23	0.1	23	0	23	0	23	0	23	0.3	23	0.4
Estonia	17	11.8	17	0	17	0	17	0	17	0	17	0	17	23.5	17	23.5
Germany	614	73.6	614	1.3	614	19.5	614	3.7	614	4.4	614	2.8	614	77.9	614	73.6
Hungary	35	34.3	35	2.9	35	31.4	35	11.4	35	5.7	35	14.3	35	88.6	35	60.0
Ireland	39	56.4	39	0	39	33.3	39	12.8	39	10.3	39	10.3	39	56.4	39	61.5
Italy	86	55.8	86	1.2	86	24.4	86	7.0	86	5.8	86	8.1	86	55.8	86	50.0
Netherlands	19	47.4	19	0	19	5.3	19	0	19	0	19	0	19	52.6	19	47.4
Spain	82	48.8	82	2.4	82	17.1	82	17.1	82	3.7	82	13.4	81	59.3	82	76.8
Total (8 MSs)	**1,286**	**54.2**	**1,286**	**1.0**	**1,286**	**15.6**	**1,286**	**4.0**	**1,286**	**3.7**	**1,286**	**3.4**	**1,286**	**60.5**	**1,286**	**60.5**

N = number of isolates tested.

% Res = percentage of resistant isolates.

1. Fattening pigs, pigs unspecified and mixed herds.

2. Breeding pigs.

Table SA23. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Typhimurium isolates from pigs in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Denmark	131	36.6	131	0	131	7.6	131	0	131	1.5	131	0	131	41.2	131	37.4
Germany	237	88.2	237	0	237	39.2	237	3.8	237	7.2	237	3.4	237	90.7	237	83.1
Ireland	17	88.2	17	0	17	76.5	17	23.5	17	23.5	17	17.6	17	88.2	17	94.1
Spain	19	89.5	19	5.3	19	26.3	19	26.3	19	5.3	19	21.1	19	89.5	19	89.5
Total (4 MSs)	**404**	**71.5**	**404**	**0.2**	**404**	**30.0**	**404**	**4.5**	**404**	**5.9**	**404**	**3.7**	**404**	**74.5**	**404**	**69.1**

N = number of isolates tested.

% Res = percentage of resistant isolates.

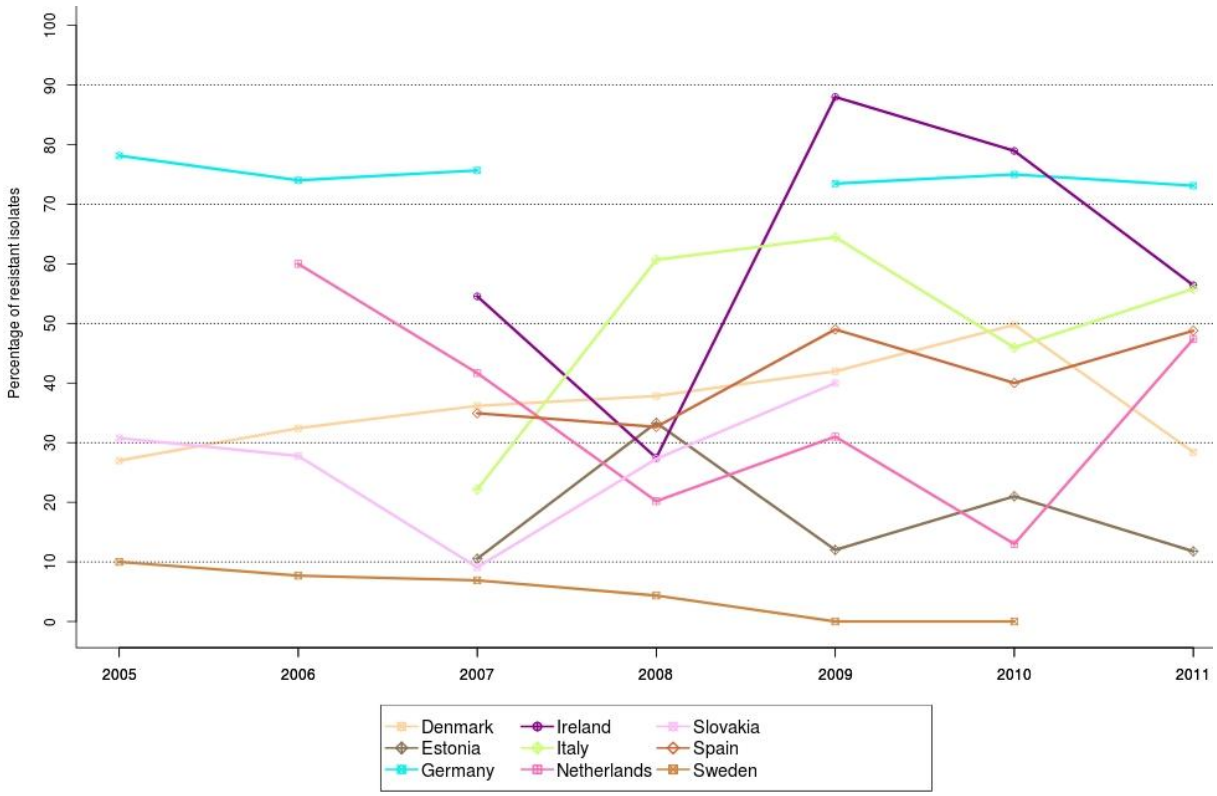
Temporal trends in resistance among *Salmonella* isolates from pigs

The temporal variation in the level of resistance to selected antimicrobials in *Salmonella* spp. isolated from pigs between 2005 and 2011 is presented in Figures SA22-SA26. The figures demonstrate that, in some MSs, resistance levels have continued to fluctuate; however, in other countries, such as Germany and Sweden the occurrence of resistance has remained fairly stable in recent years.

Over the seven reporting years, reported significantly decreasing trends in resistance were reported by the Netherlands for ampicillin, chloramphenicol and tetracyclines , by Germany for chloramphenicol and tetracyclines, by Spain for tetracyclines and by Denmark for chloramphenicol, while Italy reported statistically significant increasing trends in resistance to ampicillin and chloramphenicol. Increasing trends in resistance to ampicillin have also been reported by Denmark, Ireland and Spain. Considering resistance to (fluoro)quinolones, ciprofloxacin and nalidixic acid, both Estonia and Germany reported statistically decreasing trends in resistance to both compounds over the 2005–2011 period. In contrast, Spain showed increasing trends in resistance to these two substances. Additionally, Denmark registered decreasing trends in resistance to nalidixic acid and Ireland an increasing trend in resistance to ciprofloxacin.

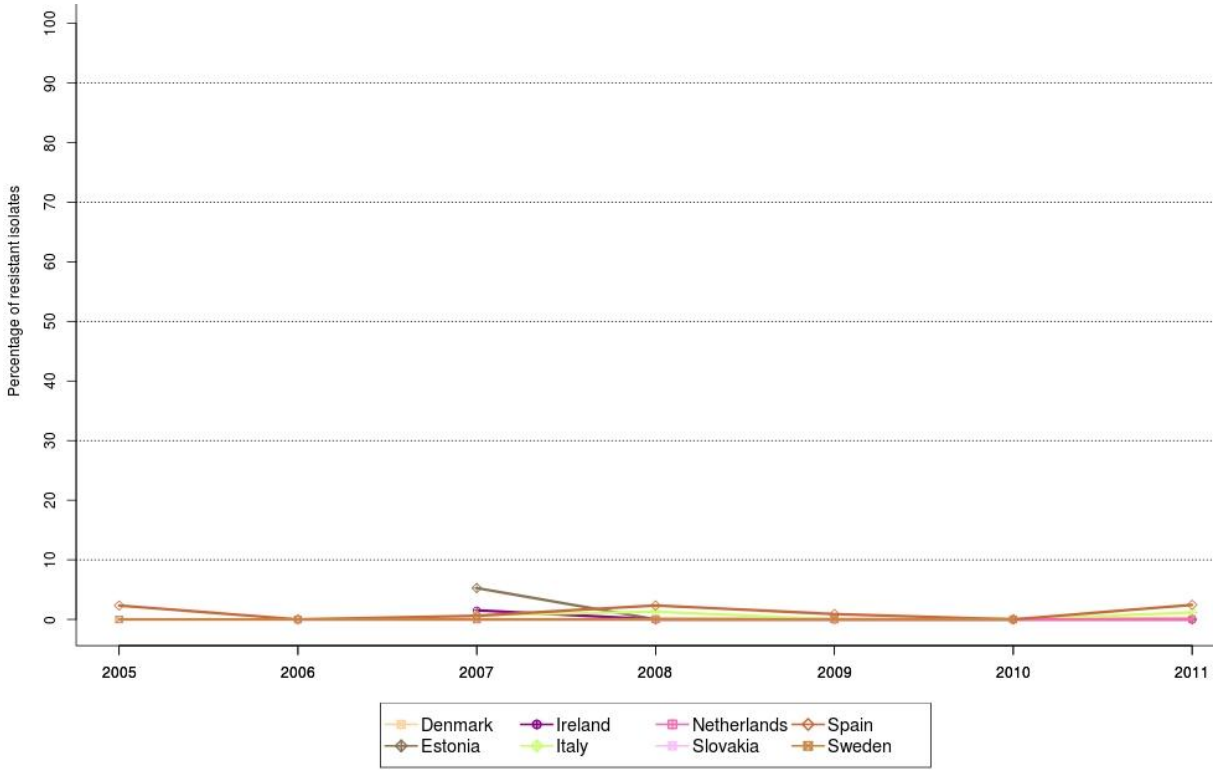
Cefotaxime resistance among *Salmonella* spp. isolates from pigs remained either low, very low or absent in the reporting MSs between 2005 and 2011; and no significant trends were detected for MSs reporting five or more years of data.

Figure SA22. Trends in ampicillin resistance in* Salmonella *spp. from pigs in reporting MSs, 2005-2011, quantitative data



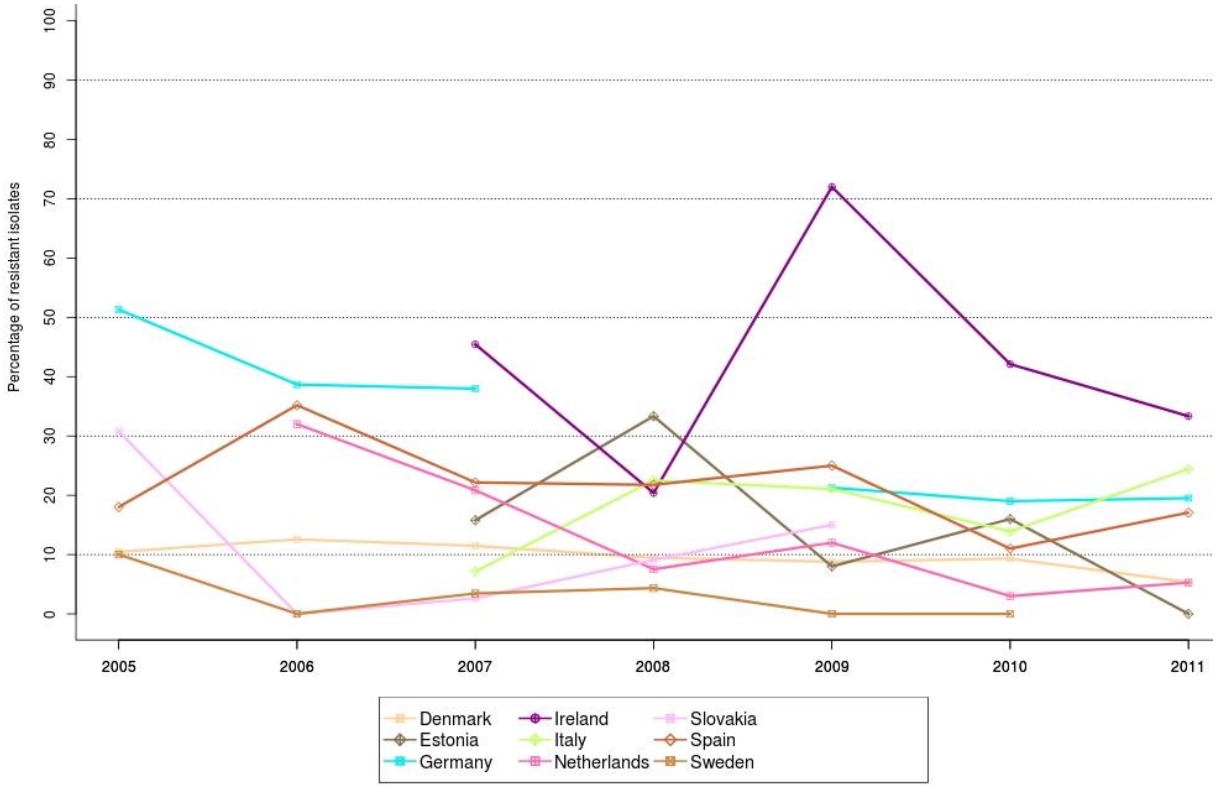
Note: Statistically significant increasing or decreasing trends for five or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Denmark (↑), Ireland (↑), Italy (↑), the Netherlands (↓) and Spain (↑).

Figure SA23. Trends in cefotaxime resistance in* Salmonella *spp. from pigs in reporting MSs, 2005-2011, quantitative data



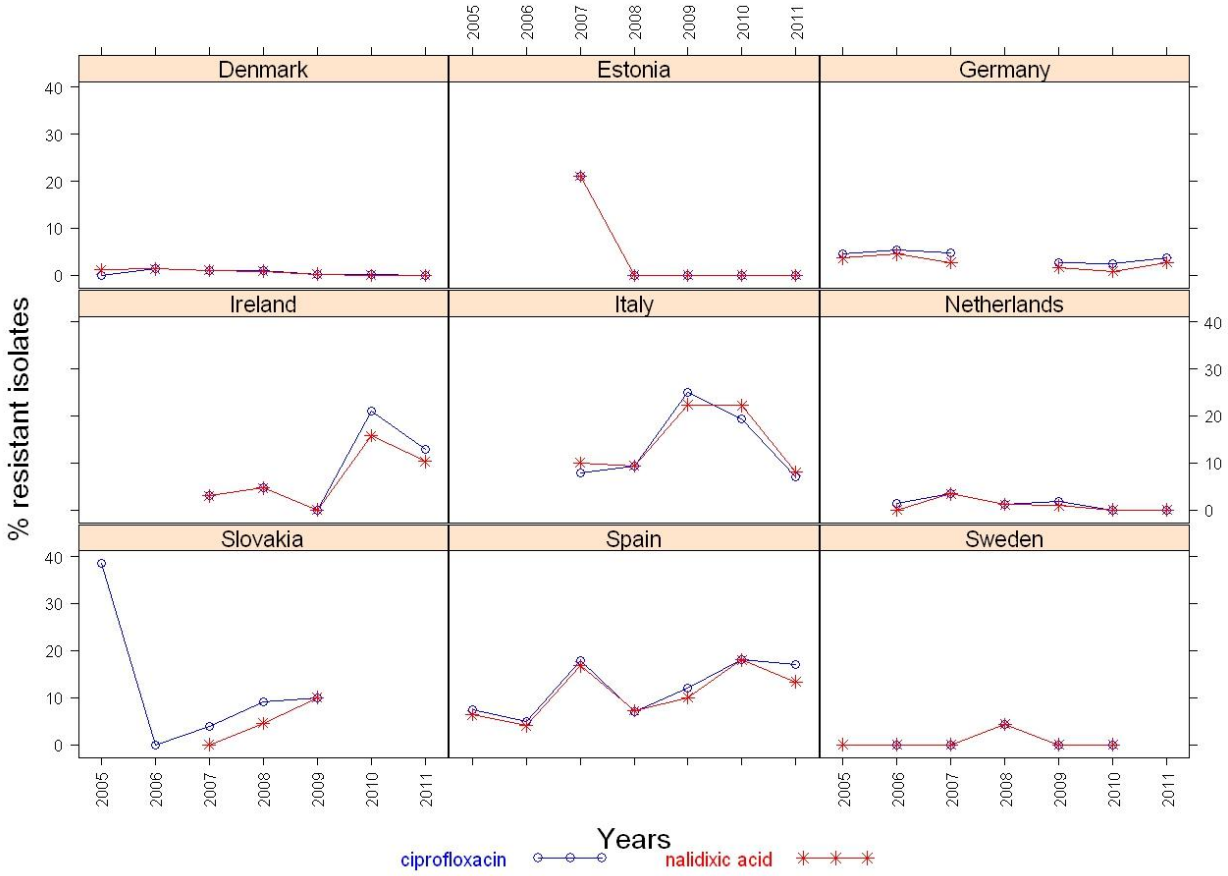
Note: No statistically significant trend for five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

Figure SA24. Trends in chloramphenicol resistance in* Salmonella *spp. from pigs in reporting MSs, 2005-2011, quantitative data



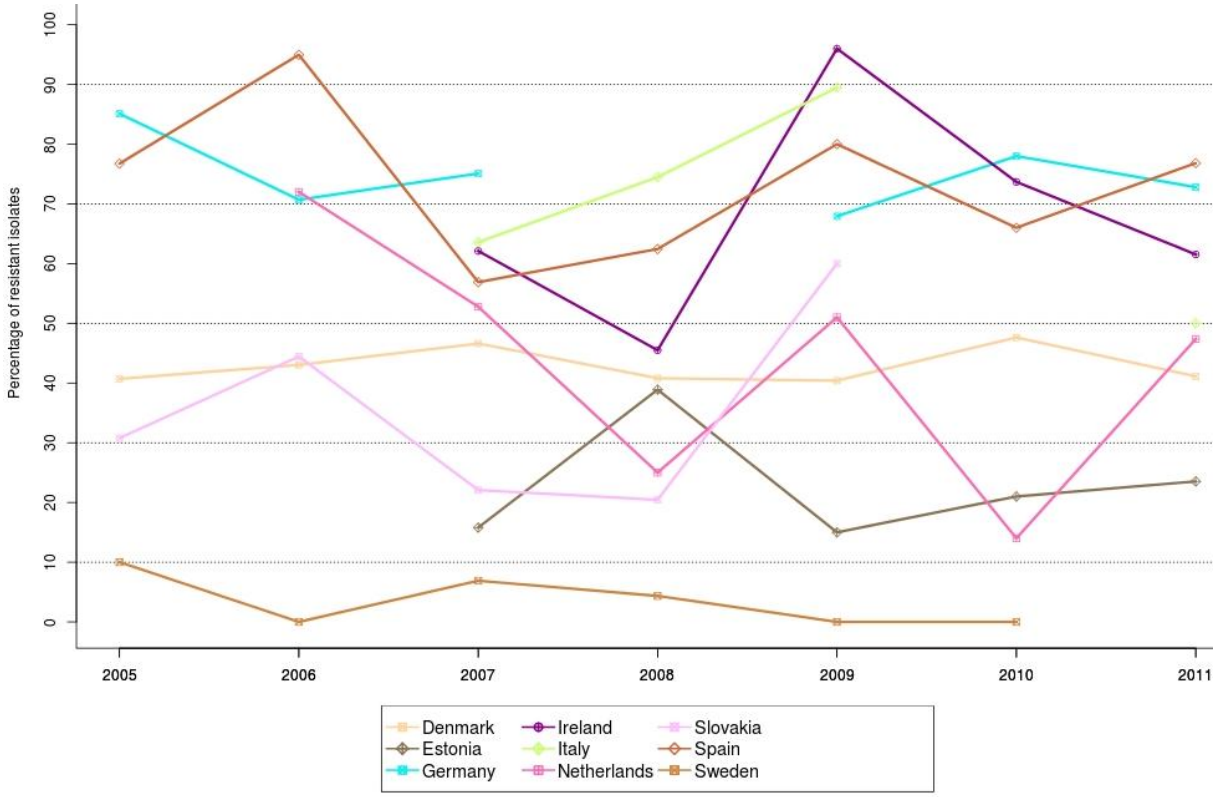
Note: A statistically significant increasing or decreasing trend for five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Denmark (↓), Germany (↓), Italy (↑) and the Netherlands (↓).

Figure SA25. Trends in ciprofloxacin and nalidixic acid resistance in* Salmonella *spp. from pigs in reporting MSs, 2005-2011, quantitative data



Note: A statistically significant decreasing trend for five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Estonia (↓) and Germany (↓), for both ciprofloxacin and nalidixic acid, and in Denmark (↓) for nalidixic acid. A statistically significant increasing trend was observed in Spain (↑) for both ciprofloxacin and nalidixic acid, and in Ireland (↑) for ciprofloxacin.

Figure SA26. Trends in tetracycline resistance in* Salmonella *spp. from pigs in reporting MSs, 2005-2011, quantitative data

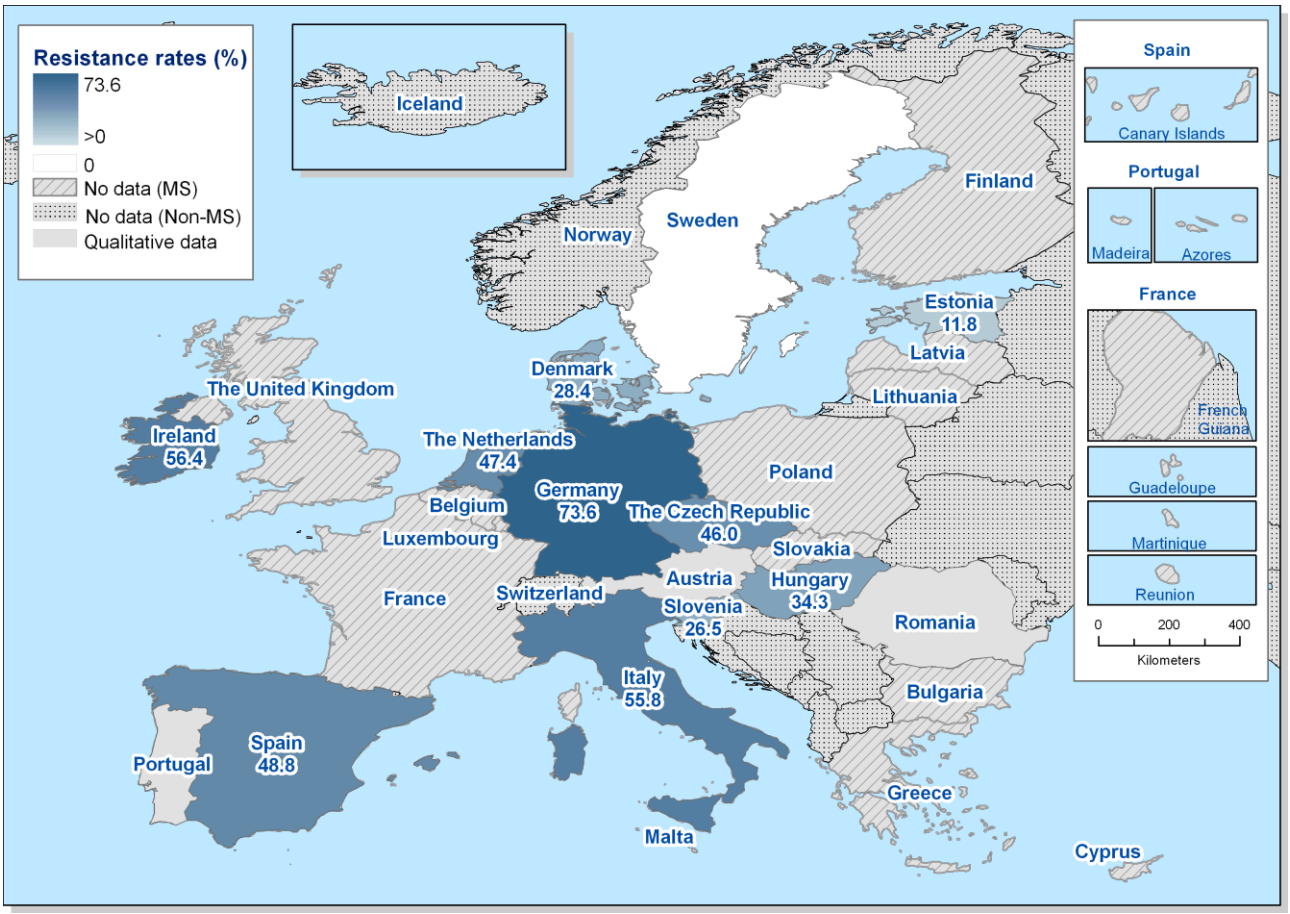


Note: A statistically significant decreasing trend for five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Germany (↓), the Netherlands (↓) and Spain (↓).

Spatial distribution of resistance among *Salmonella*

The spatial distribution of ampicillin, nalidixic acid and tetracycline resistance in *Salmonella* spp. from pigs in 2011 is shown in Figures SA27–SA29. Figures SA27 and SA29 emphasise the large differences in ampicillin and tetracycline resistance rates in different MSs, although no clear spatial distributions were observed. In most countries, nalidixic acid resistance in *Salmonella* spp. isolated from pigs was reported to be low, with no clear spatial distribution apparent (Figure SA27).

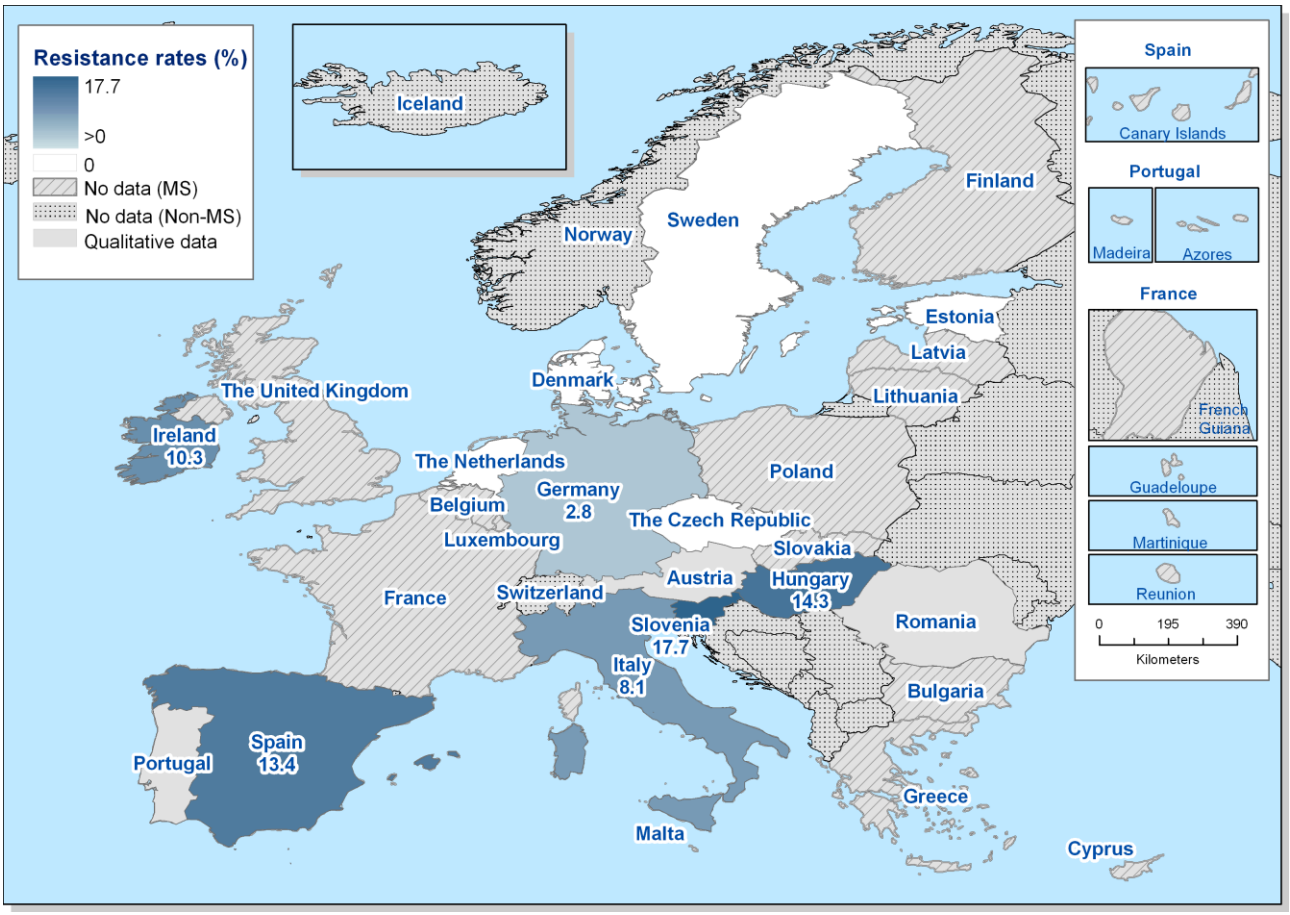
Figure SA27. Spatial distribution of ampicillin resistance among* Salmonella *spp. from pigs in countries reporting MIC data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data have been used instead. The countries labelled as 'qualitative data' therefore include those reporting either IZD data, MIC data for fewer than 10 isolates, or purely qualitative data (as proportion of resistant isolates).

1. For the Czech Republic, Slovenia and Sweden, 2010 data were used.

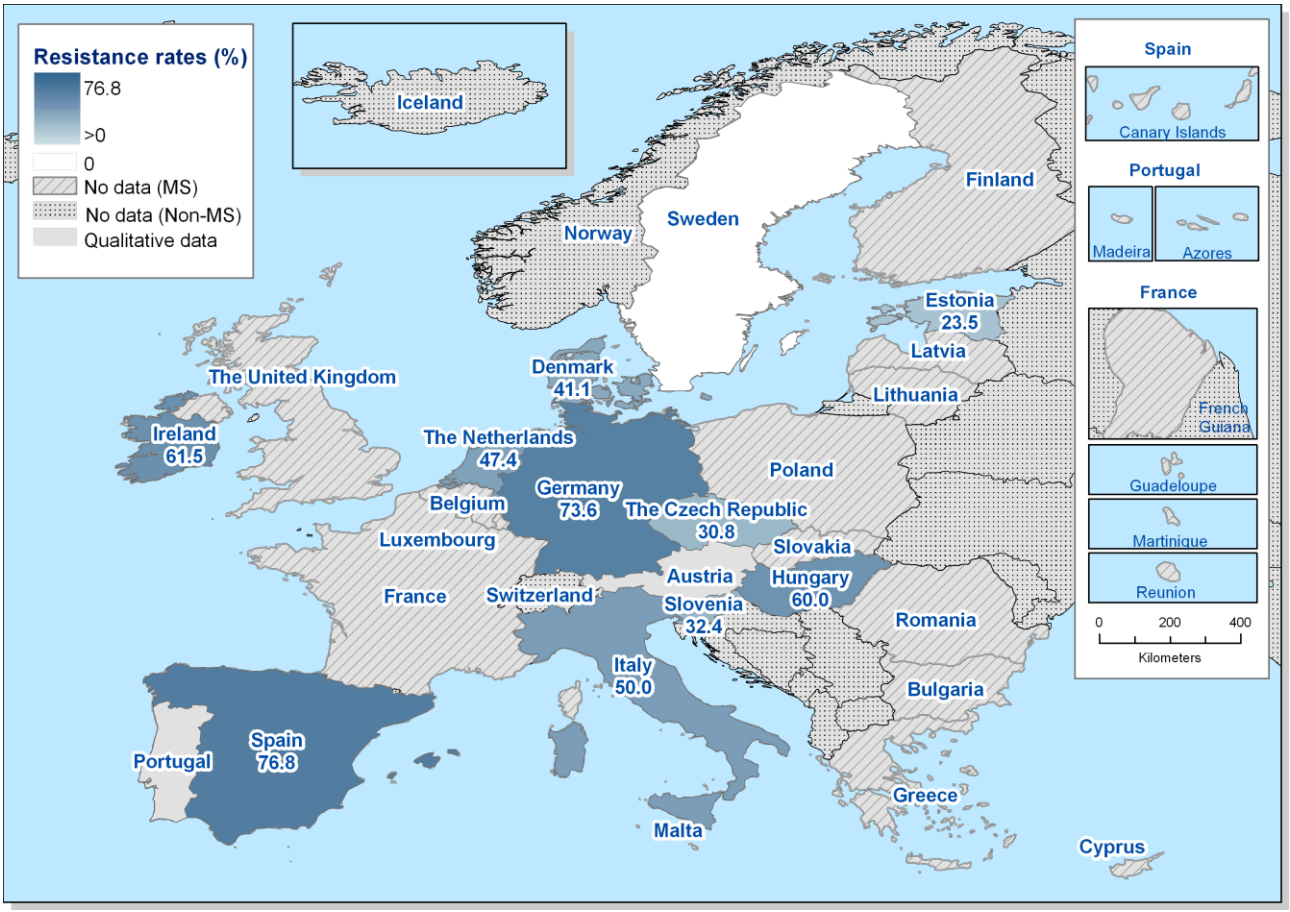
Figure SA28. Spatial distribution of nalidixic acid resistance among* Salmonella *spp. from pigs in countries reporting MIC data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data have been used instead. The countries labelled as 'qualitative data' therefore include those reporting either IZD data, MIC data for fewer than 10 isolates, or purely qualitative data (as proportion of resistant isolates).

1. For the Czech Republic, Slovenia and Sweden, 2010 data were used.

Figure SA29. Spatial distribution of tetracycline resistance among* Salmonella *spp. from pigs in countries reporting MIC data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data have been used instead. The countries labelled as 'qualitative data' therefore include those reporting either IZD data, MIC data for fewer than 10 isolates, or purely qualitative data (as proportion of resistant isolates).

1. For the Czech Republic, Slovenia and Sweden, 2010 data were used.

Multi-resistance among *Salmonella* spp. isolates from pigs

In 2011, six MSs provided isolate-based data concerning resistance in *Salmonella* spp. from pigs. The levels of complete susceptibility varied importantly between the reporting MSs, from 14.7 % in Germany to 70.6 % in Estonia, although, in the latter case, the complete susceptibility level was assessed on a sample of 17 isolates only. Multi-resistance levels were high in all reporting MSs, ranging between 23.5 % in Estonia and 74.8 % in Germany (Table SA24). The frequency distributions (Figure SA30) showed discrepancies among the multi-resistance recorded in the reporting MSs with some isolates showing reduced susceptibility to up to eight different substances in Ireland, Italy and Spain, while Estonia recorded multi-resistance to four classes at a maximum. The values of the indices of diversity summarising the frequency distributions of resistant isolates are presented in Table SA12. Very few isolates were resistant to both ciprofloxacin and cefotaxime.

Table SA24. Complete susceptibility, multi-resistance and index of diversity in Salmonella *spp. from pigs in MSs reporting isolate-based data, 2011*

Country	Susceptible to all		Multi-resistant		Index of diversity	Co-resistant to CIP and CTX			
	n	%	n	%		n		%	
Denmark (N=371)	183	49.3	118	31.8	0.408	0	(0)	0	(0)
Estonia (N=17)	12	70.6	4	23.5	0.086	0	(0)	0	(0)
Germany (N=614)	90	14.7	459	74.8	0.505	0	(0)	0	(0)
Ireland (N=39)	15	38.5	22	56.4	0.665	0	(0)	0	(0)
Italy (N=86)	27	31.4	49	57.0	0.497	1	(1)	1.2	(1.2)
Spain (N=81)	18	22.2	51	63.0	0.609	1	(0)	1.2	(0)

N = Total number of isolates tested for susceptibility against the whole common antimicrobial set for *Salmonella* spp.

n = number of isolates per category of complete susceptibility or multiple resistance.

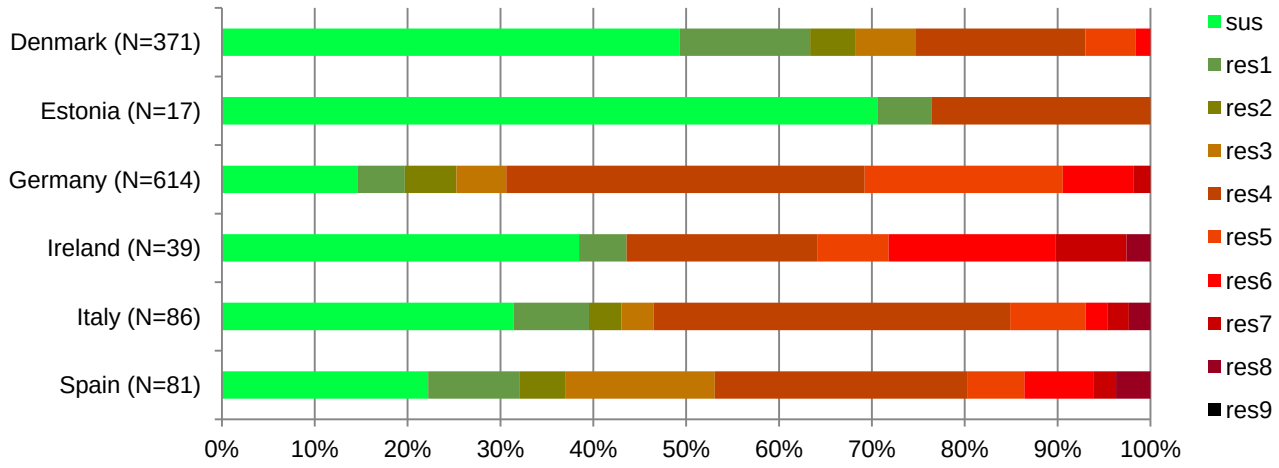
Susceptible to all =isolate susceptible to all antimicrobial substances of the EFSA common set for *Salmonella* spp.

Multi-resistant = resistant to at least 3 different antimicrobial substances, belonging to any three antimicrobial families from the common antimicrobial set.

Index of diversity = see definition in section 11.4.2.1 of Materials and Methods.

Co-resistant to ciprofloxacin (CIP) and cefotaxime (CTX) = the frequencies and percentages of *Salmonella* isolates not susceptible to concentrations greater than ECOFFs (CTX: >0.5 mg/L and CIP: >0.06 mg/L). Figures in parentheses indicate the occurrence of resistance determined using EUCAST clinical breakpoints (CTX: >2 mg/L and CIP: >1 mg/L).

Figure SA30. Frequency distribution of Salmonella *spp. from pigs isolates completely susceptible or resistant to one to nine antimicrobials in MSs reporting isolate-based data, 2011*



N = Total number of isolates tested for susceptibility against the whole common set of antimicrobial substances.

sus = susceptible to all antimicrobial substances of the common set.

res1/res9 = resistance to one antimicrobial substance/resistance to nine antimicrobial substances of the common set.

Multi-resistance among *S.* Typhimurium isolates from pigs

As fewer than four MSs reported multi-resistance isolate-based data on more than 10 isolates of *S.* Typhimurium isolates in pigs, tables and graphs on multi-resistance are not presented in this report.

3.4.2.4. Cattle (bovine animals)

In this report, calves, dairy cattle, beef cows and heifers are included under the term 'cattle'. Where data on the production level of animals have been provided, these have been included in the table footnotes. Quantitative MIC data for *Salmonella* spp. isolated from cattle in eight MSs in 2011 are included in the following analysis of antimicrobial resistance levels. Isolates tested by Estonia, Finland, Spain, Sweden and Norway were obtained through national monitoring programmes and generally consisted of faecal samples. Finland also tested lymph nodes at slaughter. Italy obtained isolates through passive surveillance.

Resistance levels in *Salmonella* spp.

The levels of resistance to selected antimicrobials in isolates of *Salmonella* spp. from cattle reported by MSs in 2011 are presented in Table SA25. High levels of resistance to ampicillin, sulfonamides and tetracyclines were commonly reported in *Salmonella* spp. from cattle in 2011; considering all reporting MSs, the levels of resistance were 29.1 %, 33.4 % and 31.1 %, respectively. Ampicillin resistance ranged from 0 % to 50.0 % across reporting MSs, while the range for both sulfonamides and tetracyclines was 0 % to 59.1 %. Only Germany and Italy reported resistance to gentamicin at low or very low levels.

At MS group level, the overall occurrence of resistance to ciprofloxacin and nalidixic acid was 1.7 % and 1.4 % respectively. Germany, Ireland and Italy were the only MSs to report resistance to ciprofloxacin or nalidixic acid in *Salmonella* spp. isolates from cattle and, in general, for these countries the levels reported were low. However, Italy reported moderate resistance to ciprofloxacin (10.7 %). Cefotaxime resistance was not reported by any of the MSs.

Resistance levels in *Salmonella* Typhimurium

Table SA26 shows the level of resistance reported among *S*. Typhimurium isolates from cattle in 2011. Across the five reporting MSs, the level of resistance to sulfonamides and tetracyclines was very high, at 57.9 % and 52.3 %, respectively. The resistance levels reported by individual MSs varied from 0 % to 76.0 % for tetracyclines and from 9.1 % to 76.0 % for sulfonamides. There were also high levels of resistance to ampicillin (45.8 %) and chloramphenicol (23.4 %) at MS group level, which ranged from 9.1 % to 62.2 % and from 0 % to 52.0 % respectively. Resistance to gentamicin in *S*. Typhimurium from cattle was detected only in Germany at the low level of 2.7 %.

The occurrence of resistance to both ciprofloxacin and nalidixic acid in the reporting MS group as a whole was very low (0.9 % for both antimicrobials) as Germany was the only country to report resistance (2.7 %). Cefotaxime resistance in *S*. Typhimurium isolates from cattle in 2011 was not reported by any MS.

Table SA25. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *spp. isolates from cattle in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Estonia	15	0	15	0	15	0	15	0	15	0	15	0	15	0	15	0
Finland[1]	11	9.1	11	0	11	0	11	0	11	0	11	0	11	9.1	11	0
Germany	146	33.6	146	0	146	7.5	146	1.4	146	0.7	146	1.4	146	32.9	146	28.8
Ireland	44	50.0	44	0	44	29.5	44	2.3	44	0	44	2.3	44	59.1	44	59.1
Italy	28	39.3	28	0	28	17.9	28	10.7	28	3.6	28	7.1	28	46.4	28	42.9
Netherlands[2]	69	23.2	69	0	69	7.2	69	0	69	0	69	0	69	34.8	69	34.8
Spain[3]	13	7.7	13	0	13	0	13	0	13	0	13	0	13	0	13	15.4
Sweden	24	8.3	24	0	24	0	24	0	24	0	24	0	24	20.8	24	12.5
Total (8 MSs)	**350**	**29.1**	**350**	**0**	**350**	**9.7**	**350**	**1.7**	**350**	**0.6**	**350**	**1.4**	**350**	**33.4**	**350**	**31.1**
Norway	12	25.0	12	0	12	0	12	8.3	12	0	12	8.3	12	25.0	12	33.3

N = number of isolates tested.

% Res = percentage of resistant isolates.

1. All isolates from adult cattle over two years old.

2. Twenty-nine of the isolates tested by the Netherlands were from dairy cows and 23 were from veal calves under one year old.

3. All isolates from beef cattle (one to two years old).

Table SA26. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Typhimurium from cattle in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Finland	11	9.1	11	0	11	0	11	0	11	0	11	0	11	9.1	11	0
Germany	37	62.2	37	0	37	18.9	37	2.7	37	2.7	37	2.7	37	56.8	37	51.4
Ireland	25	60.0	25	0	25	52.0	25	0	25	0	25	0	25	76.0	25	76.0
Netherlands	24	37.5	24	0	24	20.8	24	0	24	0	24	0	24	70.8	24	70.8
Sweden	10	10.0	10	0	10	0	10	0	10	0	10	0	10	40.0	10	10.0
Total (5 MSs)	**107**	**45.8**	**107**	**0**	**107**	**23.4**	**107**	**0.9**	**107**	**0.9**	**107**	**0.9**	**107**	**57.9**	**107**	**52.3**

N = number of isolates tested.

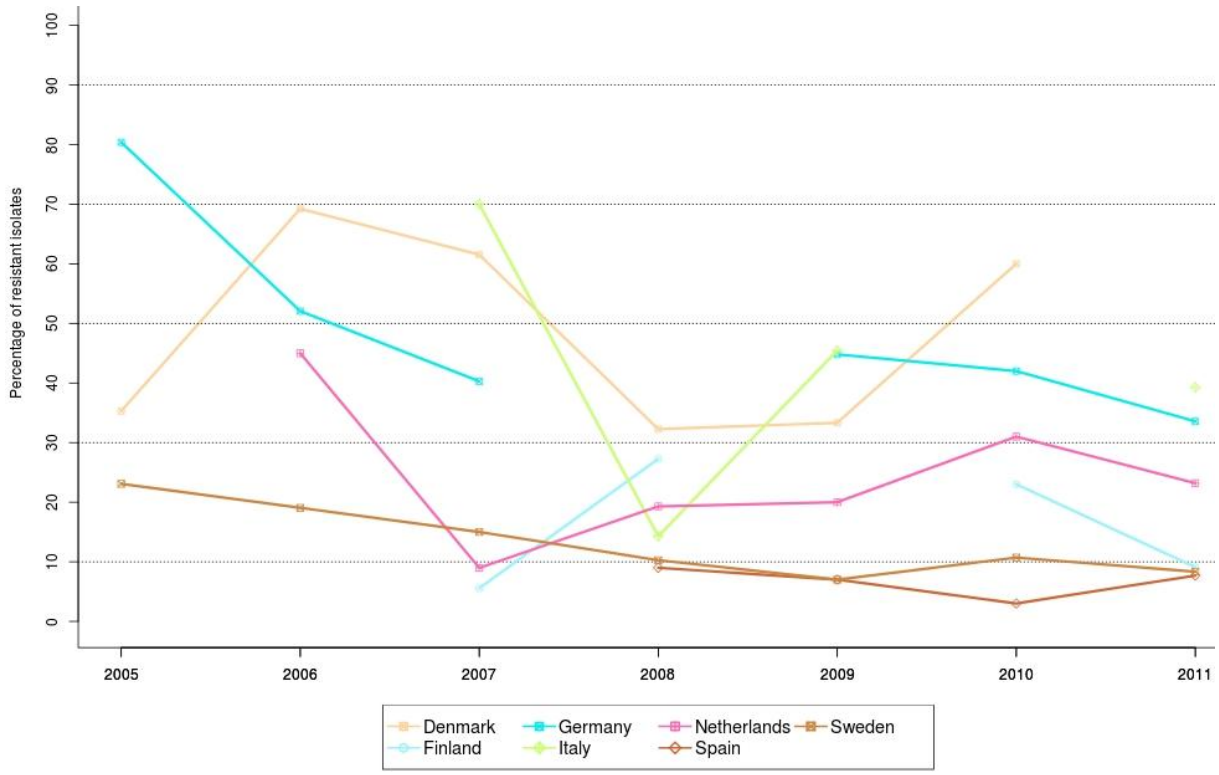
% Res = percentage of resistant isolates.

Temporal trends in resistance among *Salmonella* isolates from cattle

It is evident from figures SA31–SA34 that large variations exist between MSs in the level of resistance to some antimicrobials, particularly ampicillin and tetracyclines. The figures illustrate the trends in resistance to ampicillin, chloramphenicol, ciprofloxacin, nalidixic acid and tetracyclines among *Salmonella* isolates from cattle from 2005 to 2011.

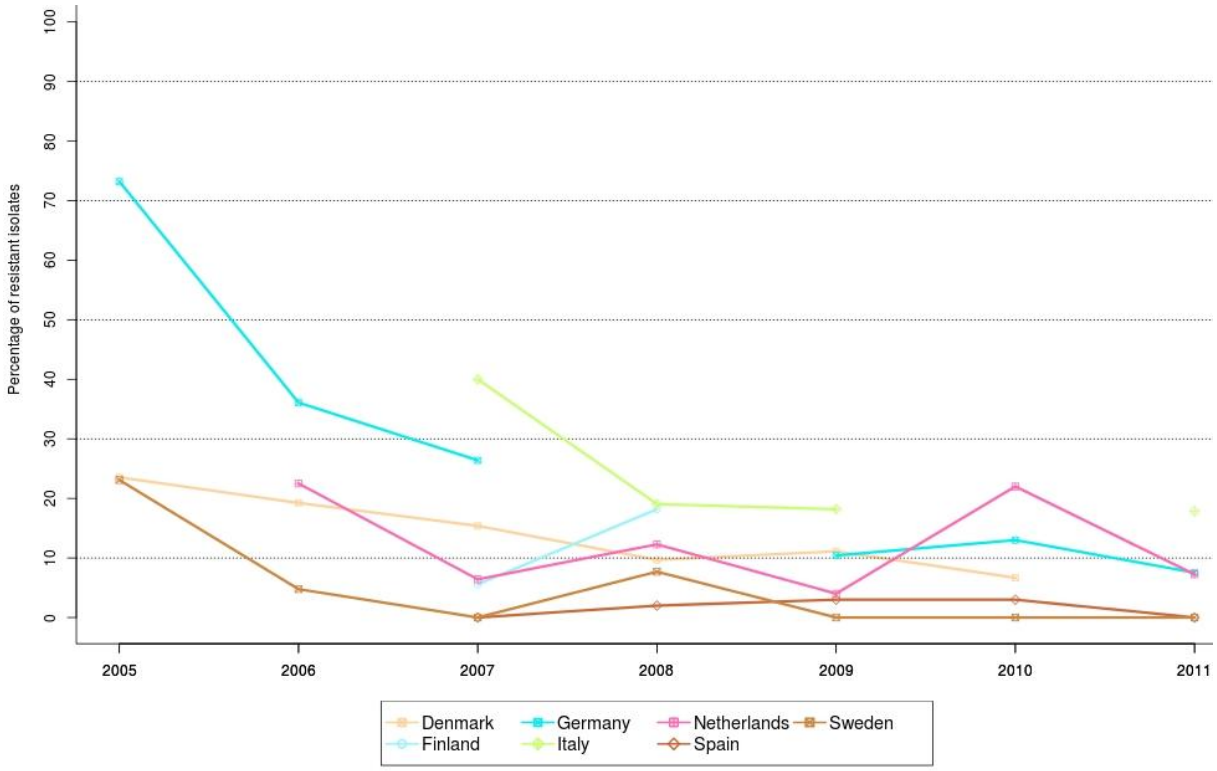
As in 2010, trends in resistance over time were mainly decreasing among *Salmonella* spp. from cattle. Germany and Sweden experienced statistically significant decreasing trends in resistance to ampicillin and chloramphenicol, and Germany also reported statistically significant decreasing trends in resistance to tetracyclines. No significant trends were observed in the reported resistance to ciprofloxacin and nalidixic acid between 2005 and 2011.

Figure SA31. Trends in ampicillin resistance in* Salmonella *spp. from cattle in reporting MSs, 2005-2011, quantitative data



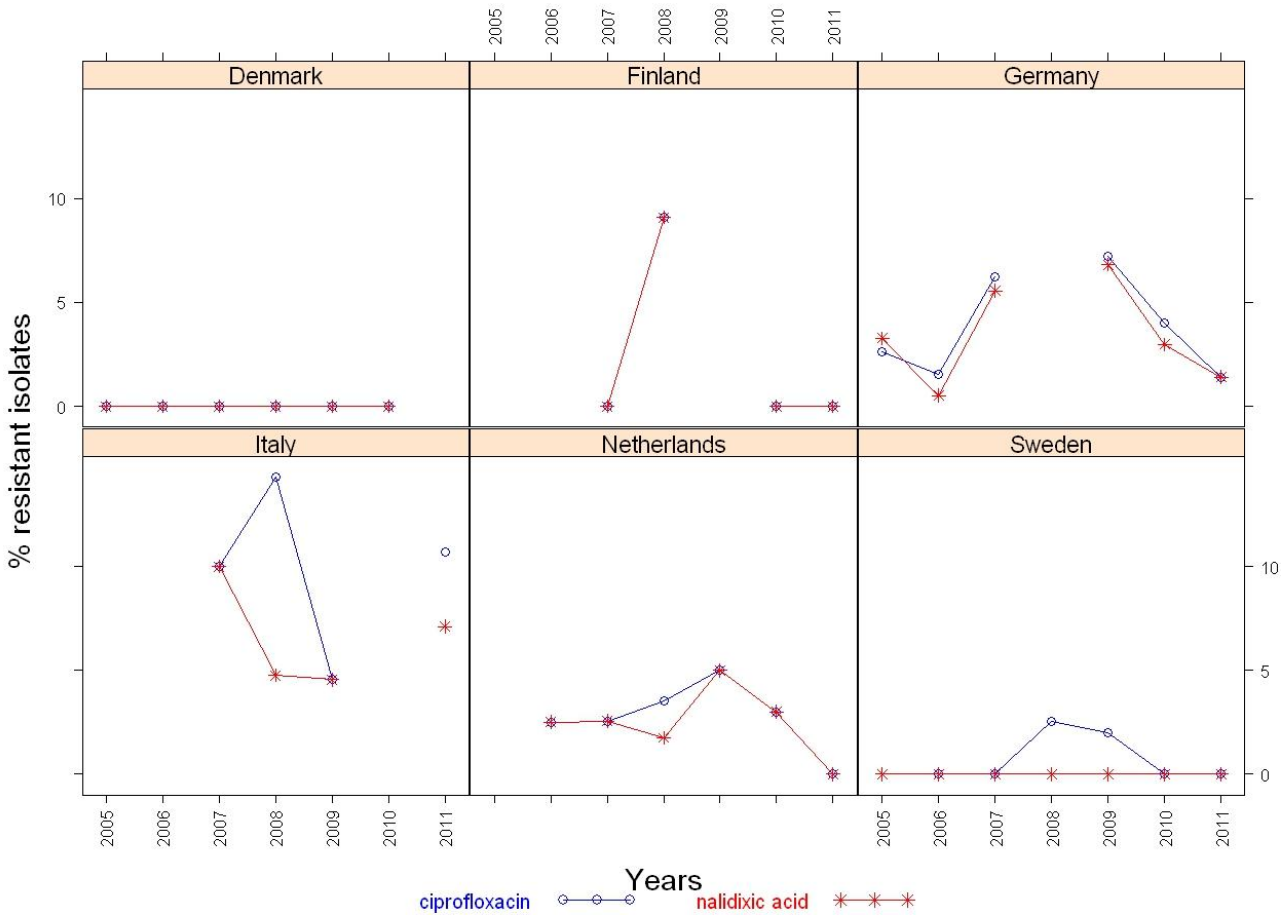
Note: A statistically significant decreasing trend for five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Germany (↓) and Sweden (↓).

Figure SA32. Trends in chloramphenicol resistance in* Salmonella *spp. from cattle in reporting MSs, 2005-2011, quantitative data



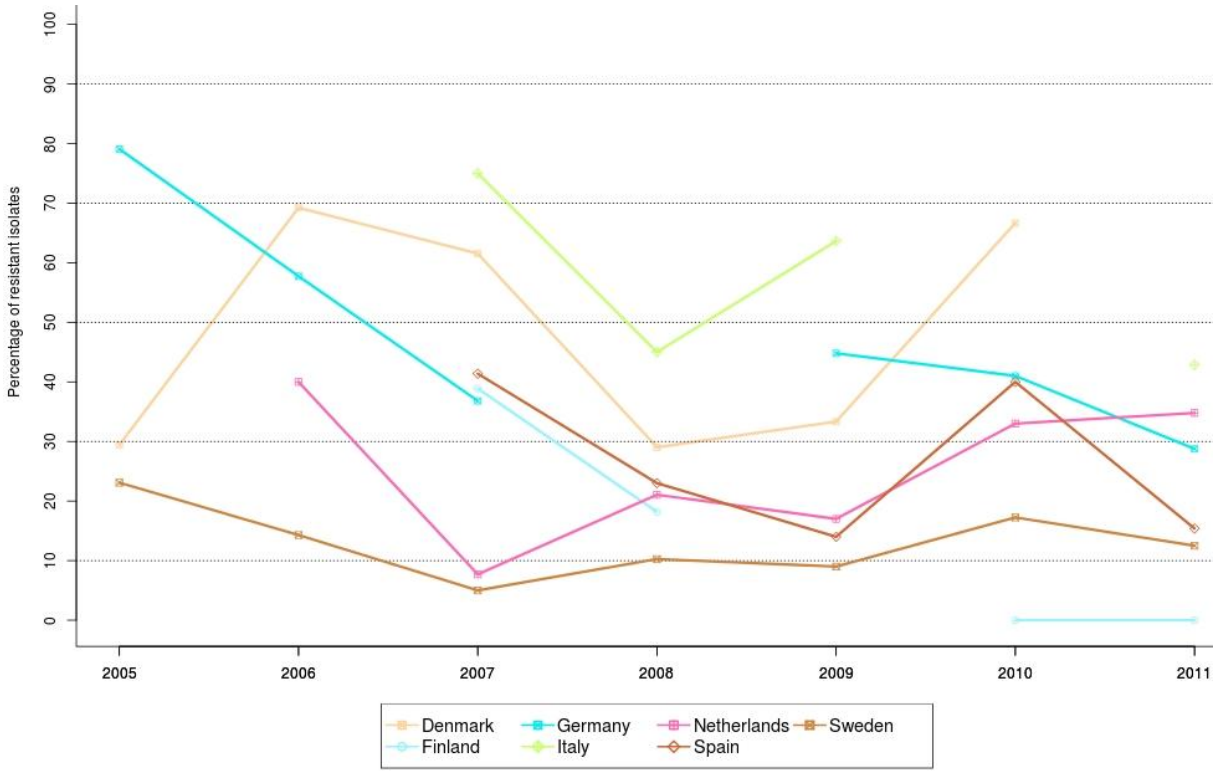
Note: A statistically significant decreasing trend for five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Germany (↓) and Sweden (↓).

Figure SA33. Trends in ciprofloxacin and nalidixic acid resistance in* Salmonella *spp. from cattle in reporting MSs, 2005-2011, quantitative data



Note: For both ciprofloxacin and nalidixic acid, no statistically significant trend for five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

Figure SA34. Trends in tetracycline resistance in* Salmonella *spp. from cattle in reporting MSs, 2005-2011, quantitative data

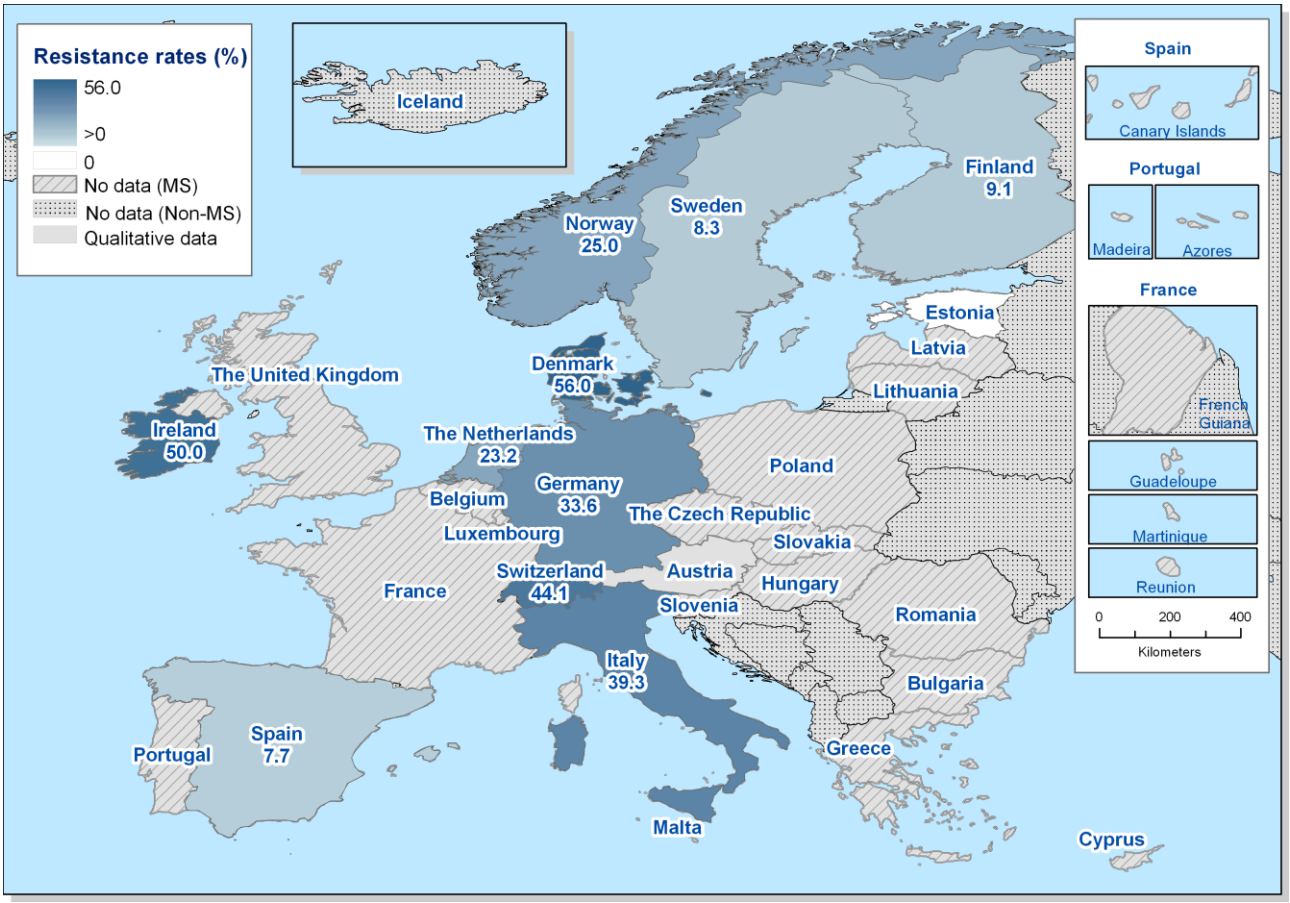


Note: A statistically significant decreasing trend for five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Germany (↓).

Spatial distribution of resistance among *Salmonella*

Figures SA35-SA37 show the spatial distributions of ampicillin, nalidixic acid and tetracycline resistance in *Salmonella* spp. isolated from cattle in 2011. Figures SA35 and SA37 illustrate the similarity in levels of ampicillin and tetracycline resistance in *Salmonella* spp. across the EU and the absence of a clear spatial distribution. Figure SA36 illustrates the continued absence, or low prevalence, of resistance to nalidixic acid in *Salmonella* spp. isolated from cattle in Europe.

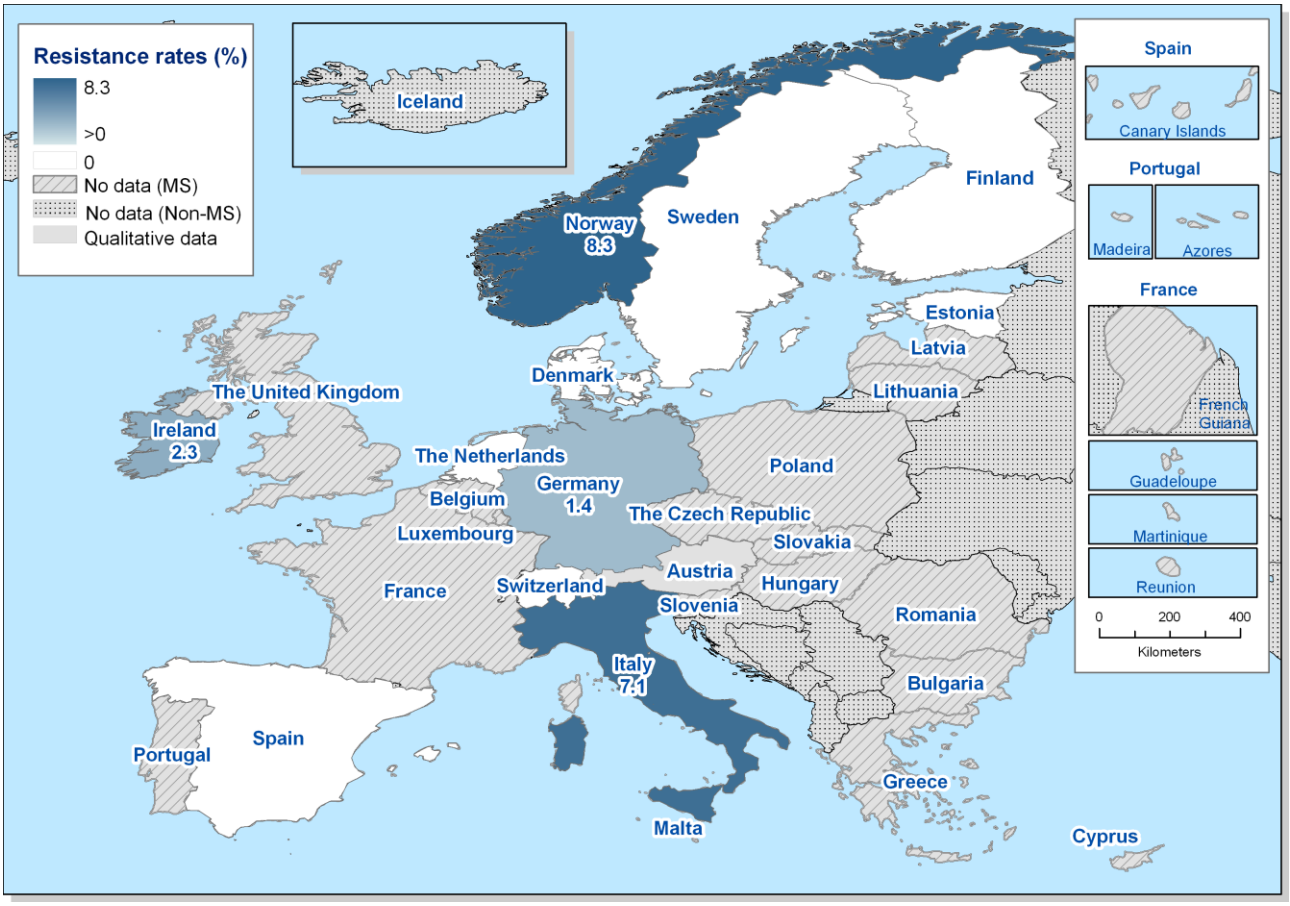
Figure SA35. Spatial distribution of ampicillin resistance among* Salmonella *spp. from cattle in countries reporting MIC data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data have been used instead. The countries labelled as 'qualitative data' therefore include those reporting either IZD data, MIC data for less than 10 isolates, or purely qualitative data (as proportion of resistant isolates).

1. For Denmark and Switzerland, 2010 data were used.

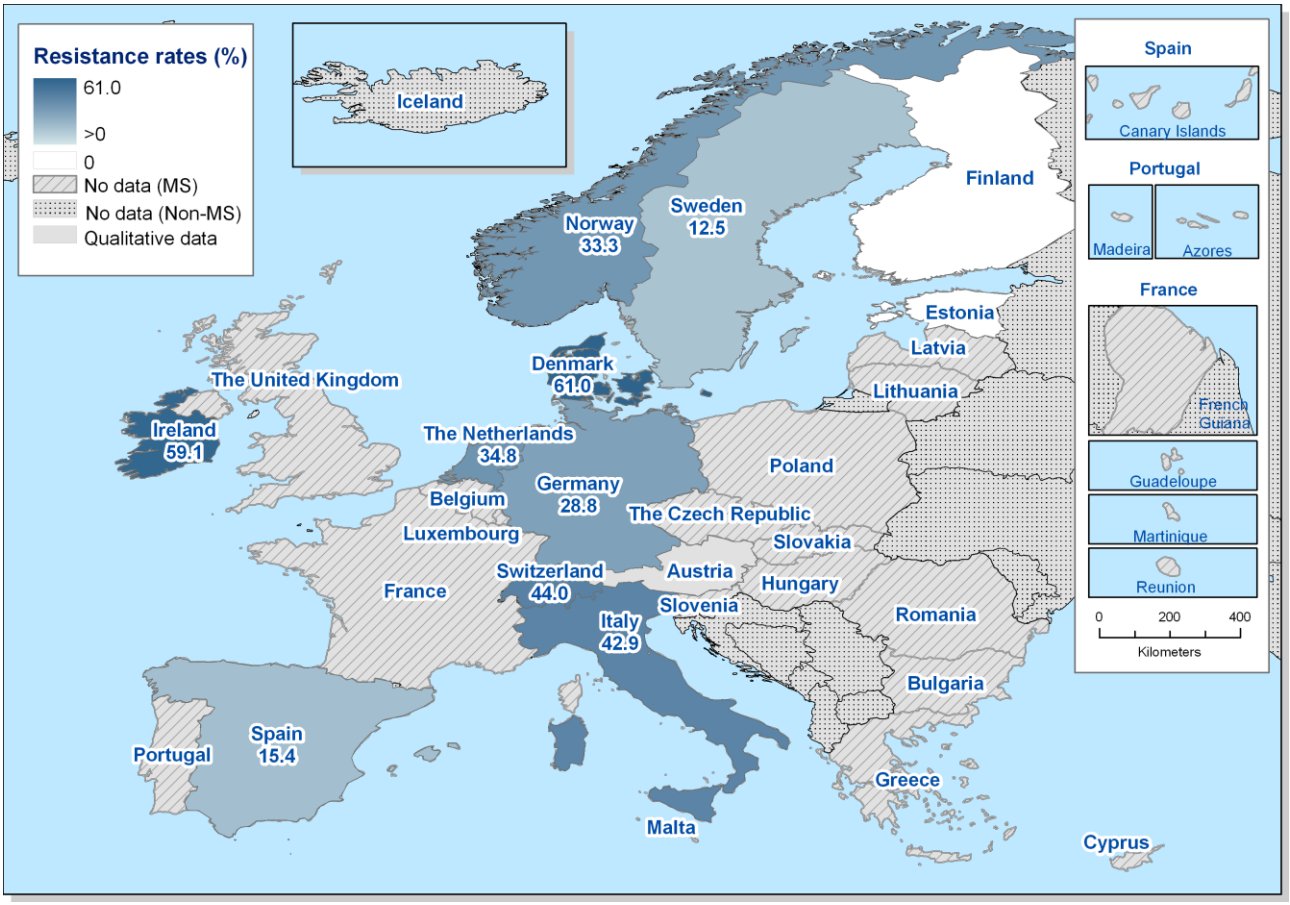
Figure SA36. Spatial distribution of nalidixic acid resistance among* Salmonella *spp. from cattle in countries reporting MIC data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data have been used instead. The countries labelled as 'qualitative data' therefore include those reporting either IZD data, MIC data for fewer than 10 isolates, or purely qualitative data (as proportion of resistant isolates).

1. For Denmark and Switzerland 2010, data were used.

Figure SA37. Spatial distribution of tetracycline resistance among* Salmonella *spp. from cattle in countries reporting MIC data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data have been used instead. The countries labelled as 'qualitative data' therefore include those reporting either IZD data, MIC data for fewer than 10 isolates, or purely qualitative data (as proportion of resistant isolates).

1. For Denmark and Switzerland, 2010 data were used.

Multi-resistance among *Salmonella* spp. isolates from cattle

In 2011, eight MSs reported isolate-based data concerning resistance in *Salmonella* spp. from cattle. The proportions of completely susceptible isolates were high and varied importantly between the reporting MSs, from 38.6 % in Ireland to 100 % in Estonia. Three reporting MSs (Estonia, Finland and Spain) did not detect any multi-resistant isolates among those tested from cattle, while Sweden recorded a multi-resistance level of 12.5 % and the remaining MSs high levels of multi-resistance ranging between 32.2 % and 59.1 % (Table SA27). The frequency distributions (Figure SA38) showed that isolates from Germany, Ireland and Italy exhibited reduced susceptibility to more different substances than isolates from the other MSs. No isolates were resistant to both ciprofloxacin and cefotaxime.

Table SA27. Complete susceptibility, multi-resistance and index of diversity in Salmonella *spp. from cattle in MSs and one non-MS reporting isolate-based data, 2011*

Country	Susceptible to all		Multi-resistant		Index of diversity	Co-resistant to CIP and CTX	
	n	%	n	%		n	%
Estonia (N=15)	15	100	0	0	NA	NA	NA
Finland (N=11)	10	90.9	0	0	0	NA	NA
Germany (N=146)	91	62.3	47	32.2	0.355	0 (0)	0 (0)
Ireland (N=44)	17	38.6	26	59.1	0.407	0 (0)	0 (0)
Italy (N=28)	14	50.0	12	42.9	0.636	0 (0)	0 (0)
Spain (N=13)	11	84.6	0	0	0.086	NA	NA
Sweden (N=24)	18	75.0	3	12.5	0.276	0 (0)	0 (0)
Norway (N=12)	8	66.7	4	33.3	0.158	0 (0)	0 (0)

N = total number of isolates tested for susceptibility against the whole common antimicrobial set for *Salmonella*.

n = number of isolates per category of complete susceptibility or multiple resistance.

NA = not applicable.

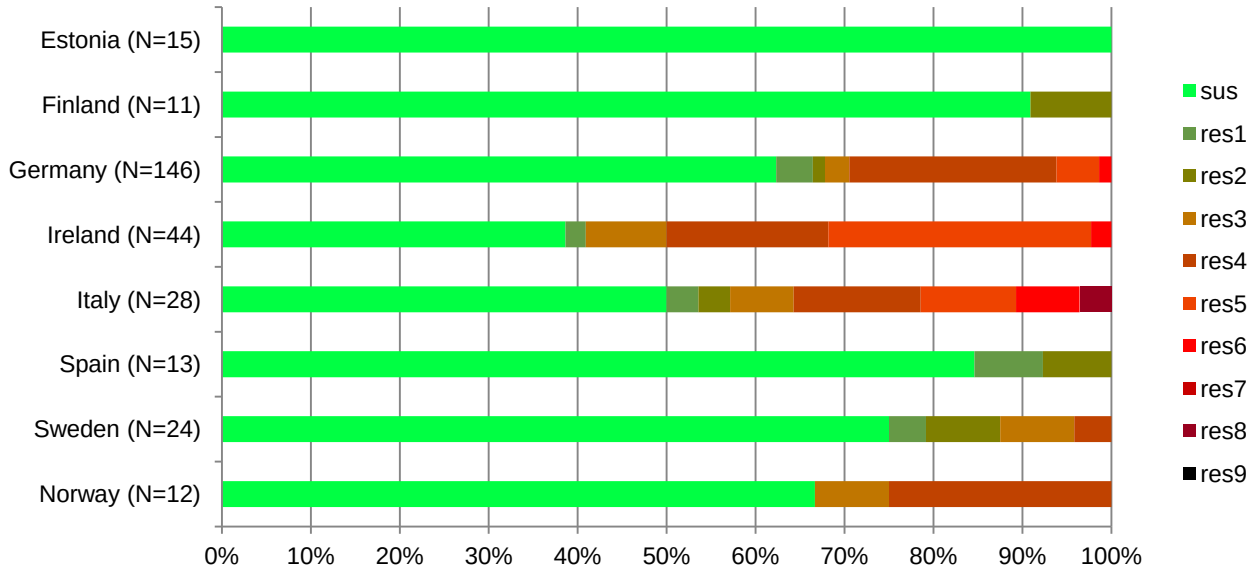
Susceptible to all = isolate susceptible to all antimicrobial substances of the EFSA common set for *Salmonella*.

Multi-resistant = resistant to at least three different antimicrobial substances, belonging to any three antimicrobial families from the common antimicrobial set.

Index of diversity = see definition in section 11.4.2.1 of Materials and Methods.

Co-resistant to ciprofloxacin (CIP) and cefotaxime (CTX) = the frequencies and percentages of *Salmonella* isolates not susceptible to concentrations greater than ECOFFs (CTX: >0.5 mg/L and CIP: >0.06 mg/L). Figures in parentheses indicate the occurrence of resistance determined using EUCAST clinical breakpoints (CTX: >2 mg/L and CIP: >1 mg/L).

Figure SA38. Frequency distribution of Salmonella *spp. from cattle completely susceptible or resistant to one to nine antimicrobials in MSs and one non-MS reporting isolate-based data, 2011*



N = Total number of isolates tested for susceptibility against the whole common set of antimicrobial substances.

sus = susceptible to all antimicrobial substances of the common set.

res1/res9 = resistance to one antimicrobial substance/resistance to nine antimicrobial substances of the common set.

Multi-resistance among *S.* Typhimurium isolates from cattle

Since fewer than four MSs reported multi-resistance isolate-based data on more than 10 isolates of *S.* Typhimurium isolates in cattle, tables and graphs on multi-resistance are not presented in this report.

3.4.3. Comparison of 'clinical' and 'microbiological' resistance to ciprofloxacin

Fluoroquinolones, including ciprofloxacin, are recognised to be critically important in human medicine **and often constitute the first-line treatment for invasive salmonellosis**. Therefore, the high levels of ciprofloxacin resistance observed among *Salmonella* spp. from some animal species that were discussed earlier in this chapter are of concern. Resistance levels were particularly high among *Gallus gallus* and turkeys when interpreted using the EUCAST ECOFFs.

When the data were re-analysed using the CLSI breakpoints, the resistance levels were considerably lower (Table SA28). Several countries reported very high or extremely high resistance to ciprofloxacin among *Salmonella* spp. from turkeys when using the EUCAST ECOFFS, none of the 10 countries reporting more than 10 isolates detected no resistance. However, when the CLSI breakpoints were applied to analyse these data, resistance was detected only in Poland (31.7 %) and Hungary (12.4 %). Among *Salmonella* spp. from *Gallus gallus*, resistance levels reached up to 63.5 % using the EUCAST ECOFFs and only two of the 16 countries reporting more than 10 isolates detected no resistance. However, using the CLSI breakpoints, resistance was only found in four countries, at low levels in Belgium (2.0 %), Slovakia (1.9 %) and Spain (1.4 %) and at a very low level in Hungary (0.4 %). Similarly, whereas several countries expressed low or moderate resistance among *Salmonella* spp. from pigs and cattle when EUCAST ECOFFS were used, none of these countries were found to have any resistant isolates when using the CLSI breakpoints.

The geographical distribution of the occurrence of resistance to ciprofloxacin in turkeys and the fact that it is high parallels the occurrence of *S.* Kentucky in that farm animal species and indicates how the clonal spread of one serovar can influence the overall picture.

Table SA28. Resistance (%) to ciprofloxacin among* Salmonella *spp. from* Gallus gallus*, turkeys, pigs and cattle in 2011, using harmonised epidemiological cut-off values or CLSI breakpoints

Country	*Gallus gallus*[1]		Turkeys[2]		Pigs[3]		Cattle	
	EUCAST % Res	CLSI % Res	EUCAST % Res	CLSI % Res	EUCAST % Res	CLSI % Res	EUCAST % Res	CLSI % Res
Austria	26.7	0	68.2	0	-	-	-	-
Belgium	33.4	2.0	-	-	-	-	-	-
Denmark	0	0	-	-	0	0	-	-
Estonia	-	-	-	-	0	0	0	0
Finland	-	-	-	-	-	-	0	0
France	2.1	0	24.1	0	-	-	-	-
Germany	7.9	0	52.6	0	3.7	0	1.4	0
Greece	22.9	0	-	-	-	-	-	-
Hungary	63.5	0.4	77.1	12.4	11.4	0	-	-
Ireland	1.5	0	14.3	0	12.8	0	2.3	0
Italy	24.1	0	25.9	0	7.0	0	10.7	0
Latvia	0	0	-	-	-	-	-	-
Netherlands	25.6	0	-	-	0	0	0	0
Poland	51.2	0	61.0	31.7	-	-	-	-
Portugal	46.5	0	80.0	0	-	-	-	-
Slovakia	55.6	1.9	-	-	-	-	-	-
Spain	35.0	1.4	77.3	0	17.1	0	0	0
Sweden	-	-	-	-	-	-	0	0
United Kingdom	4.5	0	4.8	0	-	-	-	-
Norway	-	-	-	-	-	-	8.3	0

- = no data reported.

1. *Gallus gallus*: in Estonia, two isolates (N=4) displayed reduced susceptibility to ciprofloxacin (MIC above the EUCAST ECOFF), whereas, in Finland, Sweden and Norway one, four and two isolates were respectively sensitive to ciprofloxacin (MIC below the ECOFF).
2. Turkeys: in Slovakia, one isolate (N=4) displayed reduced susceptibility to ciprofloxacin (MIC above both the EUCAST and CLSI thresholds), while, in Denmark, Finland and Norway one, two and one isolates were respectively sensitive to ciprofloxacin (MIC below the EUCAST ECOFF).
3. Pigs: in Sweden one isolate (N=9) displayed reduced susceptibility to ciprofloxacin (MIC above the EUCAST ECOFF), whereas, in Finland and Norway four and five isolate were respectively sensitive to ciprofloxacin (MIC below the EUCAST ECOFF).

3.4.4. Overview of the findings of antimicrobial resistance in *Salmonella* at MS reporting group level, 2011

Figures SA39 and SA40 illustrate the resistance levels for the groups of MSs reporting quantitative MIC data in 2011. These data were not all derived from the same group of MSs, which needs to be considered when interpreting these figures. Resistance levels to ampicillin, chloramphenicol, sulfonamides and tetracyclines in *S*. Typhimurium from *Gallus gallus* were higher than in *S*. Enteritidis from *Gallus gallus*. However, resistance to ciprofloxacin and nalidixic acid was higher in *S.* Enteritidis than in *S.* Typhimurium. In terms of all *Salmonella* spp., resistance levels in isolates from broiler meat were higher than those in isolates from *Gallus gallus*. This represents a return to the pattern observed in 2009 with an increase in resistance in isolates from broiler meat compared with the levels reported in 2010.

In a very similar pattern to that observed in 2010, resistance levels to tetracyclines, sulfonamides and ampicillin were higher in *Salmonella* isolated from turkeys, pigs and cattle than in isolates from *Gallus gallus*, whereas, for ciprofloxacin and nalidixic acid, the highest resistance was observed in turkeys and in *Gallus gallus*. The levels of resistance to sulfonamides and tetracyclines in isolates from turkeys decreased in 2011, whereas the levels of resistance to these antimicrobials in isolates from pigs increased compared with 2010.

Figure SA39. Resistance to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines in* Salmonella *spp.,* S. *Enteritidis and* S. *Typhimurium from* Gallus gallus *and* Salmonella *spp. from meat from broilers at reporting MS group level in 2011

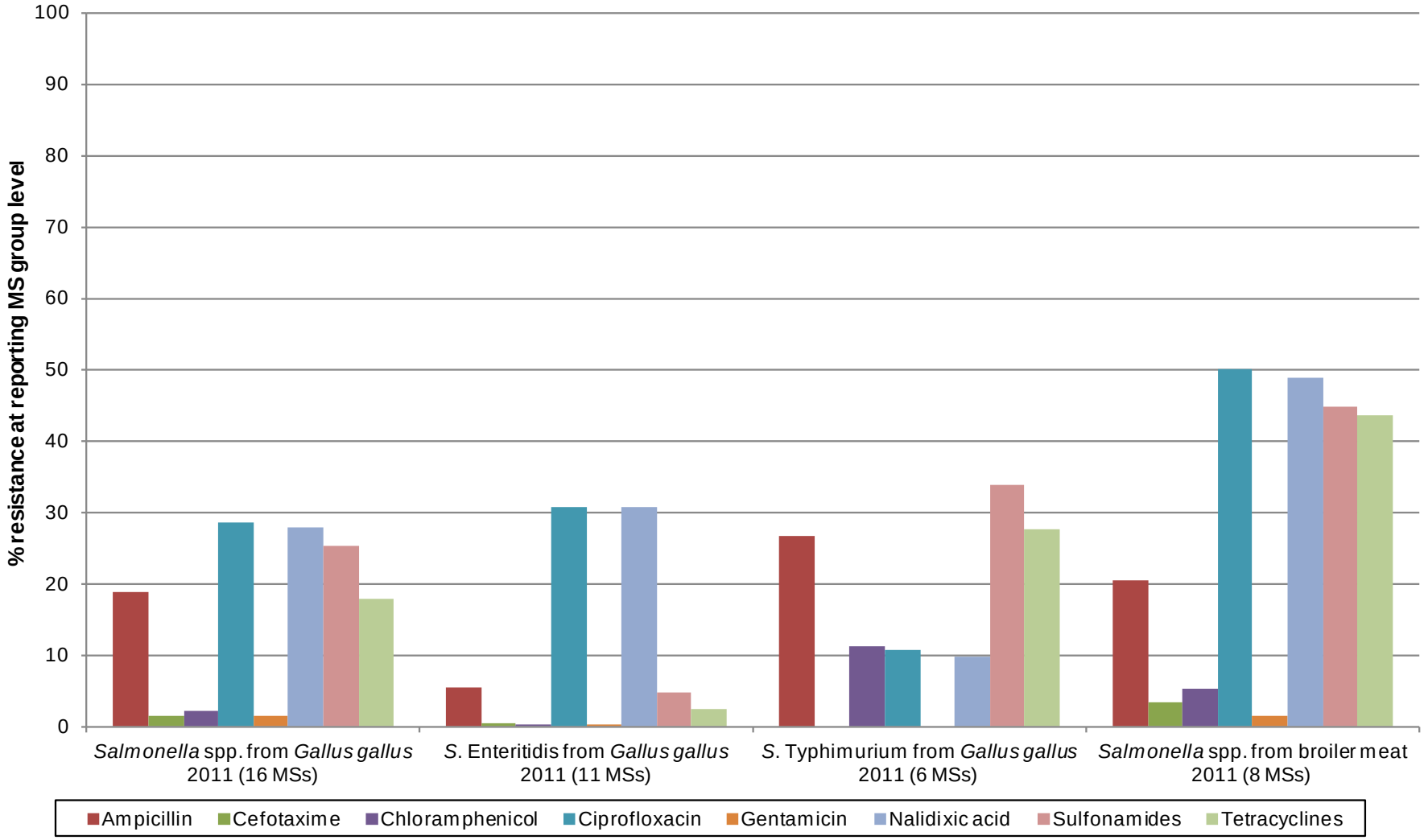
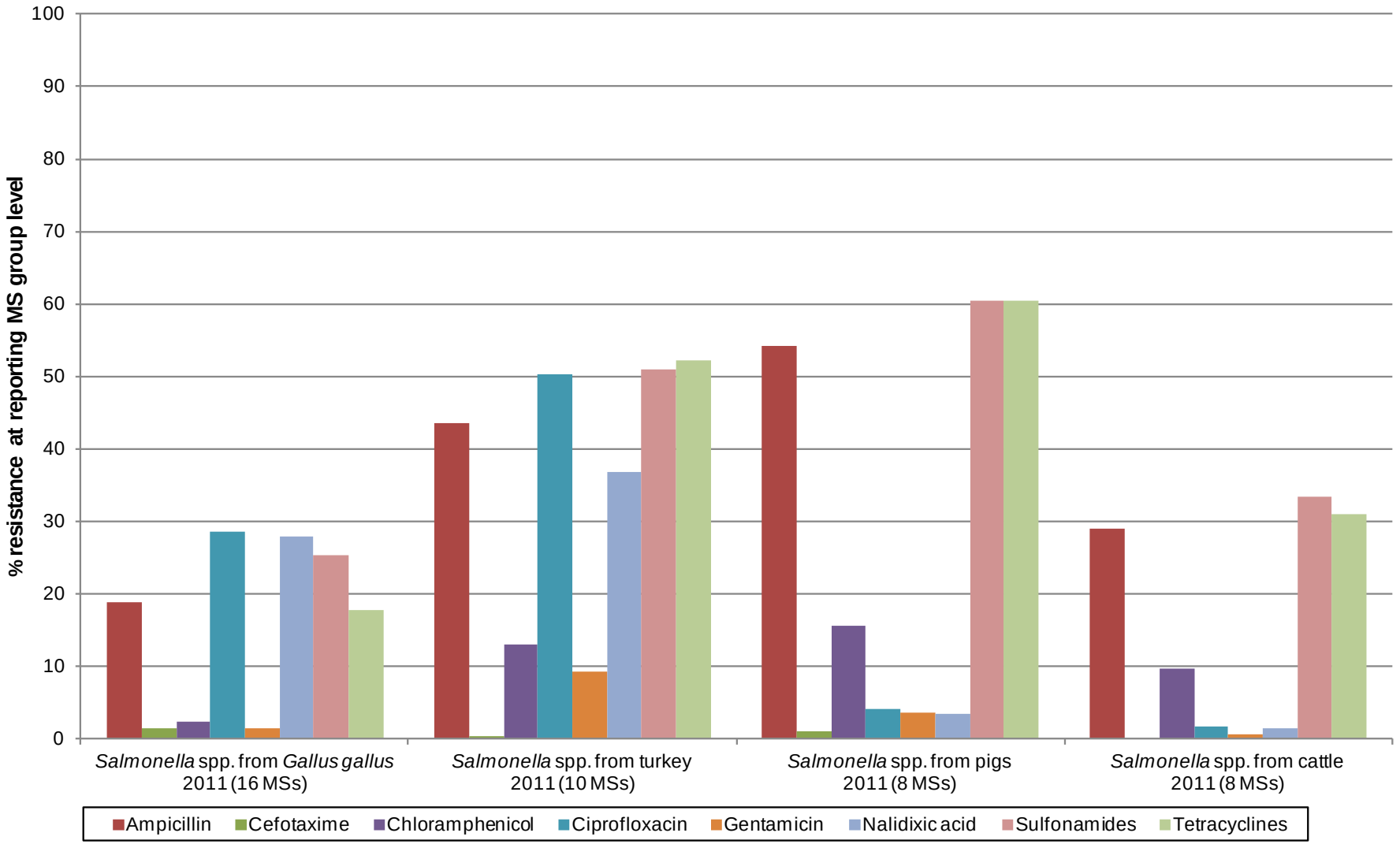


Figure SA40. Resistance to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines in Salmonella spp. from Gallus gallus, turkey, pigs and cattle at reporting MS group level in 2011



3.5. Discussion

Salmonellosis continues to be the second most commonly reported zoonotic disease in humans in the EU, after campylobacteriosis, although there has been a significant decline in human cases over the period 2007–2011. This decrease is assumed to be mainly due to the reduction in *Salmonella* prevalence in flocks of laying hens, broilers and turkeys, most likely as beneficial results of the national control and monitoring programmes implemented by the MSs in the corresponding production sectors (EFSA and ECDC, 2013).

In 2011, information on antimicrobial resistance in *Salmonella* isolates from human salmonellosis cases was reported by 19 MSs and one non-MS (Iceland). The number of isolates submitted by these countries corresponded to a quarter of the salmonellosis cases reported within the EU in 2011, which is considered a representative sample. MSs not reporting antimicrobial resistance data are, however, still encouraged to do so to achieve the best possible assessment of the levels of antimicrobial resistance in human *Salmonella* isolates in the EU.

Resistance in human *Salmonella* isolates was high for ampicillin, tetracyclines and sulfonamides and moderate for streptomycin and nalidixic acid. These are antimicrobials that are or have commonly been used for treatment in humans and animals. For these first four antimicrobials, the important resistance observed was largely due to the high to extremely high resistance levels observed among *S.* Typhimurium and particularly monophasic *S.* Typhimurium isolates. This corresponding resistance pattern (ASSuT) is the most commonly observed among the emerging monophasic *S*. Typhimurium definitive type 193/120 strains (EFSA, 2010d). In contrast, resistance to the clinically-important antimicrobials, ciprofloxacin and cefotaxime, was relatively low among the isolates tested. However, levels of resistance to ciprofloxacin were significantly higher in countries using epidemiological cut-off values or similar values for the interpretation of the resistance than in those using clinical breakpoints (with the notable exception of Italy). Resistance to quinolones (ciprofloxacin and nalidixic acid) was also generally higher in *S*. Enteritidis isolates than in *S*. Typhimurium isolates of human origin.

On average, a quarter of human *Salmonella* spp. isolates in the 12 MSs testing for all antimicrobials collected at EU level exhibited multi-drug resistance, meaning that they were clinically resistant to at least three different antimicrobial classes. Two MSs recorded multi-resistance levels greater than 50 %. More than half of all isolates tested were susceptible to the complete range of antimicrobials in the human data collection. Co-resistance to the critically important antimicrobials ciprofloxacin and cefotaxime was low and observed in a total of 65 isolates in 5 of the 12 reporting MSs.

The multi-resistance levels observed in human isolates were generally lower than those observed in turkeys, pigs and pig meat. Compared with broilers and laying hens, however, multi-resistance levels observed in humans were generally higher. Although clinical breakpoints were mainly used to estimate multi-resistance in the human isolates, because both resistant and intermediate results were combined to estimate multi-resistance in human isolates, the clinical breakpoints for only 4 out of 10 antimicrobials had less sensitive MIC values than the ECOFFs. This resulted in lower than expected difference in multi-resistance estimates between human and animal/food isolates. A striking observation was that many human isolates were resistant to a large number of antimicrobials, some even to all 10, something which was not observed in any animal or food isolates included in the analysis. This could reflect the impact of use of antimicrobials in humans, in addition to that in food-producing animals.

In order to assess the importance of travel-associated infections, antimicrobial resistance was also analysed based on the most likely country of infection and aggregated by geographical region. Overall, human *Salmonella* spp. isolates acquired within the EU/EEA countries exhibited greater resistance to ampicillin and streptomycin than isolates from other regions, while the highest levels of resistance to six of the antimicrobials tested, including ciprofloxacin, were observed in isolates acquired from Asia.

In *Salmonella* isolates from animals and meat, information on antimicrobial resistance was reported by 20 MSs and one non-MS (Norway) in accordance with EFSA's recommendations (EFSA, 2007) in 2011. The (quantitative) MIC results obtained using the methods recommended by EFSA provided the most harmonised and comparable set of data for reporting MSs, and these datasets have therefore been analysed in detail.

For the first time, this EUSR has examined the levels of resistance in isolates within different production types of animal species. Differences in animal husbandry and physiological differences between animals

involved in different production types (e.g. fattening veal calves and dairy cattle) make evaluation of the antimicrobial resistance results at the animal species level difficult, where the production types of the species in question are not comparable. Sub-division of resistance data allows for more accurate analysis; however, this is possible only where sufficient information on production type has been submitted. In 2011, the large number of MSs providing data on isolates from *Gallus gallus* by production type allowed for more accurate analysis. However, more information is required at production level for other animal species, particularly cattle, to improve these sections of the report in future years. Moreover, the analysis of the results may be hampered where there are few reporting MSs, as sub-division into production types reduces the size of isolate samples available, unless sampling plans have been previously designed at the level of production types.

Antimicrobials such as **ampicillin**, **sulfonamides** and **tetracyclines** have been widely used for many years in veterinary medicine to treat bacterial diseases.Thus, levels of resistance to these antimicrobials observed within this reporting process are generally moderate to high among isolates from food-producing animals and meat products thereof. The data submitted by MSs in 2011 are evidence of this. For ampicillin, chloramphenicol, sulfonamides and tetracyclines, resistance levels were highest in isolates from pigs, followed closely by isolates from turkeys, and then cattle. Isolates from *Gallus gallus* displayed the least resistance to these antimicrobials within the reported data, but still at moderate to high levels. Considering the production level data for *Salmonella* spp. and *S.* Enteritidis from *Gallus gallus*, higher levels of resistance were observed among isolates from broiler flocks than in isolates from laying hen flocks. This was particularly evident for tetracyclines and sulfonamides. This may reflect the relative infrequency with which laying hens are treated with antimicrobials compared with broilers, as well as the limited numbers of antimicrobial compounds which are authorised for the treatment of laying hens in many EU MSs.

Among food and animal isolates, the highest occurrence of resistance to **ciprofloxacin** was noted in *Salmonella* from turkeys, fowl (*Gallus gallus*) and broiler meat, with 50.4 %, 28.7 % and 50.1 %, respectively, of the isolates found resistant in the reporting MS group. The ciprofloxacin resistance level of 28.7 % for the *Gallus gallus* species can be further sub-divided into production types and reveals a difference between *Salmonella* isolates from laying hens, among which resistance to ciprofloxacin was 12.7 % and broilers, in which resistance to ciprofloxacin in the reporting MS group was 35.1 %. A number of reporting MSs showed increasing trends in ciprofloxacin and nalidixic acid resistance in *Salmonella* spp. isolates from *Gallus gallus* over the 2005-2011 period, whereas decreasing trends were observed in other MSs. These observations relating to *Salmonella* spp. may reflect the occurrence of *S.* Enteritidis definitive phage type 1 in *Gallus gallus* within these MSs, since this phage type commonly displays resistance to nalidixic acid and ciprofloxacin. Similarly, in turkeys, the dissemination of certain serovars (such as *S.* Newport in some MSs), which, again, are commonly resistant to nalidixic acid and ciprofloxacin, may affect the overall levels of resistance among all *Salmonella* spp. In addition, the reporting of resistance results for an expanded number of individual serovars in this report enables some of the resistances which are associated with particular serovars to be clearly seen.

Resistance to third-generation cephalosporins (such as **cefotaxime**) was detected in *Salmonella* isolates from turkeys, fowl (*Gallus gallus*), pigs, cattle and the meat derived from broilers and pigs, but at low or very low levels when all reporting MSs were considered. However, there was some variability in third-generation cephalosporin resistance observed between the different animal or meat origins in the reporting MSs. Some MSs recorded a decline in resistance to cefotaxime in *Salmonella* spp. from *Gallus gallus*. However, Austria and Hungary detected cefotaxime resistance in *S.* Enteritidis from *Gallus gallus* in 2011, whereas, in 2010, cefotaxime resistance in *S.* Enteritidis from *Gallus gallus* was reported only by the Czech Republic. As *S.* Enteritidis is one of the main serovars affecting humans, the emergence of resistance to third-generation cephalosporins is extremely undesirable. A further trend is that the number of MSs reporting cefotaxime resistance in *Salmonella* spp. from pigs has increased.

Antimicrobial resistance in certain *Salmonella* serovars and phage types may be related not only to the selective pressure exerted by the use of antimicrobials, but also to the clonal diffusion of these *Salmonella* serovars and phage types, and may also be influenced by factors such as on-farm hygienic management and animal movements and trade. It was evident in both humans and animals that isolates of *S.* Typhimurium displayed higher levels of resistance than isolates of *S.* Enteritidis to ampicillin, chloramphenicol, streptomycin, sulfonamides and tetracyclines. This is usually observed among the data reported by MSs and is not surprising since certain phage types of *S.* Typhimurium have an associated pattern of pentavalent resistance to these antimicrobials.

The MS specific **temporal trends** in the resistant *Salmonella* isolates from animals over the years 2005-2011 were analysed statistically. Some statistically significant increasing and decreasing trends were observed at MS specific level. In contrast to 2010, more decreasing trends than increasing trends were detected in isolates from *Gallus gallus*, and the same was observed for isolates from pigs. Once again in cattle isolates, all the significant trends observed were also decreasing. In 2011, an equal number of MSs had significant increasing and decreasing national trends for ciprofloxacin and/or nalidixic acid resistance in isolates from *Gallus gallus*, whereas in 2010 the majority of significant trends were increasing. Ultimately, it would be most useful to correlate trends and the occurrence of antimicrobial resistance, with the usage of antimicrobial compounds in each animal production type that is monitored.

The multi-resistance levels (proportions of isolates showing reduced susceptibility to more than three antimicrobial classes according to ECOFFs) in *Salmonella* spp. isolates were generally high in the animal populations investigated, with notable variations between reporting countries. A striking exception to this is the multi-resistance levels recorded in isolates from laying hens which are generally low to moderate, in particular compared with those observed in isolates from broilers. Generally, the proportions of *Salmonella* spp. isolates susceptible to all or resistant (or non-susceptible) to any one up to nine antimicrobials differed substantially among the reporting countries, and the relative contribution of different serovars, which may exhibit particular multi-resistance patterns, should be kept in mind, when comparing the situation between the reporting countries. Co-resistance to cefotaxime and ciprofloxacin was recorded, using ECOFFs, at low levels in very rare cases and when using clinical breakpoints, not detected, in *Salmonella* spp. isolates from meat and animal populations studied in this report (meat from pigs, broilers, laying hens, turkeys, pigs and cattle) in the reporting countries.

Salmonella spp. comprises the amalgamated results for all *Salmonella* serovars reported by a reporting MS for a different animal or food category. The relative contribution of different serovars possessing a particular resistance should ideally be considered when interpreting the results, in order to evaluate the influence of clonal dissemination of serovars. The recent proposed changes to and implementation of isolate-based reporting (EFSA, 2012a) will facilitate the evaluation of the results in this way in future. The next chapter makes an attempt to present information on antimicrobial resistance at serovar level for the serovars of most relevance for public health in 2011.

4. RESISTANCE AMONG OTHER *SALMONELLA* SEROVARS OF PUBLIC HEALTH SIGNIFICANCE

4.1. Introduction

In 2011, a substantial number of data was submitted by MSs regarding antimicrobial resistance among specific serovars of *Salmonella* of public health significance from humans, food and animal sources. The data reported for serovars of public health significance have been specifically analysed in this chapter. This section describes the data reported for a total of 15 serovars: the top 10 serovars in humans and some additional serovars displaying particular patterns of resistance. In particular, *S*. Enteritidis, *S*. Typhimurium, *S*. Hadar, *S*. Infantis and *S*. Virchow are specifically targeted by national control and monitoring programmes of *Salmonella* in poultry in the EU (see box below). Comparisons should be made with caution as interpretive criteria differ between human and animal data.

NATIONAL CONTROL PROGRAMMES FOR *SALMONELLA* IN *GALLUS GALLUS*

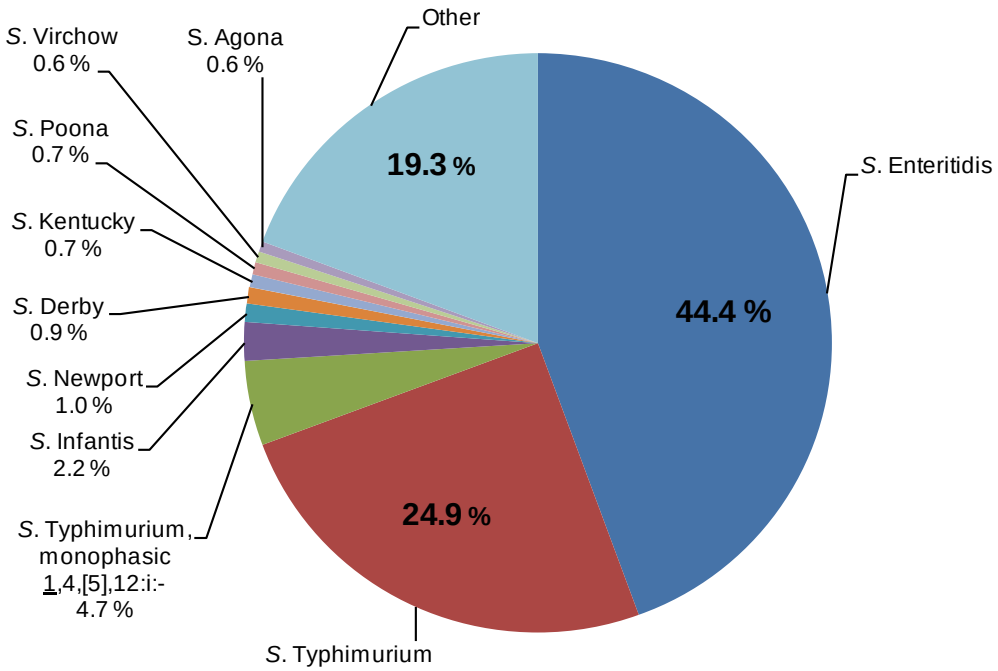
Under EU Regulation (EC) No. 2160/2003,[13] *EU MSs are required to implement National Control Programmes (NCPs) for* Salmonella *serovars that are deemed to be of particular public health significance in animal species that present a high potential risk of transmitting those* Salmonella *to humans. The NCPs are implemented in order to achieve agreed targets for the reduction in the prevalence of particular regulated* Salmonella *serovars in animal populations at the primary production level over specified time periods. The initial focus of the NCPs was* Gallus gallus*, with the NCPs for breeding flocks, laying hens, and broilers coming into place in 2007, 2008 and 2009, respectively. The targets were set by the EC in consultation with MSs. For laying and broiler flocks, the targets were set following standardised EU-wide baseline prevalence surveys. The NCPs may vary between MSs owing to different circumstances but they generally set minimum* Salmonella *monitoring requirements and control methods to be used upon finding regulated serovars. NCPs must be approved by the EC.*

S. *Enteritidis,* S. *Typhimurium and monophasic strains of* Salmonella *with the antigenic formula* S. *1,4,[5],12:i:- are regulated serovars within NCPs for breeding flocks, laying hens and broiler flocks. However, the NCPs for breeding flocks also include* S. *Infantis,* S. *Virchow and* S. *Hadar. In 2011, a number of MSs provided quantitative data on antimicrobial resistance for these three serovars in isolates from* Gallus gallus. *Although antimicrobial resistance data were not specifically provided on isolates from breeding flocks in 2011, it is interesting to present separately some information on the degree of resistance observed among these important serovars isolated from broilers and laying hens.*

[13] Commission Regulation (EC) No 2160/2003 of the European Parliament and of the Council and Regulation of 17 November 2003 on the control of *Salmonella* and other specified food-borne zoonotic agents. OJ L 325, 12.12.2003, pp. 1–15.

Information on *Salmonella* serovars in humans was available from 25 MSs in 2011. Monophasic *S.* Typhimurium was the third most commonly reported serovar in human confirmed cases in the EU after *S*. Enteritidis and *S*. Typhimurium, which represented 4.7 %, 44.4 % and 24.9 %, respectively, of confirmed cases of all reported serovars, as more MSs reported monophasic *S.* Typhimurium cases according to the new agreed serotype code. The next most frequent serovar in the list was *S.* Infantis, followed by *S*. Newport, *S*. Derby, *S*. Kentucky, *S*. Poona, *S*. Virchow and *S*. Agona (see Figure SAS1). New on the top 10 serovar list was *S*. Poona.

Figure SAS1. Distribution of the 10 most common* Salmonella *serovars in humans, TESSy data from 25 MSs, 2011



Source: The European Union Summary Report on Trends and Sources of Zoonoses, Zoonotic Agents and Food-borne Outbreaks in 2011. Available on line: http://www.efsa.europa.eu/en/efsajournal/pub/3129.htm

Data originating from food-producing animals and food have been included in the report even if there originated from fewer than four reporting MSs and fewer than 10 tested isolates. This is indicated in the footnotes of the relevant tables.

4.2. Resistance in monophasic *S*. Typhimurium

Monophasic S. *Typhimurium has been considered a new pandemic strain of* Salmonella *in Europe, typically showing resistance to four antimicrobials (ampicillin, streptomycin, sulfonamides and tetracyclines) (Mossong et al., 2007; Hopkins et al., 2010). Many isolates are genetically related and, of definitive phage-types, DT120 or DT193, have been detected in several European countries, with pigs considered the likely reservoir of infection. However, monophasic* S. *Typhimurium isolates belonging to phage type U302 have also been previously detected in Spain; these isolates have commonly been found to express additional resistance to gentamicin and trimethoprim/sulfonamides and/or chloramphenicol (Echeita et al., 1999). In monophasic* S. *Typhimurium of phage types DT120 and DT193, the resistance genes appear to be located on a new resistance island and it seems that deletions of parts of this island in related strains of the organism account for differences in the observed ampicillin, streptomycin, sulfonamides and tetracycline pattern of resistance (Hopkins et al., 2010). This serovar has been included in the list of serovar targets for the NCPs in poultry since 2010 (Commission Regulation (EU) No. 517/2011[14]).*

Monophasic S. *Typhimurium was the fourth most commonly reported serovar in 2010, with a total of 1,407 human cases (1.5 % of all* Salmonella *cases), compared with 360 in 2007 (EFSA and ECDC, 2012). There were also three outbreaks in Germany caused by pig meat or pork buffet meals, involving 45 cases, 10 hospitalisations and one death, which follows other outbreaks associated with pork meat or products in Luxembourg and France in recent years (EFSA, 2010d). Monophasic* S. *Typhimurium was also the second most common serovar in pigs (9.3 %) in 2010 and the third most common serovar in pig meat (7.4 %), cattle (4.7 %) and bovine meat (10.0 %), with several countries also reporting isolations from turkey meat and* Gallus gallus *(EFSA and ECDC, 2012). Multidrug-resistant* Salmonella *4,[5],12:i:- DT 193 has been associated with large diffuse human outbreaks in Germany since 2006 (EFSA, 2010d).*

4.2.1. In humans

In 2011, eight MSs submitted AMR data for this serovar, which was the third most common isolated with 3,666 cases (EFSA and ECDC, 2013). The highest resistance in monophasic *Salmonella* Typhimurium was observed for tetracyclines (90.9 %; N=914), ampicillin (90.4 %; N=914) and streptomycin (85.1 %; N=914). This was in accordance with the highest resistance observed for generic *S.* Typhimurium isolates described in the previous chapter. The occurrence of resistance to these antimicrobials was generally high to extremely high in the majority of reporting MSs, although the number of isolates tested was low (N=914). Resistance in sulfonamides decreased markedly from 86.5 % (N=252) in 2010 to 57.5 % (N=914) in 2011 which was due to a very low resistance to sulfonamides reported for this serovar from Spain (1.5 %; N=342), Spain did not submit data on sulfonamide resistance in this serovar in 2010 (Table SAS1). The resistance observed in monophasic *S*. Typhimurium isolates to the two most important antimicrobials for treatment of clinical human cases was low, at 1.6 % (N=914) for ciprofloxacin and 1.8 % (N=914) for cefotaxime (Table SAS1).

[14] Commission Regulation (EU) No. 517/2011 of 25 May 2011 implementing Regulation (EC) No 2160/2003 of the European Parliament and of the Council as regards a Union target for the reduction of the prevalence of certain *Salmonella* serotypes in laying hens of *Gallus gallus* and amending Regulation (EC) No 2160/2003 and Commission Regulation (EU) No 200/2010. OJ L 138, 26.05.2011, pp. 45–51.

Table SAS1. Antimicrobial resistance in monophasic* Salmonella *Typhimurium 1,4,[5],12:i:- from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Kanamycin	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	73	94.5	73	4.1	73	8.2	73	0	73	4.1	73	4.1
Denmark[1]	140	90.7	140	7.1	140	10.7	140	7.1	140	9.3	140	1.4
Estonia	2	NA	2	NA	2	NA	2	NA	2	NA	2	NA
Hungary	86	88.4	86	0	86	2.3	86	0	86	0	86	0
Ireland	28	82.1	28	0	28	7.1	28	0	28	3.6	28	3.6
Luxembourg	29	89.7	29	0	29	3.4	29	3.4	29	0	29	0
Netherlands[1]	214	93.9	214	0	214	3.7	214	1.4	214	0.5	-	-
Spain	342	88.9	342	0.9	342	5.6	342	0.3	342	3.2	342	0.9
Total (8 MSs)	**914**	**90.4**	**914**	**1.8**	**914**	**5.8**	**914**	**1.6**	**914**	**3.2**	**700**	**1.3**

Country	Nalidixic acid		Streptomycin		Sulfonamides		Tetracyclines		Trimethoprim	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	73	1.4	73	94.5	73	94.5	73	97.3	73	5.5
Denmark[1]	140	1.4	140	92.9	140	94.3	140	90.7	140	5.0
Estonia	2	NA	2	NA	2	NA	2	NA	2	NA
Hungary	86	2.3	86	84.9	86	86.0	86	74.4	86	0
Ireland	28	3.6	28	82.1	28	82.1	28	92.9	28	7.1
Luxembourg	29	3.4	29	86.2	29	86.2	29	86.2	29	10.3
Netherlands[1]	214	0.9	214	93.0	214	92.1	214	92.5	-	-
Spain	342	2.3	342	75.4	342	1.5	342	93.3	342	0.3
Total (8 MSs)	**914**	**1.9**	**914**	**85.1**	**914**	**57.5**	**914**	**90.9**	**700**	**2.4**

N = number of isolates tested.

% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable; if fewer than 10 isolates were tested, resistance was not calculated.

1. ECOFFs were used for interpretation.

4.2.2. In pigs and pig meat

In the analysis below, the *Salmonella* serovars considered as monophasic *S*. Typhimurium are *S.* 1,4,[5],12:i:-, *S.* 4,12:i:-, *S.* 4,5,12:i:- and those reported as '*S.* Typhimurium, monophasic'. However, where MSs have incorporated monophasic *S*. Typhimurium in their results for *S.* Typhimurium, the results could not be included in this analysis. Over 90 % of the isolates tested were reported by Germany and Denmark, and over 70 % from Germany alone, so the levels of resistance reported as total proportions will be heavily influenced by these results. A complete overview of the animal populations and food categories in which resistance data on monophasic *S.* Typhimurium have been reported is presented in Table SAS2.

Five MSs reported data on monophasic *S.* Typhimurium in pigs and pig meat in 2011. Italy and Spain reported data only for isolates from pigs and Ireland reported data only for isolates from pig meat. Both Denmark and Germany reported resistance levels among isolates from both sources and in the case of pigs, data from these countries made up a significant proportion of the total data.

All MSs reported extremely high levels of resistance to ampicillin (95.8 %), sulfonamides (89.4 %) and tetracyclines (95.8 %). Almost every isolate tested by Italy and Spain was resistant to these three compounds. The occurrence of resistance to chloramphenicol and gentamicin was low overall among the reporting MSs (8.4 % and 3.2 %, respectively), although Spain reported a high level of resistance to chloramphenicol (23.1 %) and a moderate level to gentamicin (15.4 %) among isolates of monophasic *S.* Typhimurium from pigs.

No resistance to ciprofloxacin and nalidixic acid was detected among isolates from pigs tested by Denmark and Italy in 2011. Germany detected low levels of resistance to both antimicrobials (2.7 % for ciprofloxacin and 1.4 % for nalidixic acid), and Spain reported moderate resistance to ciprofloxacin (15.4 %) but no resistance to nalidixic acid. Germany was the only country to report resistance to cefotaxime in monophasic *S.* Typhimurium from pigs and only at a very low level (0.9 %).

Three MSs reported data on monophasic *S.* Typhimurium in pig meat and overall the levels of resistance were similar to those reported for isolates from pigs. Extremely high levels of resistance to ampicillin (78.3 %), sulfonamides (91.3 %) and tetracyclines (93.5 %) were reported at the MS group level. Denmark did not detect resistance to chloramphenicol or gentamicin, while for Germany and Ireland, the overall resistance levels for these antimicrobials were 3.3 % and 2.2 % respectively. Germany was the only MS to report resistance to ciprofloxacin (5.3 %) and nalidixic acid (2.6 %) and none of the reporting MSs detected resistance to cefotaxime among monophasic *S.* Typhimurium from pig meat.

Table SAS2. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among monophasic* Salmonella *Typhimurium from pigs and meat from pigs in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Pigs																
Denmark	59	78.0	59	0	59	5.1	59	0	59	3.4	59	0	59	79.7	59	89.8
Germany	222	92.8	222	0.9	222	8.6	222	2.7	222	2.3	222	1.4	222	91.0	222	96.8
Italy	17	100	17	0	17	5.9	17	0	17	5.9	17	0	17	100	17	100
Spain	13	100	13	0	13	23.1	13	15.4	13	15.4	13	0	13	92.3	13	100
Total (4 MSs)	**311**	**95.8**	**311**	**0.6**	**311**	**8.4**	**311**	**2.6**	**311**	**3.2**	**311**	**1.0**	**311**	**89.4**	**311**	**95.8**
Meat from pigs																
Denmark	21	85.7	21	0	21	0	21	0	21	0	21	0	21	76.2	21	85.7
Germany	38	84.2	38	0	38	5.3	38	5.3	38	2.6	38	2.6	38	94.7	38	94.7
Ireland	33	66.7	33	0	33	3.0	33	0	33	3.0	33	0	33	97.0	33	97.0
Total (3 MSs)	**92**	**78.3**	**92**	**0**	**92**	**3.3**	**92**	**2.2**	**92**	**2.2**	**92**	**1.1**	**92**	**91.3**	**92**	**93.5**

N = number of isolates tested.

% Res = percentage of resistant isolates.

Note: Includes data where fewer than four countries have reported.

4.3. Resistance in *S.* Infantis

4.3.1. In humans

There were 1,676 *S.* Infantis infections reported at the EU level in 2011, making it the fourth most common serovar (EFSA and ECDC, 2013). Data on the antimicrobial resistance of *S.* Infantis isolates were submitted by 16 MSs and Iceland for 2011. Overall resistance to ciprofloxacin in this serovar was 16.1 % (N=683) notably higher than for all non-typhoidal *Salmonella* isolates (9.1 %; N=24,126). This was due to high levels of resistance in Denmark (57.1 %; N=21) and in the United Kingdom (53.6 %; N=166), where more sensitive interpretative criteria for resistance (ECOFFs) were used. High overall levels of resistance to nalidixic acid (56.0 %; N=627), sulfonamides (53.7 %; N=562) and tetracyclines (51.3 %; N=573) were also observed. These results were attributable to the United Kingdom and Hungary, which together accounted for at least 60 % of the isolates of *S.* Infantis tested for susceptibility to these three antimicrobials (Table SAS3).

4.3.2. In *Gallus gallus*

Twelve MSs reported antimicrobial resistance data for isolates of *S.* Infantis from *Gallus gallus* in 2011, and eight also reported the production type of animals from which isolates were obtained (Table SAS4). The majority of isolates were from broilers and so the proportions presented under 'All *Gallus gallus*' are heavily weighted by the results from this production type. For this reason, the levels of resistance observed within these two sets of data were very similar.

Extremely high levels of resistance to sulfonamides and tetracyclines were observed among isolates from all *Gallus gallus* and from broilers specifically. In *Gallus gallus,* the level of resistance to sulfonamides reported at MS group level was 73.6 % and the level of resistance to tetracyclines was 70.9 %. For broilers, the eight MSs reported resistance levels of 87.9 % for sulfonamides and 86.4 % for tetracyclines. Similar results were observed for ciprofloxacin and nalidixic acid. For isolates of *S.* Infantis from all *Gallus gallus*, the levels of resistance to ciprofloxacin and nalidixic acid were 79.5 % and 79.1 %, respectively. For broilers the levels of resistance to these two compounds were 96.5 % for ciprofloxacin and 96.0 % for nalidixic acid. Low levels of resistance to ampicillin, cefotaxime, chloramphenicol and gentamicin were reported at the MS group level for all *Gallus gallus* and broilers specifically.

As observed with *Salmonella* spp., the levels of resistance among *S.* Infantis isolated from laying hens were lower than among isolates from broilers. At the MS group level, high levels of resistance to tetracyclines (25.0 %), sulfonamides (27.5 %), ciprofloxacin and nalidixic acid (both 27.5 %) were observed in isolates from laying hens. Hungary reported moderate resistance to gentamicin (10.5 %), while no resistance to this antimicrobial was observed among isolates tested by France, Italy, Latvia or Spain. No MS reported resistance to ampicillin, chloramphenicol or cefotaxime.

Table SAS3. Antimicrobial resistance in* Salmonella *Infantis from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Kanamycin	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	69	8.7	69	5.8	69	0	69	0	69	1.4	69	0
Denmark[1]	21	4.8	21	0	21	4.8	21	57.1	21	9.5	21	14.3
Estonia	21	9.5	21	0	21	0	22	0	21	0	21	0
Germany	62	6.5	62	1.6	-	-	62	0	62	0	62	0
Hungary	222	15.3	222	0.5	222	0.9	222	0.5	222	0.5	222	0.5
Ireland	6	NA	6	NA	6	NA	6	NA	6	NA	6	NA
Italy	25	24.0	24	4.2	6	NA	27	11.1	24	25.0	5	NA
Lithuania	34	2.9	25	0	12	0	29	0	12	0	11	0
Luxembourg	2	NA	2	NA	2	NA	2	NA	2	NA	2	NA
Malta	7	NA	-	-	-	-	7	NA	7	NA	-	-
Netherlands[1]	12	8.3	12	0	12	8.3	12	25.0	12	0	-	-
Romania	6	NA	6	NA	6	NA	6	NA	6	NA	6	NA
Slovakia	14	14.3	9	NA	2	NA	10	0	7	NA	-	-
Slovenia	10	10.0	10	0	10	0	10	0	10	0	10	0
Spain	12	0	12	0	12	0	12	0	12	0	12	0
United Kingdom	165	14.5	164	0.6	165	11.5	166	53.6	165	10.9	164	35.4
Total (16 MSs)	**688**	**13.2**	**665**	**1.4**	**566**	**4.2**	**683**	**16.1**	**658**	**6.2**	**611**	**10.3**
Iceland	1	NA	-	-	1	NA	1	NA	-	-	-	-

Table continued overleaf.

N = number of isolates tested.

% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable; if fewer than 10 isolates were tested, resistance was not calculated.

1. ECOFFs were used for interpretation.

Table SAS3 (continued). Antimicrobial resistance in* Salmonella *Infantis from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Nalidixic acid		Streptomycin		Sulfonamides		Tetracyclines		Trimethoprim	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	69	53.6	69	42.0	69	40.6	69	49.3	69	4.3
Denmark[1]	21	57.1	21	47.6	21	47.6	21	42.9	21	33.3
Estonia	19	5.3	21	14.3	21	9.5	21	9.5	21	9.5
Germany	62	9.7	62	16.1	-	-	-	-	62	4.8
Hungary	222	79.3	222	35.1	222	70.3	222	59.5	222	1.4
Ireland	6	NA	6	NA	6	NA	6	NA	6	NA
Italy	8	NA	5	NA	5	NA	10	20.0	23	8.7
Lithuania	12	0	12	8.3	12	0	11	9.1	34	2.9
Luxembourg	2	NA	2	NA	2	NA	2	NA	2	NA
Malta	-	-	-	-	-	-	-	-	7	NA
Netherlands[1]	12	25.0	12	41.7	12	33.3	12	33.3	-	-
Romania	6	NA	6	NA	6	NA	6	NA	6	NA
Slovakia	-	-	-	-	-	-	7	NA	-	-
Slovenia	10	70.0	10	40.0	10	50.0	10	50.0	10	0
Spain	12	8.3	12	0	12	0	12	0	12	0
United Kingdom	166	59.0	165	1.2	164	54.3	164	56.1	166	39.2
Total (16 MSs)	**627**	**56.0**	**625**	**23.4**	**562**	**53.7**	**573**	**51.3**	**661**	**14.2**
Iceland	1	NA	-	-	-	-	-	-	1	NA

N = number of isolates tested.

% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable; if fewer than 10 isolates were tested, resistance was not calculated.

1. ECOFFs were used for interpretation.

Table SAS4. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Infantis from* Gallus gallus *in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
All *Gallus gallus*																
Austria	32	0	32	0	32	0	32	100	32	0	32	100	32	100	32	100
Denmark	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
France	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
Germany	9	33.3	9	0	9	11.1	9	22.2	9	0	9	22.2	9	55.6	9	22.2
Greece	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
Hungary	154	5.2	154	1.9	154	5.2	154	93.5	154	1.9	154	92.9	154	83.1	154	80.5
Italy	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0
Latvia	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
Netherlands	10	10.0	10	10.0	10	0	10	20	10	0	10	20	10	20	10	10.0
Slovakia	24	4.2	24	0	24	0	24	100	24	4.2	24	100	24	95.8	24	100
Spain	15	0	15	0	15	0	15	6.7	15	0	15	6.7	15	0	15	0
United Kingdom	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Total (12 MSs)	**258**	**5.0**	**258**	**1.6**	**258**	**3.5**	**258**	**79.5**	**258**	**1.6**	**258**	**79.1**	**258**	**73.6**	**258**	**70.9**
Broilers																
Austria	32	0	32	0	32	0	32	100	32	0	32	100	32	100	32	100
Denmark	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
Germany	3	33.3	3	0	3	33.3	3	66.7	3	0	3	66.7	3	100	3	66.7
Hungary	135	5.9	135	2.2	135	5.9	135	99.3	135	0.7	135	98.5	135	86.7	135	84.4
Italy	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Slovakia	24	4.2	24	0	24	0	24	100	24	4.2	24	100	24	95.8	24	100
Spain	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
United Kingdom	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Total (8 MSs)	**199**	**5.0**	**199**	**1.5**	**199**	**4.5**	**199**	**96.5**	**199**	**1.0**	**199**	**96.0**	**199**	**87.9**	**199**	**86.4**
Laying hens																
France	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
Hungary	19	0	19	0	19	0	19	52.6	19	10.5	19	52.6	19	57.9	19	52.6
Italy	3	0	3	0	3	0	3	0	3	0	3	0	3	0	3	0
Latvia	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
Spain	14	0	14	0	14	0	14	7.1	14	0	14	7.1	14	0	14	0
Total (5 MSs)	**40**	**0**	**40**	**0**	**40**	**0**	**40**	**27.5**	**40**	**5.0**	**40**	**27.5**	**40**	**27.5**	**40**	**25.0**

N = number of isolates tested.

% Res = percentage of resistant isolates.

Note: Includes data where fewer than 10 isolates have been tested.

Note: Data reported under 'All *Gallus gallus*' include data which have been reported by production level.

4.4. Resistance in *S.* Virchow

4.4.1. In humans

S. Virchow was the ninth most commonly isolated *Salmonella* serovar in Europe in 2011 with 467 cases (EFSA and ECDC, 2013). *S.* Virchow resistance data was submitted by 16 MSs and Iceland for 2011, however Denmark and the United Kingdom accounted for over 80 % of the data for all antimicrobials. There were high levels of resistance to ciprofloxacin (45.6 %; N=204) and trimethoprim (35.0 %; N=203), and very high resistance to nalidixic acid (54.8 %; N=199), when compared to all non-typhoidal *Salmonella* isolates (Table SAS5).

4.4.2. In *Gallus gallus*

Seven MSs reported antimicrobial resistance data on isolates of *S.* Virchow from *Gallus gallus* in 2011, and six of these provided information on the production type from which the isolates were obtained (Table SAS6). Overall the number of isolates tested was low with only two MSs testing more than 10 isolates.

Considering overall levels of resistance at MS group level among isolates from all *Gallus gallus*, low levels of resistance were reported for ampicillin (8.3 %) and tetracyclines (4.2 %), and moderate levels of resistance were reported for sulfonamides (10.4 %) and gentamicin (12.5 %). Resistance to ciprofloxacin and nalidixic acid among isolates from *Gallus gallus* was detected only by three MSs, where it ranged from 83.3 % to 100 %. Overall levels within the reporting MSs group were 79.2 % for ciprofloxacin and 77.1 % for nalidixic acid. No resistance to either cefotaxime or chloramphenicol was observed among isolates of *S.* Virchow in 2011.

Four MSs reported antimicrobial data on isolates of *S.* Virchow from broilers in 2011. Only 11 isolates were tested overall, so the resistance levels presented should be interpreted with caution. Only Ireland and Spain detected any resistance to selected antimicrobials among the isolates tested. A low level of resistance to tetracyclines was reported across the MS group (9.1 %), and this was due to a single resistant isolate reported by Ireland. A moderate level of resistance was reported for ampicillin at the MS group level (18.2 %), whereas high levels of resistance to sulfonamides (36.4 %) and gentamicin (45.5 %) were reported. All isolates of *S.* Virchow tested by Ireland and Spain (one and eight, respectively) were resistant to ciprofloxacin and nalidixic acid. No MSs reported resistance to chloramphenicol or cefotaxime.

Four MSs reported antimicrobial data on isolates of *S.* Virchow from laying hens in 2011 and, as for broilers, only 11 isolates were tested overall. Resistance to tetracyclines was low overall, with only France reporting any resistance, in one of the five isolates tested. A moderate level of resistance to ampicillin was observed at MS group level (18.2 %), while no resistance was reported for sulfonamides, gentamicin, chloramphenicol or cefotaxime. Only Spain reported resistance to ciprofloxacin and nalidixic acid, with three out of four and two out of four isolates, respectively, testing positive.

Table SAS5. Antimicrobial resistance in* Salmonella *Virchow from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Kanamycin	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	13	15.4	13	0	13	0	13	0	13	7.7	13	0
Denmark[1]	17	29.4	17	5.9	17	5.9	17	70.6	17	23.5	17	5.9
Estonia	1	NA	1	NA	1	NA	1	NA	1	NA	1	NA
Germany	7	NA	7	NA	-	-	7	NA	7	NA	7	NA
Greece	1	NA	-	-	1	NA	1	NA	-	-	1	NA
Ireland	2	NA	2	NA	2	NA	2	NA	2	NA	2	NA
Italy	2	NA	-	-	-	-	-	-	1	NA	-	-
Latvia	2	NA	2	NA	2	NA	-	-	-	-	-	-
Luxembourg	1	NA	1	NA	1	NA	1	NA	1	NA	1	NA
Malta	4	NA	-	-	-	-	4	NA	4	NA	-	-
Netherlands[1]	1	NA	1	NA	1	NA	1	NA	1	NA	-	-
Romania	4	NA	4	NA	4	NA	4	NA	4	NA	4	NA
Slovakia	1	NA	-	-	1	NA	-	-	1	NA	-	-
Slovenia	3	NA	3	NA	3	NA	3	NA	3	NA	3	NA
Spain	4	NA	4	NA	4	NA	4	NA	4	NA	4	NA
United Kingdom	146	17.1	145	0	145	0	146	52.1	146	23.3	145	2.1
Total (16 MSs)	**209**	**20.6**	**200**	**0.5**	**195**	**0.5**	**204**	**45.6**	**205**	**22.4**	**198**	**2.5**
Iceland	1	NA	-	-	1	NA	1	NA	-	-	-	-

Table continued overleaf.

N = number of isolates tested.

% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable; if fewer than 10 isolates were tested, resistance was not calculated.

1. ECOFFs were used for interpretation.

Table SAS5 (continued). Antimicrobial resistance in* Salmonella *Virchow from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Nalidixic acid		Streptomycin		Sulfonamides		Tetracyclines		Trimethoprim	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	13	38.5	13	7.7	13	7.7	13	7.7	13	7.7
Denmark[1]	17	70.6	17	29.4	17	41.2	17	41.2	17	41.2
Estonia	1	NA	1	NA	1	NA	1	NA	1	NA
Germany	7	NA	7	NA	-	-	-	-	7	NA
Greece	1	NA	1	NA	-	-	1	NA	-	-
Ireland	2	NA	2	NA	2	NA	2	NA	2	NA
Italy	-	-	-	-	-	-	-	-	2	NA
Latvia	-	-	-	-	-	-	-	-	-	-
Luxembourg	1	NA	1	NA	1	NA	1	NA	1	NA
Malta	-	-	-	-	-	-	-	-	4	NA
Netherlands[1]	1	NA	1	NA	1	NA	1	NA	-	-
Romania	4	NA	4	NA	4	NA	4	NA	4	NA
Slovakia	-	-	-	-	-	-	-	-	-	-
Slovenia	3	NA	3	NA	3	NA	3	NA	3	NA
Spain	4	NA	4	NA	4	NA	4	NA	4	NA
United Kingdom	145	53.1	145	13.1	145	36.6	145	34.5	145	35.9
Total (16 MSs)	**199**	**54.8**	**199**	**15.1**	**191**	**34.0**	**192**	**32.3**	**203**	**35.0**
Iceland	1	NA	-	-	-	-	-	-	1	NA

N = number of isolates tested.

% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable, if fewer than 10 isolates were tested, resistance was not calculated.

1. ECOFFs were used for interpretation.

Table SAS6. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Virchow from* Gallus gallus *in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
All *Gallus gallus*																
France	5	20.0	5	0	5	0	5	0	5	0	5	0	5	0	5	20.0
Germany	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Ireland	1	100	1	0	1	0	1	100	1	100	1	100	1	100	1	100
Italy	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
Poland	26	0	26	0	26	0	26	100	26	3.8	26	100	26	3.8	26	0
Spain	12	16.7	12	0	12	0	12	91.7	12	33.3	12	83.3	12	25.0	12	0
United Kingdom	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Total (7 MSs)	**48**	**8.3**	**48**	**0**	**48**	**0**	**48**	**79.2**	**48**	**12.5**	**48**	**77.1**	**48**	**10.4**	**48**	**4.2**
Broilers																
Germany	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Ireland	1	100	1	0	1	0	1	100	1	100	1	100	1	100	1	100
Italy	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Spain	8	12.5	8	0	8	0	8	100	8	50.0	8	100	8	37.5	8	0
Total (4 MSs)	**11**	**18.2**	**11**	**0**	**11**	**0**	**11**	**81.8**	**11**	**45.5**	**11**	**81.8**	**11**	**36.4**	**11**	**9.1**
Laying hens																
France	5	20.0	5	0	5	0	5	0	5	0	5	0	5	0	5	20.0
Italy	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Spain	4	25.0	4	0	4	0	4	75.0	4	0	4	50.0	4	0	4	0
United Kingdom	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Total (4 MSs)	**11**	**18.2**	**11**	**0**	**11**	**0**	**11**	**27.3**	**11**	**0**	**11**	**18.2**	**11**	**0**	**11**	**9.1**

N = number of isolates tested.

% Res = percentage of resistant isolates.

Note: Includes data where fewer than 10 isolates have been tested and fewer than four countries have reported.

Note: Data reported under 'All *Gallus gallus*' include data which have been reported by production level.

4.5. Resistance in *S*. Hadar in *Gallus gallus*

Only three MSs reported quantitative MIC data on antimicrobial resistance among *S.* Hadar from *Gallus gallus* in 2011 (Table SAS7). All three countries provided information on the production type of the birds; Austria only tested only broilers while Italy and Spain tested broilers as well as laying hens and breeding flocks. Only 23 isolates of *S*. Hadar were tested in total, with fewer than 10 tested in each country. Roughly three-quarters of the isolates were from broilers.

All 23 *S.* Hadar isolates from *Gallus gallus* were resistant to ciprofloxacin and nalidixic acid. However, no resistance was detected against cefotaxime, chloramphenicol or sulfonamides. All of the isolates from Austria and Italy were resistant to ampicillin and tetracyclines. In contrast, only one and four, respectively, of the six isolates from Spain were resistant to these antimicrobials, respectively. Thus, the overall occurrence of resistance at the reporting MS group level was extremely high, at 78.3 % for ampicillin and 91.3 % for tetracyclines. Austria and Spain reported full sensitivity to gentamicin whereas Italy reported resistance in one of the eight isolates tested, resulting in a low overall level of resistance at the reporting MS group level of 4.3 %.

As most of the isolates from *Gallus gallus* were from broilers, the results for this production type are very similar to those for *Gallus gallus* as a whole. None of the isolates from broilers in Spain was resistant to ampicillin, and only one out of three isolates was resistant to tetracyclines. However, broilers accounted for a smaller proportion of the *Gallus gallus* isolates in Spain than in the other two countries, both of which showed full resistance to these antimicrobials. Therefore, the overall occurrence of resistance to ampicillin at the reporting MS group level was actually slightly higher in broilers than in *Gallus gallus,* at 83.3 %; however, for tetracyclines, it was slightly lower at 88.9 %. With respect to gentamicin, one of the six *S.* Hadar isolates from broilers in Italy was resistant, resulting in an overall reporting MS group level resistance of 5.6 %.

Italy and Spain each tested a single isolate of *S*. Hadar from laying hens. Both of these isolates expressed resistance to ampicillin, ciprofloxacin, nalidixic acid and tetracyclines, but none of the other antimicrobials.

Table SAS7. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Hadar from* Gallus gallus *in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
All *Gallus gallus*																
Austria	9	100	9	0	9	0	9	100	9	0	9	100	9	0	9	100
Italy	8	100	8	0	8	0	8	100	8	12.5	8	100	8	0	8	100
Spain	6	16.7	6	0	6	0	6	100	6	0	6	100	6	0	6	66.7
Total (3 MSs)	**23**	**78.3**	**23**	**0**	**23**	**0**	**23**	**100**	**23**	**4.3**	**23**	**100**	**23**	**0**	**23**	**91.3**
Broilers																
Austria	9	100	9	0	9	0	9	100	9	0	9	100	9	0	9	100
Italy	6	100	6	0	6	0	6	100	6	16.7	6	100	6	0	6	100
Spain	3	0	3	0	3	0	3	100	3	0	3	100	3	0	3	33.3
Total (3 MSs)	**18**	**83.3**	**18**	**0**	**18**	**0**	**18**	**100**	**18**	**5.6**	**18**	**100**	**18**	**0**	**18**	**88.9**
Laying hens																
Italy	1	100	1	0	1	0	1	100	1	0	1	100	1	0	1	100
Spain	1	100	1	0	1	0	1	100	1	0	1	100	1	0	1	100
Total (2 MSs)	**2**	**100**	**2**	**0**	**2**	**0**	**2**	**100**	**2**	**0**	**2**	**100**	**2**	**0**	**2**	**100**

N = number of isolates tested.

% Res = percentage of resistant isolates.

Note: Includes data where fewer than 10 isolates have been tested and fewer than four countries have reported.

Note: Data reported under 'All *Gallus gallus*' include data which have been reported by production level.

4.6. Resistance in *S.* Newport

There were 831 cases of S. *Newport infection in humans in the EU in 2010, rendering it the fifth most common cause of salmonellosis, responsible for 0.9 % of cases (EFSA and ECDC, 2012). In addition, there were two strong evidence outbreaks involving 16 cases. In 2010,* S. *Newport was the second most commonly reported (13.6 %) serovar isolated from turkey meat and the third most common serovar (3.7 %) in turkeys.* S. *Newport was one of the most common serovars to express multi-drug resistance among all* Salmonella *isolates collected via routine surveillance of British turkeys between 1995 and 2006 (Papadopoulou et al., 2009).* S. *Newport is one of the serovars which can acquire pentavalent resistance (to ampicillin, chloramphenicol, streptomycin, sulfonamides, tetracyclines) (Velge et al., 2005), although isolates reported from turkeys in 2011 were susceptible to chloramphenicol.*

4.6.1. In humans

A total of 771 *S.* Newport cases were reported at the EU level in 2011, making this the fifth most commonly isolated serovar in 2011 (EFSA and ECDC, 2013). Data on the antimicrobial resistance of *S.* Newport isolates were submitted by 14 MSs for 2011. Overall resistance to all antimicrobials was lower than for non-typhoidal *Salmonella* isolates, most notably ampicillin (7.5 %; N=358), nalidixic acid (1.7 %; N=348) and tetracyclines (8.1 %; N=283). At least 50 % of all *S.* Newport data were submitted by the United Kingdom for all antimicrobials (Table SAS8).

Table SAS8. Antimicrobial resistance in* Salmonella *Newport from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Kanamycin	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	16	25.0	16	12.5	16	18.8	16	0	16	0	16	6.3
Denmark[1]	16	0	16	0	16	0	16	0	16	0	16	0
Germany	64	4.7	64	1.6	-	-	64	0	64	0	64	0
Greece	6	NA	-	-	6	NA	6	NA	-	-	6	NA
Ireland	10	0	10	0	10	0	10	0	10	0	10	0
Italy	9	NA	4	NA	3	NA	9	NA	7	NA	1	NA
Lithuania	1	NA	1	NA	-	-	1	NA	-	-	-	-
Malta	2	NA	-	-	-	-	2	NA	2	NA	-	-
Netherlands[1]	27	7.4	27	0	27	0	27	0	27	0	-	-
Romania	1	NA	1	NA	1	NA	1	NA	1	NA	1	NA
Slovakia	1	NA	-	-	-	-	-	-	-	-	-	-
Slovenia	1	NA	1	NA	1	NA	1	NA	1	NA	1	NA
Spain	24	8.3	24	0	24	0	24	0	24	0	24	0
United Kingdom	180	3.9	179	0.6	180	1.7	181	1.7	180	1.7	179	2.2
Total (14 MSs)	**358**	**7.5**	**343**	**1.2**	**284**	**2.1**	**358**	**0.8**	**348**	**2.3**	**318**	**1.6**

Table continued overleaf.

N = number of isolates tested.

% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable; if fewer than 10 isolates were tested, resistance was not calculated.

1. ECOFFs were used for interpretation.

Table SAS8 (continued). Antimicrobial resistance in* Salmonella *Newport from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Nalidixic acid		Streptomycin		Sulfonamides		Tetracyclines		Trimethoprim	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	16	6.3	16	18.8	16	37.5	16	43.8	16	25.0
Denmark[1]	16	0	16	6.3	16	6.3	16	6.3	16	6.3
Germany	64	3.1	64	1.6	-	-	-	-	64	0
Greece	6	NA	6	NA	-	-	6	NA	-	-
Ireland	10	10.0	10	0	10	0	10	0	10	0
Italy	3	NA	1	NA	1	NA	3	NA	8	NA
Lithuania	-	-	-	-	-	-	-	-	1	NA
Malta	-	-	-	-	-	-	-	-	2	NA
Netherlands[1]	27	0	27	14.8	27	3.7	27	3.7	-	-
Romania	1	NA	1	NA	1	NA	1	NA	1	NA
Slovakia	-	-	-	-	-	-	-	-	-	-
Slovenia	1	NA	1	NA	1	NA	1	NA	1	NA
Spain	24	0	24	4.2	24	0	24	4.2	24	0
United Kingdom	180	1.7	180	1.7	179	4.5	179	5.6	181	3.3
Total (14 MSs)	**348**	**2.0**	**346**	**3.8**	**275**	**6.5**	**283**	**8.1**	**324**	**5.2**

N = number of isolates tested.

% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable; if fewer than 10 isolates were tested, resistance was not calculated.

1. ECOFFs were used for interpretation.

4.6.2. In turkeys

Five MSs reported antimicrobial resistance data for isolates of *S.* Newport from turkeys in 2011 (Table SAS9). It should be noted when interpreting the data that all five MSs tested a relatively low number of isolates. Across the reporting MSs, a high level of resistance to ampicillin was reported (54.7 %). The level of resistance differed substantially between the MSs with France reporting no resistance and Hungary reporting ampicillin resistance in all of the seven isolates tested. The United Kingdom was the only country to report resistance to tetracyclines out of those testing more than 10 isolates, and this was observed at a high level (29.4 %). Poland reported a low level of resistance to sulfonamides among isolates of *S.* Newport from turkeys (6.3 %) while an extremely high level of resistance to sulfonamides was reported by the United Kingdom (88.2 %). All MSs excluding Italy detected resistance to ciprofloxacin and nalidixic acid and the overall levels of resistance for the reporting MS group were high for both antimicrobials (37.5 % for ciprofloxacin and 25.0 % for nalidixic acid). None of the reporting MSs detected resistance to cefotaxime, chloramphenicol or gentamicin among isolates of *S.* Newport from turkeys.

Table SAS9. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Newport from turkeys in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin	
	N	% Res	N	% Res	N	% Res	N	% Res
Belgium	103	78.6	103	0	103	13.6	103	3.9
Denmark	28	60.7	28	0	28	17.9	28	0
Germany	20	90.0	20	0	20	40.0	20	10.0
Hungary	12	75.0	12	0	12	33.3	12	8.3
Ireland	57	70.2	57	0	57	38.6	57	7.0
Italy	12	58.3	12	0	12	16.7	12	25.0
Romania	18	77.8	18	0	18	27.8	18	33.3
Total (7 MSs)	**250**	**74.4**	**250**	**0**	**250**	**24.0**	**250**	**8.0**

Country	Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res
Belgium	103	0	103	1.9	103	53.4	103	41.7
Denmark	28	0	28	0	28	60.7	28	50.0
Germany	20	0	20	10.0	20	85.0	20	75.0
Hungary	12	0	12	0	-	-	12	58.3
Ireland	57	1.8	57	7.0	57	82.5	57	82.5
Italy	12	8.3	12	33.3	12	58.3	12	75.0
Romania	18	0	18	22.2	18	72.2	18	72.2
Total (7 MSs)	**250**	**0.8**	**250**	**6.4**	**250**	**62.4**	**250**	**59.2**

N = number of isolates tested.

% Res = percentage of resistant isolates.

4.7. Resistance in *S.* Kentucky

In 2010, there were 780 reported cases of human salmonellosis due to S. Kentucky within the EU, which was an increase of 69.6 % relative to the number in 2009, and this serovar accounted for 0.8 % of all human cases of salmonellosis (EFSA and ECDC, 2012). S. Kentucky was the second most frequently reported serovar isolated from broiler meat in 2010 (5.7 % of Salmonella *isolates) and this was largely due to the high prevalence reported by Ireland (EFSA and ECDC, 2012). Isolates of S. Kentucky which possess either an ESBL (SHV-12) or an AmpC (CMY2) enzyme have recently been reported from broilers in Ireland (Boyle et al., 2010) and these were found to be related at the molecular level to pan-susceptible S. Kentucky isolates from human, poultry and environmental sources. The cephalosporin resistant S. Kentucky isolates detected in Irish poultry possessed either an ESBL (SHV-12) or an AmpC (CMY2) enzyme. These isolates differ from those causing travel-associated S. Kentucky infections in humans, which generally show ESBL resistance through possession of CTX-M-1, as well as resistance to ciprofloxacin and trimethoprim/ sulfonamides (Collard et al., 2007).*

S. Kentucky also made up 7.5 % of Salmonella *isolates from turkey meat in the EU in 2010 (EFSA and ECDC, 2012), with Ireland reporting a high proportion of these isolates. However, isolates of S. Kentucky have also recently been described in turkeys, turkey neck skin and turkey products in Poland (Wasyl and Hoszowski, 2012). In these Polish isolates, the most commonly observed resistance profile was ampicillin, streptomycin, sulfonamides, tetracyclines, gentamicin, nalidixic acid and ciprofloxacin, occurring in 68 % (49/72) of isolates. It was found that 89 % of the 72 isolates examined were resistant to both nalidixic acid and ciprofloxacin, with the unusual feature that the ciprofloxacin MIC was high at ≥8 mg/L in almost all resistant isolates. The most frequently observed pulsed-field gel electrophoresis (PFGE) pattern exhibited by the Polish S. Kentucky isolates was indistinguishable from that observed in S. Kentucky ST198 by Le Hello et al. (2011), who described the international spread of S. Kentucky ST198 resistant to ciprofloxacin in humans. Between 2002 and 2008, there were about 500 human infections in France, England, Wales, Denmark and the USA caused by multidrug-resistant S. Kentucky isolates displaying high-level resistance to ciprofloxacin (Le Hello et al., 2011). These isolates belonged to a single clone referred to as ST198-X1. Since 2010, this clone has also been recorded in turkey meat products in Germany (Beutlich et al., 2012).*

4.7.1. In humans

In 2011, a total of 559 *S.* Kentucky cases were reported to the EU level, making this serotype the seventh most commonly isolated serovar in 2011 (EFSA and ECDC, 2013). Fourteen MSs and Iceland submitted data on *S.* Kentucky. Overall, resistance levels to all antimicrobials, except cefotaxime, were very high to extremely high when compared with all non-typhoidal *Salmonella* isolates. This was most notable for ampicillin (66.2%; N=222), ciprofloxacin (81.5 %; N=222), gentamicin (59.7 %; N=221) and nalidixic acid (84.3 %; N=216). For all antimicrobials, over 57 % of all *S.* Kentucky data were submitted from the United Kingdom (Table SAS10).

Table SAS10. Antimicrobial resistance in* Salmonella *Kentucky from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Kanamycin	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	14	100	14	0	14	0	14	92.9	14	78.6	14	7.1
Denmark[1]	16	50.0	16	0	16	18.8	16	93.8	16	81.3	16	6.3
Estonia	1	NA	1	NA	1	NA	1	NA	1	NA	1	NA
Germany	20	90.0	20	0	-	-	20	95.0	20	75.0	20	5.0
Ireland	4	NA	4	NA	4	NA	4	NA	4	NA	4	NA
Italy	2	NA	2	NA	1	NA	2	NA	1	NA	1	NA
Lithuania	1	NA	1	NA	1	NA	1	NA	1	NA	1	NA
Luxembourg	1	NA	1	NA	1	NA	1	NA	1	NA	1	NA
Malta	5	NA	-	-	-	-	5	NA	5	NA	-	-
Netherlands[1]	14	71.4	14	0	14	0	14	85.7	14	71.4	-	-
Romania	1	NA	1	NA	1	NA	1	NA	1	NA	1	NA
Slovenia	1	NA	1	NA	1	NA	1	NA	1	NA	1	NA
Spain	14	64.3	14	0	14	0	14	85.7	14	57.1	14	0
United Kingdom	128	63.3	128	0.8	128	11.7	128	79.7	128	50.8	128	10.9
Total (14 MSs)	**222**	**66.2**	**217**	**0.5**	**196**	**9.2**	**222**	**81.5**	**221**	**59.7**	**202**	**8.9**
Iceland	2	NA	-	-	2	NA	2	NA	-	-	-	-

Table continued overleaf.

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

NA = not applicable; if fewer than 10 isolates were tested, resistance was not calculated.

1. ECOFFs were used for interpretation.

Table SAS10 (continued). Antimicrobial resistance in* Salmonella *Kentucky from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Nalidixic acid		Streptomycin		Sulfonamides		Tetracyclines		Trimethoprim	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	14	100	14	78.6	14	85.7	14	85.7	14	14.3
Denmark[1]	16	93.8	16	75.0	16	87.5	16	93.8	16	31.3
Estonia	1	NA	1	NA	1	NA	1	NA	1	NA
Germany	20	100	20	85.0	-	-	-	-	20	10.0
Ireland	4	NA	4	NA	4	NA	4	NA	4	NA
Italy	1	NA	1	NA	1	NA	1	NA	2	NA
Lithuania	1	NA	1	NA	1	NA	1	NA	1	NA
Luxembourg	1	NA	1	NA	1	NA	1	NA	1	NA
Malta	-	-	-	-	-	-	-	-	5	NA
Netherlands[1]	14	85.7	14	71.4	14	85.7	14	85.7	-	-
Romania	1	NA	1	NA	1	NA	1	NA	1	NA
Slovenia	1	NA	1	NA	1	NA	1	NA	1	NA
Spain	14	85.7	14	57.1	14	7.1	14	71.4	14	0
United Kingdom	128	78.9	128	14.1	128	68.8	128	71.9	128	14.8
Total (14 MSs)	**216**	**84.3**	**216**	**38.0**	**196**	**68.9**	**196**	**76.0**	**208**	**13.9**
Iceland	2	NA	-	-	-	-	-	-	2	NA

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

NA = not applicable;, if fewer than 10 isolates were tested, resistance was not calculated.

1. ECOFFs were used for interpretation.

4.7.2. In poultry

Eight MSs reported antimicrobial resistance data for *S.* Kentucky isolates in 2011 (Table SAS11). Only Ireland and Italy reported data for more than 10 isolates from *Gallus gallus*, while Hungary and Poland reported data for mor than 10 isolates from turkeys.

For *Gallus gallus,* moderate to high levels of resistance to sulfonamides (16.7 %), tetracyclines (20.8 %) and ampicillin (41.7 %) were reported by Italy, while Ireland reported low levels of resistance to all three compounds (3.6 %, 1.8 % and 3.6 %, respectively). Low levels of resistance were reported for both chloramphenicol and gentamicin at the reporting MS group level (6.5 % for gentamicin and 3.3 % for chloramphenicol). A high level of resistance to ciprofloxacin or nalidixic acid was reported among isolates of *S.* Kentucky from *Gallus gallus* at the reporting MS group level (28.3 % for both compounds). Both Ireland and Italy detected a low level of resistance to cefotaxime (1.8 % and 8.3 %, respectively); whilst no resistance was reported by the remaining MSs.

For isolates of *S.* Kentucky from turkeys, extremely high levels of resistance were observed for ampicillin (94.1 %) and sulfonamides (90.2 %) across the reporting MS group. Hungary also reported an extremely high level of resistance to tetracyclines (94.1 %) while one of the two isolates tested by Slovakia was resistant and no resistance was observed among isolates from Poland. None of the reporting MSs detected resistance to cefotaxime or chloramphenicol, but all three reported extremely high levels of resistance to gentamicin (90.2 % overall). Extremely high levels of resistance were also reported for ciprofloxacin and nalidixic acid at the MS group level (94.1 % for both compounds overall). All of the isolates tested by Hungary were resistant to the (fluoro-)quinolones.

Table SAS11. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Kentucky from poultry in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin	
	N	% Res	N	% Res	N	% Res	N	% Res
Gallus gallus								
Denmark	3	0	3	0	3	0	3	0
France	1	0	1	0	1	0	1	0
Hungary	3	33.3	3	0	3	0	3	33.3
Ireland	55	3.6	55	1.8	55	0	55	0
Italy	24	41.7	24	8.3	24	12.5	24	87.5
Slovakia	1	100	1	0	1	0	1	100
Spain	5	20.0	5	0	5	0	5	60.0
Total (7 MSs)	**92**	**16.3**	**92**	**3.3**	**92**	**3.3**	**92**	**28.3**
Turkeys								
Hungary	34	97.1	34	0	34	0	34	100
Poland	15	86.7	15	0	15	0	15	86.7
Slovakia	2	100	2	0	2	0	2	50.0
Total (3 MSs)	**51**	**94.1**	**51**	**0**	**51**	**0**	**51**	**94.1**

Table continued overleaf.

N = number of isolates tested.

% Res = percentage of resistant isolates.

Note: Includes data where fewer than 10 isolates have been tested and fewer than four countries have reported.

Table SAS11 (continued). Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Kentucky from poultry in 2011, using harmonised epidemiological cut-off values

Country	Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res
Gallus gallus								
Denmark	3	0	3	0	3	0	3	0
France	1	0	1	0	1	0	1	0
Hungary	3	33.3	3	33.3	3	66.7	3	100
Ireland	55	0	55	0	55	3.6	55	1.8
Italy	24	8.3	24	87.5	24	16.7	24	20.8
Slovakia	1	100	1	100	1	100	1	100
Spain	5	40.0	5	60.0	5	60.0	5	40.0
Total (7 MSs)	**92**	**6.5**	**92**	**28.3**	**92**	**13.0**	**92**	**13.0**
Turkeys								
Hungary	34	94.1	34	100	34	94.1	34	94.1
Poland	15	86.7	15	86.7	15	86.7	15	0
Slovakia	2	50.0	2	50.0	2	50.0	2	50.0
Total (3 MSs)	**51**	**90.2**	**51**	**94.1**	**51**	**90.2**	**51**	**64.7**

N = number of isolates tested.

% Res = percentage of resistant isolates.

Note: Includes data where fewer than 10 isolates have been tested and fewer than four countries have reported.

4.8. Resistance in *S.* Derby

There were 665 cases of salmonellosis attributable to S. Derby in 2010, which is comparable to the number reported in 2009, and rendered S. Derby the eighth most commonly reported serovar. In the EU-wide baseline survey of holdings with breeding pigs conducted in 2008 (EFSA, 2008c), S. Derby was the most frequently isolated serovar from both breeding and production holdings, detected in 29.6 % and 28.5 % of the Salmonella*-positive holdings, respectively. The resulting estimated EU prevalence of positive breeding and production holdings was 8.9 % and 9.0 %, respectively. This serovar was also the second most commonly isolated serovar from pig meat in the EU in 2010, accounting for 16.2 % of* Salmonella *isolates from this source.*

A recent study in Germany (Hauser et al., 2011) examined 82 epidemiologically unrelated isolates of S. Derby recovered from pigs, pork and humans over 2006–2008 and found 72 % of isolates to be fully-susceptible, while the remaining isolates were resistant only to tetracyclines or multiply-resistant with different resistance profiles. S. Derby has also been detected with Salmonella *genomic island 1, which can confer resistance to ampicillin, chloramphenicol, streptomycin, sulfonamides and tetracyclines (Beutlich et al., 2011).*

4.8.1. In humans

S. Derby was the sixth most commonly reported *Salmonella* serovar at the EU level in 2011, accounting for 704 cases of salmonellosis (EFSA and ECDC, 2013). *S.* Derby resistance data were submitted by 14 MSs for 2011. High overall resistance to tetracyclines was observed (43.4 %; N=122), particularly in Spain (64.3 %; N=14) and Italy (47.1 %; N=34). There was low overall resistance to ampicillin (9.9 %; N=232), ciprofloxacin (1.3 %; N=237) and nalidixic acid (3.1 %; N=193) compared with all non-typhoidal *Salmonella* isolates (Table SAS12).

4.8.2. In pigs

In 2011, eight MSs reported antimicrobial resistance data for *S.* Derby from pigs, but three MSs tested fewer than 10 isolates each (Table SAS13). More than half of the isolates were tested by Denmark, so its results will have a large influence on those for the reporting MS group as a whole.

Overall, there was a high level of resistance to tetracyclines (39.4 %) and sulfonamides (31.8 %), with resistance levels in the individual countries ranging between 32.3 % and 92.3 % for the former and between 15.5 % and 75.0 % for the latter. For ampicillin, there was a moderate level of resistance of 14.7 % at the reporting MS group level. Estonia (three isolates), Spain (13 isolates) and Sweden (one isolate) reported full sensitivity to this antimicrobial, but the other countries reported between 9.5 % and 37.5 % resistance. Similarly, Estonia, Spain and Sweden, each with the same number of isolates reported for ampicillin, and the Netherlands (reporting three isolates) reported no resistance to chloramphenicol. The other countries reported levels between 4.1 % and 43.8 %, resulting in an overall level of 8.1 %. Concerning ciprofloxacin and nalidixic acid, Germany reported 8.1 % resistance to both and Italy reported 7.7 % resistance to both, resulting in a low overall level of 2.3 % for both antimicrobials. Resistance to gentamicin was low (1.5 %) at the reporting MS group level, with most MSs reporting full sensitivity and Denmark, Hungary and Italy reporting low levels of resistance. Germany was the only country to report resistance to cefotaxime (4.8 %), so overall resistance at the reporting MS group level was low at 1.2 %.

Table SAS12. Antimicrobial resistance in* Salmonella *Derby from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Kanamycin	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	5	NA	5	NA	5	NA	5	NA	5	NA	5	NA
Denmark[1]	12	16.7	12	0	12	0	12	0	12	0	12	0
Estonia	3	NA	3	NA	3	NA	3	NA	3	NA	3	NA
Germany	72	4.2	72	1.4	-	-	72	0	72	1.4	72	2.8
Greece	2	NA	-	-	2	NA	2	NA	-	-	2	NA
Ireland	2	NA	2	NA	2	NA	2	NA	2	NA	2	NA
Italy	69	18.8	66	1.5	33	6.1	74	4.1	54	25.9	23	0
Lithuania	5	NA	5	NA	3	NA	5	NA	3	NA	3	NA
Netherlands[1]	10	0	10	0	10	0	10	0	10	0	-	-
Romania	7	NA	7	NA	7	NA	7	NA	7	NA	7	NA
Slovakia	2	NA	1	NA	2	NA	1	NA	1	NA	-	-
Slovenia	1	NA	1	NA	1	NA	1	NA	1	NA	1	NA
Spain	14	0	14	0	14	7.1	14	0	14	7.1	14	0
United Kingdom	28	7.1	28	0	29	0	29	0	29	0	28	0
Total (14 MSs)	**232**	**9.9**	**226**	**0.9**	**123**	**3.3**	**237**	**1.3**	**213**	**8.0**	**-**	**-**

Table continued overleaf.

N = number of isolates tested.

% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable; if fewer than 10 isolates were tested, resistance was not calculated.

1. ECOFFs were used for interpretation.

Table SAS12 (continued). Antimicrobial resistance in* Salmonella *Derby from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Nalidixic acid		Streptomycin		Sulfonamides		Tetracyclines		Trimethoprim	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	5	NA	5	NA	5	NA	5	NA	5	NA
Denmark[1]	12	0	12	25.0	12	25.0	12	33.3	12	16.7
Estonia	3	NA	3	NA	3	NA	3	NA	3	NA
Germany	72	2.8	72	13.9	-	-	-	-	72	1.4
Greece	2	NA	2	NA	-	-	2	NA	-	-
Ireland	2	NA	2	NA	2	NA	2	NA	2	NA
Italy	33	9.1	24	41.7	21	38.1	34	47.1	64	10.9
Lithuania	3	NA	3	NA	3	NA	3	NA	5	NA
Netherlands[1]	10	0	10	20.0	10	10.0	10	30.0	-	-
Romania	7	NA	7	NA	7	NA	7	NA	7	NA
Slovakia	-	-	-	-	-	-	1	NA	-	-
Slovenia	1	NA	1	NA	1	NA	1	NA	1	NA
Spain	14	7.1	14	35.7	14	0	14	64.3	14	0
United Kingdom	29	0	29	3.4	28	25.0	28	35.7	29	0
Total (14 MSs)	**193**	**3.1**	**184**	**21.7**	**106**	**25.5**	**122**	**43.4**	**214**	**4.7**

N = number of isolates tested.

% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable; if fewer than 10 isolates were tested, resistance was not calculated.

1. ECOFFs were used for interpretation.

Table SAS13. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Derby from pigs in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Denmark	148	9.5	148	0	148	4.1	148	0	148	1.4	148	0	148	15.5	148	34.5
Estonia	3	0	3	0	3	0	3	0	3	0	3	0	3	0	3	0
Germany	62	21.0	62	4.8	62	8.1	62	8.1	62	0	62	8.1	62	50.0	62	32.3
Hungary	16	37.5	16	0	16	43.8	16	0	16	6.3	16	0	16	75.0	16	62.5
Italy	13	30.8	13	0	13	23.1	13	7.7	13	7.7	13	7.7	13	46.2	13	61.5
Netherlands	3	33.3	3	0	3	0	3	0	3	0	3	0	3	33.3	3	33.3
Spain	13	0	13	0	13	0	13	0	13	0	13	0	12	75.0	13	92.3
Sweden	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Total (8 MSs)	**259**	**14.7**	**259**	**1.2**	**259**	**8.1**	**259**	**2.3**	**259**	**1.5**	**259**	**2.3**	**258**	**31.8**	**259**	**39.4**

N = number of isolates tested.

% Res = percentage of resistant isolates.

Note: Includes data where fewer than 10 isolates have been tested.

4.9. Resistance in *S.* Mbandaka

In 2010, S. Mbandaka was the ninth most common serovar isolated in human salmonellosis cases (EFSA and ECDC, 2012). It was isolated from 0.5 % of cases, and there were also two strong evidence outbreaks involving 161 cases, of whom 33 were hospitalised. Similarly to S. Agona, isolations of this serovar from livestock are commonly feed-related. S. Mbandaka was the fifth most frequently reported serovar from both Gallus gallus *and cattle in 2010, responsible for 6.2 % and 2.6 % of* Salmonella *isolations from these species, respectively. Also like S. Agona, this serovar was responsible for a greater proportion of cases in humans, animal and food than in the preceding year.*

4.9.1. In humans

In 2011, a total of 218 *S.* Mbandaka cases were reported at the EU level. This serovar was the eighth most common serovar isolated in 2010 (EFSA and ECDC, 2013) and in the top 25 in 2011. Data on antimicrobial resistance of *S.* Mbandaka isolates were submitted by nine MSs for 2011, but over 50 % of all data was reported by the United Kingdom. Overall resistance levels to all antimicrobials were low or very low and a maximum of only 137 isolates were tested for each antimicrobial (Table SAS14).

4.9.2. In *Gallus gallus*, turkeys, pigs, cattle and meat products thereof

In 2011, nine MSs submitted antimicrobial resistance data concerning *S.* Mbandaka from *Gallus gallus* (Table SAS15). A total of 114 isolates were tested, but five countries tested fewer than 10 isolates each. At the reporting MS group level, there was a high overall occurrence of resistance to ampicillin (21.9 %), sulfonamides (23.7 %) and tetracyclines (32.5 %). Resistance levels varied markedly between countries, with four or five countries reporting no resistance to each of these antimicrobials, but others reporting up to 83.3 % resistance. Overall, a low level of resistance was reported for chloramphenicol (1.8 %), ciprofloxacin (7.9 %) and nalidixic acid (5.3 %). The United Kingdom reported 4.3 % resistance to all three of these antimicrobials, and Italy and Poland reported resistance to two of them; all other countries reported full sensitivity. No resistance to cefotaxime or gentamicin was recorded in any of the reporting countries.

Six MSs reported data concerning isolates of *S.* Mbandaka from broilers in 2011. Data were submitted for a total of 53 isolates although most of these were tested by either France or the United Kingdom. At the reporting MS group level, high levels of resistance against ampicillin (39.6 %), sulfonamides (45.3 %) and tetracyclines (43.4 %) were observed. Italy reported resistance to chloramphenicol in one of the seven isolates tested and the United Kingdom reported a low level of resistance (4.8 %), but all other countries reported full sensitivity, resulting in an overall resistanct of 3.8 % at the reporting MS group level. The United Kingdom was the only country to report resistance to ciprofloxacin or nalidixic acid (4.8 % in both cases), resulting in a low overall level of 1.9 % resistance in each case. No resistance to cefotaxime or gentamicin was observed.

Seven MSs reported antimicrobial data on isolates of *S.* Mbandaka from laying hens in 2011, with 33 isolates tested overall. France was responsible for nearly half of the isolates and was the only country to test more than 10 isolates. Resistance to tetracyclines was high at the reporting MS group level (42.4 %) with resistance levels in individual countries ranging from 0 % to 80.0 %. One isolate from Italy tested resistant to ampicillin, ciprofloxacin and sulfonamides, resulting in a low overall occurrence of resistance at the reporting MS group level of 3.0 %. No resistance to cefotaxime, chloramphenicol, gentamicin or nalidixic acid was reported.

Only two MSs submitted data concerning isolates of *S.* Mbandaka from turkeys in 2011: France tested eight isolates and the United Kingdom tested one. France reported resistance to sulfonamides in three isolates and resistance to ampicillin and tetracyclines in one isolate each. No resistance to the other antimicrobials in the single isolate from the United Kingdom was reported.

Estonia was the only MS to report data for *S.* Mbandaka collected from pigs. A single isolate was tested and was found to be fully sensitive to all of the antimicrobials tested. In addition, Ireland was the only MS to report data for *S.* Mbandaka collected from meat from pigs. Similarly, no resistance was reported for the single isolate tested.

In 2011, Ireland and Spain submitted antimicrobial resistance data for three *S.* Mbandaka isolates collected from cattle. No resistance was detected to any of the antimicrobials.

Ireland and Italy submitted data for three isolates from bovine meat. The isolate from Ireland was resistant to sulfonamides and one of the isolates from Italy was resistant to tetracyclines. The isolates were fully susceptible to all other antimicrobials.

Table SAS14. Antimicrobial resistance in* Salmonella *Mbandaka from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Kanamycin	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	25	0	25	0	25	0	25	0	25	0	25	0
Denmark[1]	10	0	10	0	10	0	10	0	10	0	10	0
Germany	8	NA	8	NA	-	-	8	NA	8	NA	8	NA
Ireland	5	NA	5	NA	5	NA	5	NA	5	NA	5	NA
Luxembourg	1	NA	1	NA	1	NA	1	NA	1	NA	1	NA
Netherlands[1]	1	NA	1	NA	1	NA	1	NA	1	NA	-	-
Slovenia	6	NA	6	NA	6	NA	6	NA	6	NA	6	NA
Spain	12	8.3	12	0	12	0	12	0	12	8.3	12	0
United Kingdom	69	5.8	69	1.4	69	0	69	8.7	69	0	69	0
Total (9 MSs)	**137**	**4.4**	**137**	**0.7**	**129**	**0**	**137**	**5.1**	**137**	**0.7**	**136**	**0**

Country	Nalidixic acid		Streptomycin		Sulfonamides		Tetracyclines		Trimethoprim	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	25	0	25	0	25	4.0	25	0	25	4.0
Denmark[1]	10	0	10	0	10	0	10	0	10	0
Germany	8	NA	8	NA	-	-	-	-	8	NA
Ireland	5	NA	5	NA	5	NA	5	NA	5	NA
Luxembourg	1	NA	1	NA	1	NA	1	NA	1	NA
Netherlands[1]	1	NA	1	NA	1	NA	1	NA	-	-
Slovenia	6	NA	6	NA	6	NA	6	NA	6	NA
Spain	12	0	12	0	12	0	12	0	12	0
United Kingdom	69	1.4	69	0	69	2.9	69	4.3	69	4.3
Total (9 MSs)	**137**	**0.7**	**137**	**0**	**129**	**3.1**	**129**	**2.3**	**136**	**4.4**

N = number of isolates tested.

% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable, if fewer than 10 isolates were tested resistance was not calculated.

1. ECOFFs were used for interpretation.

Table SAS15. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Mbandaka from* Gallus gallus*, turkeys, pigs, cattle and meat products thereof in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
All *Gallus gallus*																
Austria	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	83.3
Denmark	2	50.0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
France	36	50.0	36	0	36	0	36	0	36	0	36	0	36	50.0	36	69.4
Ireland	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
Italy	12	16.7	12	0	12	8.3	12	8.3	12	0	12	0	12	25.0	12	25.0
Poland	25	12.0	25	0	25	0	25	28.0	25	0	25	20.0	25	8.0	25	0
Spain	7	0	7	0	7	0	7	0	7	0	7	0	7	0	7	28.6
Sweden	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
United Kingdom	23	4.3	23	0	23	4.3	23	4.3	23	0	23	4.3	23	17.4	23	8.7
Total (9 MSs)	**114**	**21.9**	**114**	**0**	**114**	**1.8**	**114**	**7.9**	**114**	**0**	**114**	**5.3**	**114**	**23.7**	**114**	**32.5**
Broilers																
Austria	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	100
Denmark	1	100	1	0	1	0	1	0	1	0	1	0	1	0	1	0
France	21	85.7	21	0	21	0	21	0	21	0	21	0	21	85.7	21	85.7
Ireland	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
Italy	7	14.3	7	0	7	14.3	7	0	7	0	7	0	7	28.6	7	28.6
United Kingdom	21	4.8	21	0	21	4.8	21	4.8	21	0	21	4.8	21	19.0	21	9.5
Total (6 MSs)	**53**	**39.6**	**53**	**0**	**53**	**3.8**	**53**	**1.9**	**53**	**0**	**53**	**1.9**	**53**	**45.3**	**53**	**43.4**

Table continued overleaf.

N = number of isolates tested.

% Res = percentage of resistant isolates.

Note: Includes data where fewer than 10 isolates have been tested and fewer than four countries have reported.

Table SAS15 (continued). Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Mbandaka from* Gallus gallus*, turkeys, pigs, cattle and meat products thereof in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Laying hens																
Austria	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	80.0
Denmark	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
France	15	0	15	0	15	0	15	0	15	0	15	0	15	0	15	46.7
Italy	3	33.3	3	0	3	0	3	33.3	3	0	3	0	3	33.3	3	33.3
Spain	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	33.3
Sweden	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
United Kingdom	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
Total (7 MSs)	**33**	**3.0**	**33**	**0**	**33**	**0**	**33**	**3.0**	**33**	**0**	**33**	**0**	**33**	**3.0**	**33**	**42.4**
Turkeys																
France	8	12.5	8	0	8	0	8	0	8	0	8	0	8	37.5	8	12.5
United Kingdom	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Total (2 MSs)	**9**	**11.1**	**9**	**0**	**9**	**0**	**9**	**0**	**9**	**0**	**9**	**0**	**9**	**33.3**	**9**	**11.1**
Pigs																
Estonia	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Meat from pigs																
Ireland	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Cattle																
Ireland	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Spain	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
Total (2 MSs)	**3**	**0**	**3**	**0**	**3**	**0**	**3**	**0**	**3**	**0**	**3**	**0**	**3**	**0**	**3**	**0**
Meat from bovine animals																
Ireland	1	0	1	0	1	0	1	0	1	0	1	0	1	100	1	0
Italy	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	50.0
Total (2 MSs)	**3**	**0**	**3**	**0**	**3**	**0**	**3**	**0**	**3**	**0**	**3**	**0**	**3**	**33.3**	**3**	**33.3**

N = number of isolates tested.

% Res = percentage of resistant isolates.

Note: Includes data where fewer than 10 isolates have been tested and fewer than four countries have reported.

4.10. Resistance in *S.* Agona

S. Agona was the tenth most common serovar isolated in human cases of salmonellosis in the EU in 2010, responsible for 459 cases in 2011 (EFSA and ECDC, 2013). This serovar is frequently isolated from poultry, pigs and cattle, often as a result of animal feed contamination. In 2010, S. Agona was the eighth most common serovar in both cattle (responsible for 1.3 % of Salmonella *isolations) and pig meat (0.9 %) as well as the seventh most common in broiler meat (2.0 %). In addition, S. Agona was responsible for a greater proportion of* Salmonella *isolations from humans and both these animal species and food types relative to 2009. A recent international outbreak of 163 laboratory-confirmed cases in seven European countries was associated with pre-cooked meat products (Nicolay et al., 2011).*

4.10.1. In humans

S. Agona resistance data were submitted by 14 MSs for 2011, with Denmark, Spain and the United Kingdom accounting for over 60% of isolates in which antimicrobials were tested. Overall, levels of resistance to ampicillin (10.8 %; N=250), gentamicin, (0.8 %; N=247) and streptomycin (3.3 %; N=246) were low when compared with all non-typhoidal *Salmonella* isolates (Table SAS16).

4.10.2. In *Gallus gallus*, turkeys, pigs and meat products thereof

Five MSs submitted antimicrobial resistance data for isolates of *S.* Agona from *Gallus gallus* in 2011 (Table SAS17). All of these countries provided information on the production type of the birds. Just over two-thirds of the *S.* Agona isolates were collected from laying hens. The five MSs tested a total of 50 isolates from *Gallus gallus*, of which 35 were from laying hens and 11 were from broilers. Ampicillin was the only antimicrobial to which any resistance was detected. A single isolate from a broiler in Austria tested resistant, resulting in a resistance level in this country of 3.6 % among *Gallus gallus* and 20.0 % among broilers (one out of the five isolates tested). All other isolates were fully susceptible to all antimicrobials.

Two MSs reported data concerning isolates from meat from broilers. Only five isolates were tested in total and they were all fully susceptible to all of the antimicrobials tested.

Four MSs reported antimicrobial data on *S.* Agona isolates from turkeys in 2011. Overall, 20 isolates were tested although 16 of these were from France, so results from this country dominated those for the reporting MS group as a whole. France was the only country that detected any antimicrobial resistance among the isolates from turkeys. Half of its isolates were resistant to sulfonamides. France also reported a high level of resistance to tetracyclines (43.8 %) and ampicillin (25.0 %) and a moderate level of resistance to chloramphenicol (18.8 %).

Only two MSs reported data on isolates from pigs in 2011, in a total of five *S.* Agona isolates. Two of the three isolates tested by Estonia were resistant to ampicillin, sulfonamides and/or tetracyclines. No resistance to the other antimicrobials was detected. Denmark also reported full sensitivity to all antimicrobials in the two isolates that it tested. One MS, Estonia, reported data for *S.* Agona isolates from pig meat. Three isolates were tested, one of which was positive for ampicillin, sulfonamides and/or tetracyclines. The remaining isolates were fully sensitive.

Sweden and Romania each reported a single isolate from cattle and meat from bovine animals, respectively. Both isolates were fully sensitive to all antimicrobials tested.

Table SAS16. Antimicrobial resistance in* Salmonella *Agona from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Kanamycin	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	13	15.4	13	0	13	0	13	0	13	0	13	0
Denmark[1]	22	13.6	22	4.5	22	4.5	22	4.5	22	0	22	0
Estonia	2	NA	2	NA	2	NA	2	NA	2	NA	2	NA
Germany	3	NA	3	NA	-	-	3	NA	3	NA	3	NA
Ireland	5	NA	5	NA	5	NA	5	NA	5	NA	5	NA
Italy	1	NA	1	NA	-	-	-	-	-	-	-	-
Lithuania	1	NA	1	NA	1	NA	1	NA	1	NA	1	NA
Luxembourg	1	NA	1	NA	1	NA	1	NA	1	NA	1	NA
Netherlands[1]	5	NA	5	NA	5	NA	5	NA	5	NA	-	-
Romania	7	NA	7	NA	7	NA	7	NA	7	NA	7	NA
Slovakia	2	NA	-	-	-	-	-	-	-	-	-	-
Slovenia	1	NA	1	NA	1	NA	1	NA	1	NA	1	NA
Spain	37	2.7	37	2.7	37	0	37	0	37	0	37	0
United Kingdom	150	10.7	149	2.0	149	4.7	150	11.3	150	1.3	149	2.0
Total (14 MSs)	**250**	**10.8**	**247**	**2.4**	**243**	**3.7**	**247**	**8.1**	**247**	**0.8**	**241**	**1.7**

Table continued overleaf.

N = number of isolates tested.

% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable; if fewer than 10 isolates were tested, resistance was not calculated.

1. ECOFFs were used for interpretation.

Table SAS16 (continued). Antimicrobial resistance in* Salmonella *Agona from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Nalidixic acid		Streptomycin		Sulfonamides		Tetracyclines		Trimethoprim	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	13	7.7	13	7.7	13	7.7	13	23.1	13	0
Denmark[1]	22	0	22	13.6	22	9.1	22	4.5	22	4.5
Estonia	2	NA	2	NA	2	NA	2	NA	2	NA
Germany	3	NA	3	NA	-	-	-	-	3	NA
Ireland	5	NA	5	NA	5	NA	5	NA	5	NA
Italy	-	-	-	-	-	-	-	-	1	NA
Lithuania	1	NA	1	NA	1	NA	1	NA	1	NA
Luxembourg	1	NA	1	NA	1	NA	1	NA	1	NA
Netherlands[1]	5	NA	5	NA	5	NA	5	NA	-	-
Romania	7	NA	7	NA	7	NA	7	NA	7	NA
Slovakia	-	-	-	-	-	-	1	NA	-	-
Slovenia	1	NA	1	NA	1	NA	1	NA	1	NA
Spain	37	0	37	0	37	0	37	2.7	37	0
United Kingdom	149	9.4	149	0	149	25.5	149	37.6	149	18.8
Total (14 MSs)	**246**	**7.7**	**246**	**3.3**	**243**	**18.5**	**244**	**28.3**	**242**	**12.4**

N = number of isolates tested.

% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable; if fewer than 10 isolates were tested, resistance was not calculated.

1. ECOFFs were used for interpretation.

Table SAS17. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Agona from* Gallus gallus*, turkeys, pigs, cattle and meat products thereof in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
All *Gallus gallus*																
Austria	28	3.6	28	0	28	0	28	0	28	0	28	0	28	0	28	0
France	9	0	9	0	9	0	9	0	9	0	9	0	9	0	9	0
Hungary	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
Italy	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0
Spain	7	0	7	0	7	0	7	0	7	0	7	0	7	0	7	0
Total (5 MSs)	**50**	**2.0**	**50**	**0**	**50**	**0**	**50**	**0**	**50**	**0**	**50**	**0**	**50**	**0**	**50**	**0**
Broilers																
Austria	5	20.0	5	0	5	0	5	0	5	0	5	0	5	0	5	0
France	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0
Total (2 MSs)	**11**	**9.1**	**11**	**0**	**11**	**0**	**11**	**0**	**11**	**0**	**11**	**0**	**11**	**0**	**11**	**0**
Laying hens																
Austria	23	0	23	0	23	0	23	0	23	0	23	0	23	0	23	0
France	3	0	3	0	3	0	3	0	3	0	3	0	3	0	3	0
Hungary	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
Italy	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
Spain	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0
Total (5 MSs)	**35**	**0**	**35**	**0**	**35**	**0**	**35**	**0**	**35**	**0**	**35**	**0**	**35**	**0**	**35**	**0**

Table continued overleaf.

N = number of isolates tested.

% Res = percentage of resistant isolates.

Note: Includes data where fewer than 10 isolates have been tested and fewer than four countries have reported.

Table SAS17 (continued). Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Agona from* Gallus gallus*, turkeys, pigs, cattle and meat products thereof in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Meat from broilers																
Ireland	3	0	3	0	3	0	3	0	3	0	3	0	3	0	3	0
Slovakia	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
Total (2 MSs)	**5**	**0**	**5**	**0**	**5**	**0**	**5**	**0**	**5**	**0**	**5**	**0**	**5**	**0**	**5**	**0**
Turkeys																
Austria	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
France	16	25.0	16	0	16	18.8	16	0	16	0	16	0	16	50.0	16	43.8
Hungary	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Slovakia	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Total (4 MSs)	**20**	**20.0**	**20**	**0**	**20**	**15.0**	**20**	**0**	**20**	**0**	**20**	**0**	**20**	**40.0**	**20**	**35.0**
Pigs																
Denmark	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
Estonia	3	66.7	3	0	3	0	3	0	3	0	3	0	3	66.7	3	66.7
Total (2 MSs)	**5**	**40.0**	**5**	**0**	**5**	**0**	**5**	**0**	**5**	**0**	**5**	**0**	**5**	**40.0**	**5**	**40.0**
Meat from pigs																
Estonia	3	33.3	3	0	3	0	3	0	3	0	3	0	3	33.3	3	33.3
Cattle																
Sweden	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Meat from bovine animals																
Romania	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

N = number of isolates tested.

% Res = percentage of resistant isolates.

Note: Includes data where fewer than 10 isolates have been tested and fewer than four countries have reported.

4.11. Resistance in *S.* Java

Salmonella enterica Paratyphi B var Java has the same somatic and flagellar antigens as other S. Paratyphi B variants but is differentiated by its use of d-tartrate. It is generally less virulent, although invasive infections can still occur resulting in typhoid-like clinical symptoms. S. Java has caused numerous outbreaks through contamination of foods, including a multi-country outbreak in 2007 involving over 200 cases in Denmark, Finland, the Netherlands, Norway, Sweden and the United Kingdom (Denny et al., 2007). In 2010, there were two strong-evidence outbreaks in the EU involving 132 cases, of whom 17 were hospitalised (EFSA and ECDC, 2012). S. Java was the third most frequently reported serovar (4.6 %) in broiler meat in the EU in 2010 (EFSA and ECDC, 2012). This ranking is partly attributable to the very high prevalence in Germany and the Netherlands, where this serovar was responsible for 20.7 % and 53.5 %, respectively, of all Salmonella isolates in broiler meat (EFSA and ECDC, 2012). A multi-resistant clone of S. Java became predominant in poultry production in Germany during the 1990s, and has since been identified in Belgium and the Netherlands (Miko et al., 2003). S. Java is the most common serovar reported in poultry in the Netherlands (EFSA, 2008b, van Asselt et al., 2009) and an increase in the prevalence of this serovar in poultry has been reported in Germany (Dorn et al., 2001).

Two distinct clonal lines of S. Java have been described–one frequently associated with aquaria, in particular tropical fish aquaria, and another associated with poultry. Strains associated with tropical fish commonly demonstrate resistance to ampicillin, chloramphenicol, streptomycin, sulfonamides and tetracyclines (Denny et al., 2007). S. Java is one of the serovars which has been shown to have acquired SGI1, which confers this pattern of resistance (Velge et al., 2005). Reports in Eurosurveillance show that in the Netherlands the proportion of Salmonella isolates in poultry accounted for by S. Java increased from less than 2 % prior to 1996 to 60 % in 2002. Despite likely exposure through the food chain, cases of S. Java infection in humans remain rare in the Netherlands (0.3 % of all Salmonella infections), although molecular typing has shown that 50 % of human isolates are identical to the poultry clone (van Pelt et al., 2003). The antimicrobial resistance monitoring report for the Netherlands for 2009 (MARAN, 2011) records that, of all ESBL-producing isolates, 22 (67 %) were S. Java isolates derived either from poultry or from an unspecified source.

4.11.1. In humans

In 2011, a total of 229 *S.* Java cases were reported at the EU level. This serovar is very common in poultry (EFSA and ECDC, 2013). In 2011, nine MSs and Iceland submitted data on the antimicrobial resistance of *S.* Java. Overall resistance to all antimicrobials was low or very low. Over 50 % of all data came from the United Kingdom (Table SAS18).

Table SAS18. Antimicrobial resistance in* Salmonella *Java from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Kanamycin	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	21	4.8	21	0	21	9.5	21	4.8	21	0	21	0
Denmark[1]	10	0	10	0	10	0	10	0	10	10.0	10	0
Estonia	1	NA	1	NA	1	NA	1	NA	1	NA	1	NA
Ireland	1	NA	1	NA	1	NA	1	NA	1	NA	1	NA
Netherlands[1]	14	28.6	14	7.1	14	0	14	7.1	14	0	-	-
Romania	6	NA	6	NA	6	NA	6	NA	6	NA	6	NA
Slovenia	22	4.5	22	0	22	0	22	0	22	0	22	0
Spain	31	0	31	0	31	0	31	0	31	0	31	0
United Kingdom	111	14.4	111	0	112	5.4	112	4.5	112	0.9	111	0.9
Total (9 MSs)	**217**	**10.6**	**217**	**0.5**	**218**	**4.1**	**218**	**3.2**	**218**	**0.9**	**203**	**0.5**
Iceland	3	NA	-	-	3	NA	3	NA	-	-	-	-

Country	Nalidixic acid		Streptomycin		Sulfonamides		Tetracyclines		Trimethoprim	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	21	4.8	21	14.3	21	9.5	21	9.5	21	4.8
Denmark[1]	10	NA	10	10.0	10	10.0	10	0	10	0
Estonia	1	NA	1	NA	1	NA	1	NA	1	NA
Ireland	1	NA	1	NA	1	NA	1	NA	1	NA
Netherlands[1]	14	7.1	14	21.4	14	0	14	0	-	-
Romania	6	NA	6	NA	6	NA	6	NA	6	NA
Slovenia	22	0	22	0	22	4.5	22	0	22	0
Spain	31	0	31	0	31	0	31	0	31	0
United Kingdom	112	3.6	112	0.9	111	12.6	111	9.0	112	5.4
Total (9 MSs)	**218**	**2.8**	**218**	**4.1**	**217**	**9.7**	**217**	**5.5**	**204**	**3.4**
Iceland	3	NA	-	-	-	-	-	-	3	NA

N = number of isolates tested.

% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable, if fewer than 10 isolates were tested resistance was not calculated.

1. ECOFFs were used for interpretation.

4.11.2. In *Gallus gallus*

In 2011, three MSs reported antimicrobial resistance data for isolates of *S.* Java (Table SAS19). Germany and the Netherlands both submitted data on isolates from *Gallus gallus* and meat from broilers, and Belgium reported data on isolates from meat from broilers only. Among isolates from *Gallus gallus* in both Germany and the Netherlands, the reported resistance levels were generally higher than those reported in 2010. Both MSs reported very high levels of resistance to ampicillin and, in Germany, resistance to this antimicrobial increased from 4 % in 2010 to 61.5 % in 2011, although only a small number of isolates were tested. An extremely high level of resistance to sulfonamides among isolates of *S.* Java from *Gallus gallus* was reported across the two MSs (73.0 %) while resistance to tetracyclines was fewer prevalent (23.8 %). Resistance to chloramphenicol was not observed in the Netherlands but reported at a low level in Germany (7.7 %), while both MSs reported low levels of resistance to gentamicin (3.2 % overall).

Both MSs reported very high to extremely high levels of resistance to nalidixic acid and ciprofloxacin, of 71.4 % to 73.0 % overall. All isolates of *S.* Java from *Gallus gallus* reported by Germany were resistant to ciprofloxacin. Cefotaxime resistance was detected at a low level in Germany (7.7 %), but was found in 16.0 % of isolates from the Netherlands. This was twice the proportion reported by the Netherlands in 2010 (8 %).

In general, both Germany and the Netherlands detected similar levels of resistance to the tested antimicrobials among isolates from meat from broilers as in isolates from *Gallus gallus.* Belgium reported extremely high levels of resistance to ampicillin and sulfonamides among isolates of *S.* Java from meat from broilers (91.7 % and 73.3 % respectively), and moderate resistance to tetracyclines (13.3 %). Across the three MSs, extremely high levels of resistance to ciprofloxacin (78.2 %) and nalidixic acid (76.4 %) were observed among isolates from meat from broilers. Belgium reported no resistance amongst isolates tested to chloramphenicol and gentamicin, while the Netherlands reported a low level of resistance to chloramphenicol only (5.0 %). Moderate resistance to both antimicrobials was reported by Germany in 2011 (15.0 % for chloramphenicol and 10.0 % for gentamicin).

Cefotaxime resistance was detected at a low level in Germany (5.0 %) and at a moderate level in Belgium (13.3 %). A high level of resistance was reported by the Netherlands (35.0 %) which correlates with the increase in resistance observed in this country among isolates from *Gallus gallus.*

Table SAS19. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Java from* Gallus gallus *and meat from broilers in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
All *Gallus gallus*																
Germany	13	61.5	13	7.7	13	7.7	13	100	13	7.7	13	92.3	13	69.2	13	15.4
Netherlands	50	62.0	50	16.0	50	0	50	66.0	50	2.0	50	66.0	50	74.0	50	26.0
Total (2 MSs)	**63**	**61.9**	**63**	**14.3**	**63**	**1.6**	**63**	**73.0**	**63**	**3.2**	**63**	**71.4**	**63**	**73.0**	**63**	**23.8**
Broiler meat																
Belgium	12	91.7	15	13.3	15	0	15	46.7	15	0	15	46.7	15	73.3	15	13.3
Germany	20	45.0	20	5.0	20	15.0	20	85.0	20	10.0	20	85.0	20	60.0	20	35.0
Netherlands	20	60.0	20	35.0	20	5.0	20	95.0	20	0	20	90.0	20	80.0	20	40.0
Total (3 MSs)	**52**	**61.5**	**55**	**18.2**	**55**	**7.3**	**55**	**78.2**	**55**	**3.6**	**55**	**76.4**	**55**	**70.9**	**55**	**30.9**

N = number of isolates tested.

% Res = percentage of resistant isolates.

Note: Includes data fewer than four countries have reported.

4.12. Resistance in *S.* Dublin

S. Dublin is a common serovar in cattle. In 2010, there were 1,868 reports from cattle in the EU, which was an increase relative to the 1,339 reports in 2009 (EFSA and ECDC, 2012). This made S. Dublin the most common serovar in cattle, responsible for 44.3 % of bovine Salmonella *reports. In addition, S. Dublin was the second most common serovar in bovine meat, responsible for 18.1 % of* Salmonella *isolations (EFSA and ECDC, 2012). Human S. Dublin outbreaks have previously been associated with infected cows' milk cheese (Maguire et al., 1992; Vaillant et al., 1996).*

4.12.1. In humans

In 2011, a total of 192 *S.* Dublin cases were isolated. This serovar is known to cause disease in cattle. In 2011, six MSs submitted data on the antimicrobial resistance of *S.* Dublin. Overall, resistance to all antimicrobials was notably lower than resistance levels for all non-typhoidal *Salmonella* isolates, with the exception of increased resistance in streptomycin (36.0 %; N=75) and comparable resistance for ampicillin (24.6 %; N=57). Over 70 % of all data came from Denmark (Table SAS20), where susceptibility data are interpreted by ECOFFs or other more sensitive interpretive criteria.

4.12.2. In cattle

Five MSs submitted data concerning antimicrobial resistance in *S*. Dublin from cattle in 2011, however only two of the reporting MSs tested more than 10 isolates (Table SAS21). The Netherlands tested 28 isolates and Germany tested 13 isolates. For both sulfonamides and tetracyclines, Germany reported 23.1 % resistance and the Netherlands reported 3.6 % resistance resulting in a low overall level of 7.1 % resistance. Germany also reported 23.1 % resistance to chloramphenicol, but the Netherlands reported no resistance, so the overall level was lower, at 5.4 %. Both countries reported a low occurrence of resistance to ampicillin, of 7.7 % in Germany and 3.6 % in the Netherlands. Thus, the overall level of resistance was 3.6 %. None of the MSs reporting fewer than 10 isolates detected any resistance to the antimicrobials tested. In addition, neither Germany or the Netherlands reported any resistance to cefotaxime, ciprofloxacin, gentamicin or nalidixic acid.

Table SAS20. Antimicrobial resistance in* Salmonella *Dublin from humans per country in 2011, using clinical breakpoints, with some exceptions[1]

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Kanamycin	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	1	NA	1	NA	1	NA	1	NA	1	NA	1	NA
Denmark[1]	41	29.3	41	0	41	0	41	7.3	41	0	41	0
Germany	3	NA	3	NA	-	-	3	NA	3	NA	3	NA
Ireland	2	NA	2	NA	2	NA	2	NA	2	NA	2	NA
Italy	1	NA	1	NA	-	-	1	NA	1	NA	-	-
Netherlands[1]	7	NA	7	NA	7	NA	7	NA	7	NA	-	-
United Kingdom	2	NA	22	0	21	0	24	8.3	23	0	21	0
Total (7 MSs)	**57**	**24.6**	**77**	**0**	**72**	**1.4**	**79**	**7.6**	**78**	**1.3**	**68**	**0**

Country	Nalidixic acid		Streptomycin		Sulfonamides		Tetracyclines		Trimethoprim	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	1	NA	1	NA	1	NA	1	NA	1	NA
Denmark[1]	41	4.9	41	58.5	41	2.4	41	31.7	40	0
Germany	3	NA	3	NA	-	-	-	-	3	NA
Ireland	2	NA	2	NA	2	NA	2	NA	2	NA
Italy	-	-	-	-	-	-	1	NA	1	NA
Netherlands[1]	7	NA	7	NA	7	NA	7	NA	-	-
United Kingdom	22	9.1	21	0	21	4.8	21	0	24	0
Total (7 MSs)	**76**	**6.6**	**75**	**36.0**	**72**	**4.2**	**73**	**17.8**	**71**	**0**

N = number of isolates tested.

% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable; if fewer than 10 isolates were tested, resistance was not calculated.

1. ECOFFs were used for interpretation.

Table SAS21. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, sulfonamides and tetracyclines among* Salmonella *Dublin from cattle in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Nalidixic acid		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Estonia	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0
Germany	13	7.7	13	0	13	23.1	13	0	13	0	13	0	13	23.1	13	23.1
Ireland	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0
Netherlands	28	3.6	28	0	28	0	28	0	28	0	28	0	28	3.6	28	3.6
Sweden	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0
Total (5 MSs)	**56**	**3.6**	**56**	**0**	**56**	**5.4**	**56**	**0**	**56**	**0**	**56**	**0**	**56**	**7.1**	**56**	**7.1**

N = number of isolates tested.

% Res = percentage of resistant isolates.

Note: Includes data where fewer than 10 isolates have been tested.

RESISTANCE IN *S.* SAINTPAUL FROM TURKEYS

Salmonella *Saintpaul is associated with turkeys, food products and human salmonellosis (Beutlich et al., 2010). A baseline survey on the prevalence of* Salmonella *in turkey flocks carried out in 2006-2007 identified* Salmonella *Saintpaul as the fourth most frequently reported serovar in turkeys (EFSA, 2008b). Studies have demonstrated that isolates from turkeys can display resistance to ampicillin, streptomycin, sulfonamides, nalidixic acid, ciprofloxacin and gentamicin (Beutlich et al., 2010).*

In 2011, three MSs submitted quantitative MIC data on antimicrobial resistance among isolates of S. *Saintpaul from turkey meat and six MSs submitted data on isolates from turkeys. Among the 39 isolates from meat, a high or very high or extremely high level of resistance to ampicillin (59.0 %), ciprofloxacin (71.8 %), nalidixic acid (69.2 %), sulfonamides (61.1 %) and tetracyclines (41.0 %) was observed. There was also a moderate level of resistance to gentamicin (15.4 %) but only low resistance to cefotaxime (5.1 %) and chloramphenicol (2.6 %). Regarding turkeys, sensitivity data were reported for a total of 58 isolates; however, Hungary submitted the data for 35 (60 %) of these isolates whilst two other MSs submitted data concerning only a single isolate of* S. *Saintpaul. Similarly to the isolates from meat, there was a high or very high or extremely high level of resistance against ampicillin (32.8 %), ciprofloxacin (84.5 %), nalidixic acid (79.3 %), sulfonamides (32.8 %) and tetracyclines (32.8 %). There was low resistance to chloramphenicol (3.4 %) and gentamicin (8.6 %), and no resistance was observed against cefotaxime among the tested isolates.*

S. STANLEY

Salmonella *enterica serovar Stanley (*S. *Stanley) is commonly associated with human salmonellosis in south-east Asia, and thus human cases within the EU are usually associated with a history of travel to this part of the world. A multi-national outbreak of human infection with nalidixic acid-resistant* S. *Stanley occurred in 2012 with almost 700 human cases with an indistinguishable strain reported from ten Member States (Austria, Belgium, the Czech Republic, Germany, Greece, Hungary, Italy, Slovakia, Sweden and the United Kingdom) (ECDC, 2013). Previously, reports of* S. *Stanley in food and animals in the EU have been rare. In 2011, 311* S. *Stanley isolations were reported by EU MSs, Norway and Switzerland from turkey fattening flocks, turkey breeding flocks and turkey meat, broiler flocks,* Gallus gallus *breeding flocks, broiler meat, pigs, and other poultry and hedgehogs (ECDC and EFSA, 2013).*

Only two MSs reported antimicrobial resistance data for S. *Stanley from animals or food in 2011. Hungary tested a single isolate from* Gallus gallus *and found it to be resistant to ciprofloxacin and nalidixic acid. It also tested 47 isolates from turkeys and reported low to moderate levels of resistance to sulfonamides (8.5 %) and tetracyclines (14.9 %), high levels of resistance to ampicillin (25.5 %) and gentamicin (21.3 %), and extremely high levels of resistance to ciprofloxacin (97.9 %) and nalidixic acid (100 %). Austria tested four isolates from turkeys and found all of the isolates to be resistant to both ciprofloxacin and nalidixic acid. A joint ECDC/EFSA report (ECDC and EFSA, 2012) and a recent update (ECDC, 2013) concludes that the turkey production chain is strongly implicated as the source of the on-going outbreak of human infection, although a contribution from other food and animal sources cannot be ruled out.*

S. GOLDCOAST

Salmonella *enterica serovar Goldcoast (S. Goldcoast) was first isolated in 1953 and has since been responsible for a number of outbreaks of salmonellosis, including outbreaks in the United Kingdom (Threlfall et al., 1986), Germany, where an outbreak in 2001 was thought to be caused by consumption of raw fermented sausage (Bremer et al., 2004) and internationally, in tourists returning from Majorca (HPA, 2005). S. Goldcoast was among the 10 most commonly isolated serovars from pig production holdings in the EU in 2008 and from cattle in the EU in 2009 (EFSA and ECDC, 2011), although it was poorly represented amongst the serotypes tested by MSs in 2011 and included in this report.*

In 2011, only Hungary reported quantitative MIC data on the antimicrobial resistance of S. Goldcoast, reporting on a single isolate from pigs. This isolate expressed resistance to ampicillin, chloramphenicol, sulfonamides and tetracyclines.

S. POONA

Salmonella *enterica serovar Poona (S. Poona) was the eighth most common* Salmonella *serovar isolated in Europe in 2011 with 548 cases (EFSA and ECDC, 2013). Data on the antimicrobial resistance of S. Poona isolates were submitted by seven MSs for 2011, but over 75 % of all isolates reported were from Spain. Overall resistance levels to all antimicrobials were low to very low.*

4.13. Discussion

The resistance shown by a number of different individual *Salmonella* serovars has been included in this report and the findings are discussed below. The serovars presented were selected based upon their importance to human health as reported in the last two European Summary Reports on the Trends and Sources of Zoonoses, Zoonotic agents and Food-borne Outbreaks (EFSA and ECDC, 2012 and 2013), or on their predominance within a particular species (e.g. *S.* Dublin in cattle).

For the year 2011, a limited number of MSs are now providing isolate-based data, i.e. data where the susceptibility result for each antimicrobial can be linked back to an individual isolate. This will allow analysis and investigation of the patterns of multi-resistance, which can also be related to the serovar of *Salmonella* involved. Many of the findings for the analysis at serovar level accurately reflect phenotypic resistance traits previously reported in the scientific literature, for example in *S.* Infantis and monophasic *S.* Typhimurium (Nógrády et al., 2007; Hopkins et al., 2010).

The continued emergence of **monophasic *S.* Typhimurium** strains, such as S. 1,4,[5],12:i:-, that are resistant to ampicillin, streptomycin, sulfonamides and tetracyclines is evident from the data reported on isolates from pigs and pig meat in 2011. The four typical resistances carried by the monophasic strains of *S*. Typhimurium are located on a resistance island and appear to be rather frequently deleted, accounting for the rather variable occurrence of resistance to all four antimicrobials (ampicillin, streptomycin, sulfonamides and tetracyclines) observed in these isolates (Hopkins et al., 2010).

There was notably higher resistance to ciprofloxacin, nalidixic acid, sulfonamides and tetracyclines in human ***S.* Infantis** isolates when compared with all non-typhoidal *Salmonella* isolates, a pattern that also was observed in *Gallus gallus*. However, prevalence of *S*. Infantis in *Gallus gallus* at the EU level was rare in breeding flocks to low in laying hen and broiler flocks. The most common resistances observed in *S*. Infantis from broilers were to sulfonamides, tetracyclines and ciprofloxacin/nalidixic acid. The molecular basis of the resistance is unknown for these isolates, though qnrS genes have been reported in *S*. Infantis (Veldman et al., 2011). *S*. Infantis isolates resistant to streptomycin, sulfonamides, tetracyclines and nalidixic acid have been described in Hungary in broiler chickens, where their numbers, compared with the numbers of other serotypes have proportionately increased in recent years (Nógrády et al., 2007). An interesting feature in the EUSR is that isolates from Central Europe (Austria, Hungary and Slovakia) tended to share a similar resistance profile, whereas isolates from the Netherlands and Spain had a different profile, perhaps suggesting the involvement of different regional clones. Recent work in which *S*. Infantis isolates from nine European countries were examined (Nógrády et al., 2012) has suggested that there are two large related clusters of *S*. Infantis in broilers, one which is largely susceptible and one which shows resistance to streptomycin, sulfonamides, tetracyclines and nalidixic acid and which was detected in various European countries. Isolates from Austria and Poland were found to be closely related to the dominant clone present in Hungary.

***S.* Virchow** is a *Salmonella* serovar in which ESBLs have been detected, including TEM-52, CTX-M-2 from poultry in the Netherlands (Hasman et al. 2005) and CTX-M-9 from poultry in France (Weill et al. 2004). It is therefore of interest that resistance to cefotaxime was not detected in isolates of this serovar in the monitoring of *Gallus gallus* performed in 2011. The numbers of isolates reported from *Gallus gallus* by some MSs were low. In some MSs (Poland and Spain) a high proportion of isolates from *Gallus gallus* were resistant to ciprofloxacin. Bertrand et al. (2006) describe a clone of *S*. Virchow affecting man and poultry in Belgium over the period 2000-2003, which showed reduced susceptibility to ciprofloxacin and resistance to tetracyclines and trimethoprim/sulfonamides and carried the ESBL CTX-M-2. In a recent study of human *S*. Virchow isolates in Switzerland (Bonalli et al., 2011) nalidixic acid resistance/reduced susceptibility to ciprofloxacin was noted in a particular PFGE cluster of isolates, which were also commonly resistant to tetracyclines, trimethoprim and sulfonamides. The monitoring appears to highlight a further permutation in that isolates have been detected with nalidixic acid resistance/reduced susceptibility to ciprofloxacin, but without resistance to tetracyclines or, in many cases, sulfonamides. *Salmonella* Hadar isolates from *Gallus gallus* (mainly from broilers) were consistently resistant to nalidixic acid and ciprofloxacin and commonly also resistant to tetracyclines and ampicillin.

***S.* Hadar** resistant to nalidixic acid has previously been reported from Germany, where the percentage of *Salmonella* isolates from poultry resistant to nalidixic acid rose from 0.3 % in 1989 to 14.4 % in 1994 and most of these nalidixic acid resistant isolates were *S.* Hadar (Malorny et al., 1999). Aubry-Damon and Courvalin (1999) commented that fluoroquinolone resistance was not observed in *S.* Hadar before 1987, prior to the introduction of ciprofloxacin and enrofloxacin into human and veterinary medicine respectively. An outbreak of *S.* Hadar in Spain associated with the consumption of pre-cooked chicken occurred in 2005 and isolates were resistant to ampicillin, cephalothin, streptomycin, nalidixic acid and tetracycline (Lenglet, 2005).

Among the specific serovars of public health significance, ***S.* Kentucky** isolates from humans exhibited a very high or extremely high resistance to all tested antimicrobials, when compared with all non-typhoidal *Salmonella* isolates, except for cefotaxime. This could reflect the clonal spread of *S.* Kentucky in humans but also in animals, e.g. turkeys, in Europe.

Most isolates of ***S.* Agona** were susceptible to the panel of antimicrobials tested; a proportion of isolates from France originating from turkeys, showed resistance to ampicillin, chloramphenicol, sulfonamides or tetracyclines. Isolate-level data are required to determine whether individual isolates were resistant to all of these compounds. *Salmonella* genomic island 1 (SGI1) is an antimicrobial resistance gene cluster carried by *S.* Typhimurium DT104, which has also been detected in certain other serotypes, notably *S.* Agona, *S.* Java and *S.* Newport (Velge et al., 2005) and which confers resistance to ampicillin, chloramphenicol, streptomycin, sulfonamides and tetracyclines. There are at least two other variant SGI1 clusters described in *S.* Agona (Velge et al., 2005), one of which carries only the gene conferring resistance to ampicillin and it is interesting to note that isolates form some MSs showed resistance only to ampicillin, amongst those antimicrobials tested.

Although ***S.* Java** causes relatively few human infections, the occurrence of resistance to cefotaxime is likely to have treatment implications, since this antimicrobial, as well as ciprofloxacin, may be used as the first-line treatment for human salmonellosis, where this is necessary.

***S.* Dublin** remained susceptible to the majority of antimicrobials in reporting MSs in 2011.

Some serovars in which third-generation cephalosporin resistance has previously been detected, for example *S.* Virchow in poultry from Belgium and France in 2000–2003 (Bertrand et al., 2006) do not show cefotaxime resistance in the current EFSA monitoring programme. Analysis of detailed national reports and case studies may help to determine whether these resistant organisms are no longer present in food-producing animal populations or are present but occur at a frequency below the limits of currently recommended detection procedures. Clearly, the monitoring programme is capable of detecting new and emerging organisms (*S.* Kentucky with ciprofloxacin resistance and *S.* Stanley with nalidixic acid resistance are good examples), but statistical considerations indicate that resistant organisms occurring at a very low prevalence of between 1 % and 2 % might not be detected when following the recommendations of sampling and testing 170 isolates.

5. ANTIMICROBIAL RESISTANCE IN *CAMPYLOBACTER*

5.1. Introduction

The *Campylobacter* species most commonly associated with human infection are *C. jejuni* followed by *C. coli* and *C. lari*, but other species are also known to cause infections in humans. The infective dose of these bacteria is generally low.

The incubation period in humans ranges from two to five days. Patients may experience mild to severe symptoms, commonly including watery, sometimes bloody, diarrhoea, abdominal pain, fever, headache and nausea. Infections are usually self-limiting and last only a few days; treatment with antimicrobials is therefore usually not required. Extra-intestinal infections, invasive infections or post-infection complications such as reactive arthritis and neurological disorders can occur, but these are infrequent. *C. jejuni* is a recognised antecedent cause of Guillain–Barré syndrome, a form of paralysis that can sometimes result in dysfunction of the respiratory and neurological systems and can even be fatal.

Thermotolerant *Campylobacter* species are widespread in nature. The primary reservoirs are the alimentary tract of birds and mammals including food-producing animals (poultry, cattle, pigs and sheep). *Campylobacter* species have been isolated from pet animals, including cats and dogs, from wild birds, from water and from various environmental samples. Clinical disease resulting from infection with thermotolerant *Campylobacter* species is rare in animals.

Campylobacter can readily contaminate various food-stuffs including meat, raw milk and dairy products and less frequently fish and fish products, mussels and fresh vegetables. Considering sporadic human cases, contact with live poultry, consumption of poultry meat, drinking water from untreated water sources and contact with pets and other animals have been identified as significant and major sources of infection. Raw milk and drinking water contaminated with *Campylobacter* have caused large outbreaks.

Campylobacteriosis continues to be the most commonly reported zoonosis in humans in the EU since 2005. In 2011, the number of notified cases of thermotolerant *Campylobacter* in the EU increased by 2.3 % compared with 2010. The EU notification rate of confirmed cases of human campylobacteriosis shows a statistically significant increasing trend in the last four years, 2008–2011 (EFSA and ECDC, 2013). In 2011, fresh broiler and other poultry meat were again the foodstuffs in which *Campylobacter* was most frequently reported. Overall, more than one-third of the samples were reported positive, even though there were large differences between the MSs (EFSA and ECDC, 2013). As in previous years, most MSs reported high to extremely high prevalence of *Campylobacter* in broiler flocks (EFSA and ECDC, 2013).

5.2. Overview of reported data in humans, animals and food

Thirteen MSs and Iceland provided data for 2011 from *Campylobacter* isolates from human cases. These countries reported qualitative data, i.e. interpreted AST results for tested isolates (S, I or R), mainly derived from diffusion methods, but no MIC values or inhibition zone diameters.

In 2011, 17 MSs and two non-MSs (Norway and Switzerland) reported quantitative dilution data on antimicrobial resistance in *Campylobacter* isolates from animals and food. Antimicrobial susceptibility testing was carried out only for *C. jejuni* and *C. coli*, all other *Campylobacter* species were excluded from the monitoring programme of antimicrobial resistance in *Campylobacter*. Twelve MSs reported data where no method was specified.

Table CA1 presents an overview of the countries reporting antimicrobial resistance data on *Campylobacter* spp. from humans and various animal and food categories in 2011.

Table CA1. Overview of countries reporting antimicrobial resistance data using MIC and disc inhibition zones on* Campylobacter coli *and* Campylobacter jejuni *from humans and various animal and food categories in 2011

Bacterial species	Method	Origin	Total number of MSs reporting	Countries
C. coli	Diffusion	Human	8	**MSs:** AT, EE, FR, IT, LT[4], LU, RO, SI
		Gallus gallus (fowl)	2	**MSs:** FR[1], SK[2]
		Pigs	2	**MSs:** FR[1], SK[2]
		Meat from broilers (*Gallus gallus*)	3	**MSs:** ES[3], LU[1], PL[1]
	Dilution	Human	5	**MSs:** EE, ES, SK[4], SI, UK
		Gallus gallus (fowl)	10	**MSs:** AT, CZ, DE, ES, FI, FR, HU, IE, IT, NL
				Non-MS: CH
		Turkeys	1	**MS:** NL
		Pigs	6	**MSs:** DK, ES, FR, HU, NL, SE
				Non-MS: CH
		Cattle (bovine animals)	4	**MSs:** AT, ES, IT, NL
		Meat from broilers (*Gallus gallus*)	10	**MSs:** AT, BE, DE, EE, HU, IT, NL, PL, PT, RO
		Meat from turkey	4	**MSs:** HU, NL, PL, RO
		Meat from pig	3	**MSs:** BE, DE, PL
		Meat from bovine animals	1	**MS:** PL
C. jejuni	Diffusion	Human	8	**MSs:** AT, EE, FR, IT, LT[4], LU, RO, SI
		Gallus gallus (fowl)	2	**MSs:** FR[1], SI[2]
		Pigs	1	**MS:** SK[2]
		Cattle (bovine animals)	2	**MSs:** LU[3], SK[2]
		Meat from broilers (*Gallus gallus*)	4	**MSs:** ES[3], LU[1], PL[1], SI[2]
		Meat from pig	1	**MS:** BE[2]
	Dilution	Human	5	**MSs:** EE, ES, SK[4], SI, UK
		Gallus gallus (fowl)	11	**MSs:** AT, CZ, DE, DK, ES, FI, FR, HU, IE, IT, NL
				Non-MSs: CH, NO
		Turkeys	1	**MS:** NL
		Pigs	3	**MSs:** HU, IT, NL
		Cattle (bovine animals)	5	**MSs:** AT, DK, ES, IT, NL
		Meat from broilers (*Gallus gallus*)	11	**MSs:** AT, BE, DE, DK, EE, HU, IT, NL, PL, PT, RO
		Meat from turkey	3	**MSs:** HU, NL, PL
		Meat from pig	1	**MS:** PL
		Meat from bovine animals	1	**MS:** PL

1. These data were submitted with no test method specified and this information could not be obtained from the National Zoonoses Reports.
2. These data were submitted with the test method listed as dilution but no MIC distribution data were supplied.
3. These data were submitted with no test method specified but are believed to have been tested by disc diffusion based on information in the National Zoonoses Report.
4. Clinical breakpoints shown are from the 2010 report; clinical breakpoints for 2011 were not reported.

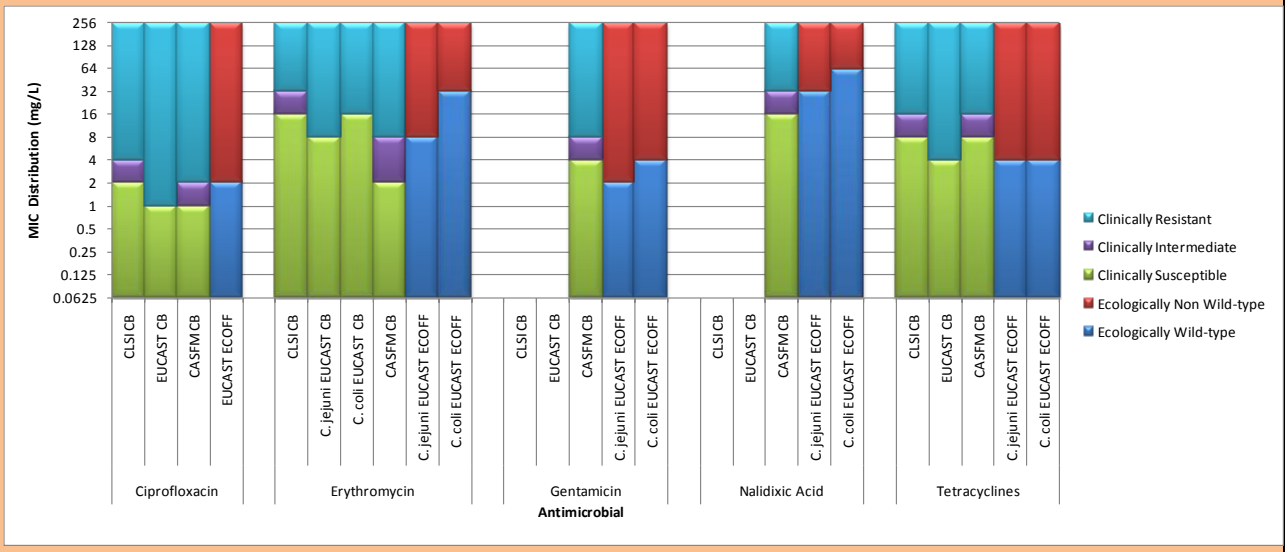
5.3. Antimicrobial resistance in *Campylobacter* isolates from humans

METHODS AND INTERPRETATIVE THRESHOLDS OF RESISTANCE IN *CAMPYLOBACTER* IN HUMANS

The method of testing for antimicrobial susceptibility varied between countries. Disc diffusion was the most common method, but often a combination of disc diffusion and dilution was used, depending on the reason for the testing. In several countries, the reference laboratories typed only a fraction of the isolates. The remaining isolates were typed by hospitals or local laboratories and the methods used by these are not reported. The guidelines used for the methodology and interpretation of antimicrobial susceptibility testing for Campylobacter *differed between countries and also within countries for different antimicrobials, but were more harmonised in 2011 than in 2010 (for detailed information, see Materials and methods, Table MM2). The guidelines used by several countries were from the CLSI, EUCAST and the French Society for Microbiology (CA-SFM).*

Of the five antimicrobials tested in both human and animal/food isolates, resistance according to the EUCAST clinical breakpoints and ECOFFS were at the same MIC value or only differing by one concentration step for ciprofloxacin, erythromycin and tetracycline, while no EUCAST clinical breakpoints were available for gentamicin and nalidixic acid. The CA-SFM breakpoints differed from the ECOFFS by two concentration steps for tetracycline, the combination of C. coli*/erythromycin and the combination of* C. jejuni*/gentamicin. In all other cases the breakpoints for CA-SFM and the ECOFFs were at the same MIC value or only differing by one concentration step. The level of resistance determined by CLSI breakpoints and ECOFFS were at the same MIC value or only differing by one concentration step except for tetracycline and the combination of* C. jejuni*/erythromycin where there was a two step difference. CLSI clinical breakpoints were not available for gentamicin or nalidixic acid (Figure CA1). Due to the variety of breakpoints used under each set of guidelines, results should be interpreted with caution in the case of antimicrobials where there are major differences in the interpretive criteria and direct comparisons between countries should be avoided.*

Figure CA1. Comparison of clinical breakpoints and epidemiological cut-off values used to interpret MIC data reported for* Campylobacter *spp. from humans, animals or food



Note: CLSI from 2011, EUCAST from 2011, CASFM from 2010, EUCAST ECOFFS as utilised by EFSA in 2011.

5.3.1. Antimicrobial resistance in *Campylobacter* spp. in humans

Thirteen MSs and Iceland submitted 2011 data on the antimicrobial susceptibility of *Campylobacter* spp. isolates from human clinical cases to ECDC. Twelve MSs and Iceland reported susceptibility results for more than 20 isolates, which was the limit set for presenting the level of resistance. One MS (Romania), reported susceptibility results for fewer than 20 isolates and was included only in the analysis totals.

A large variation was observed among the reporting countries with regard to the number of antimicrobials tested, ranging from six countries testing for amoxicillin to all 13 countries testing for ciprofloxacin (Table CA2). This most likely reflects the variation in the clinical importance of the antimicrobials. Fluoroquinolone antibiotics, such as ciprofloxacin, are also being increasingly used in many countries in the treatment of severe campylobacteriosis while the macrolide substance erythromycin remains the most commonly used antimicrobial for this purpose. The antibiotic for which the greatest number of *Campylobacter* spp. isolates were tested for susceptibility was erythromycin, at 34,888, representing 15.8 % of the total number of confirmed cases of campylobacteriosis reported in 25 countries in EU (N=220,209) (EFSA and ECDC, 2013).

The highest frequency of resistance in all *Campylobacter* spp. isolates tested was observed for nalidixic acid (47.8 %; N=21,240) and ciprofloxacin (44.4 %; N=34,395) followed by ampicillin (35.3 %; N=7,583) and tetracyclines (30.5 %; N=4,722) (Table CA2). *Campylobacter jejuni* and *C. coli* were the most commonly reported *Campylobacter* spp. in reporting MSs in 2011, accounting for, respectively, 81,975 and 5,623 reported human cases. Results for antimicrobial resistance are presented separately for these two *Campylobacter* species.

Levels of multi-drug resistance to six antimicrobials among *C. jejuni* and *C. coli* isolates from human are also presented. The six antimicrobials were amoxicillin, ampicillin, ciprofloxacin/nalidixic acid, erythromycin, gentamicin and tetracyclines. Of these, amoxicillin and ampicillin are not on the list of antimicrobials tested for in food and animal isolates. Multi-drug resistance is defined as non-susceptibility to at least three different antimicrobial classes. Co-resistance to ciprofloxacin and erythromycin was also estimated as these two antimicrobials are considered the most important for treatment of severe campylobacteriosis (EFSA, 2009d).

In order to assess whether there were any differences in resistance levels between human *Campylobacter* infections acquired within the EU/EEA and infections acquired when travelling outside the EU/EEA, resistance data are presented by region based on most likely country of infection.

Table CA2. Antimicrobial resistance in* Campylobacter *spp. from humans per country in 2011, using clinical breakpoints

Country	Amoxicillin		Ampicillin		Ciprofloxacin		Erythromycin		Gentamicin		Nalidixic Acid		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	429	0	429	27.0	429	65.7	429	0.9	429	0.5	429	64.8	429	30.3
Estonia	61	9.8	62	35.5	190	57.4	189	2.1	65	1.5	26	42.3	156	28.8
France	5,196	0	5,198	31.0	5,196	51.5	5,196	2.6	5,196	0	5,198	53.4	-	-
Hungary	-	-	-	-	94	75.5	-	-	-	-	-	-	-	-
Italy	-	-	120	60.0	213	65.7	233	7.7	131	2.3	123	74.8	169	56.8
Lithuania	-	-	-	-	378	81.2	428	0.5	-	-	-	-	-	-
Luxembourg	-	-	-	-	684	53.9	684	2.6	-	-	684	54.7	-	-
Malta	-	-	-	-	202	64.9	204	2.9	-	-	-	-	-	-
Romania	-	-	-	-	3	NA	3	NA	3	NA	3	NA	3	NA
Slovakia	-	-	100	15.0	929	20.1	1,030	0.5	11	NA	-	-	1,009	8.1
Slovenia	790	4.9	997	37.4	997	64.2	997	1.3	997	0.4	790	58.7	996	17.7
Spain	221	9.0	221	50.7	221	84.6	221	11.3	214	4.2	236	93.6	221	79.2
United Kingdom	162	14.2	456	77.9	24,859	41.0	25,274	3.9	1,067	0.7	13,751	43.1	1,739	42.2
Total (13 MSs)	**6,859**	**1.3**	**7,583**	**35.3**	**34,395**	**44.4**	**34,888**	**3.5**	**8,113**	**0.4**	**21,240**	**47.8**	**4,722**	**30.5**
Iceland	-	-	-	-	122	45.9	123	0	-	-	-	-	-	-

N = number of isolates tested.

% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable; if fewer than 20 isolates were tested, resistance was not calculated.

5.3.2. Antimicrobial resistance in *C. jejuni* in humans

In 2011, 12 MSs and Iceland reported data on antimicrobial resistance in *C. jejuni* for ≥20 isolates (ranging from six MSs for amoxicillin to all 13 countries for ciprofloxacin (Table CA3)). The highest frequencies of resistance in *C. jejuni* isolates were observed for nalidixic acid (52.7 %; N=6,865) and ciprofloxacin (52.5 %; N=8,647) (Table CA3). Erythromycin, or another suitable macrolide, is the first choice drug for the treatment of campylobacteriosis in humans (EFSA, 2009d). In 2011, the level of resistance for erythromycin reported in humans was low, on average 1.5 % (N=8,808). In the EU, the highest proportions of resistant isolates were reported by Italy with 6.3 % (N=189), and Spain, with 4.8 % (N=166) (Table CA3), although in the case of Italy a lower breakpoint was applied for resistance to erythromycin (see Table MM2).

Ciprofloxacin is the second-choice drug for treatment of campylobacteriosis in humans (EFSA, 2009d) although resistance evolves rapidly. The resistance to ciprofloxacin reported in each country was moderate to extremely high ranging from 20.9 % to 87.3 %. The highest levels of resistance, 87.3 % (N=166) and 83.1 % (N=260), were observed in Spain and Lithuania, respectively (Table CA3).

Nalidixic acid is normally used as an indicator of ciprofloxacin resistance. Resistance to nalidixic acid and ciprofloxacin was comparable and the levels of resistance to nalidixic acid ranged from 45.4 % to 94.9 % (Table CA3), although the breakpoints used differed between countries.

Country-specific trends for erythromycin over the years 2007–2011 are presented in Figure CA3. There were few common trends between countries over the years. The exception was a peak in resistance observed in 2010 in both Iceland (5.5 %; N=54) and Malta (10.2 %; N=127). In the years before and after 2010, resistance levels in both countries were at, or close to, 0 % (Figure CA2). Some of the fluctuations observed over time could be attributed to a low number of isolates being tested in these countries and it is likely that the resistance levels will become more stable when the number of isolates tested increases. A possible example of this is Estonia, where the number of isolates tested increased over the five-year period and where the resistance in *C. jejuni* to erythromycin decreased from 8.1 % (N=37) in 2007 to 0 % in 2009 (N=143) and 2010 (N=178) and, in 2011, was at 2.2 % (N=183).

Country-specific trends in resistance to ciprofloxacin over the years 2007–2011 are presented in Figure CA2. There were few noticeable changes in resistance to ciprofloxacin in the reporting countries over this period; however, a trend of increasing resistance was observed in Iceland, Italy, Lithuania and Slovenia since 2009 and in Estonia since 2008. In contrast to *Salmonella*, the breakpoints used for MIC determination for ciprofloxacin for *Campylobacter* differed less between the countries, with a maximum of two dilutions difference. The disc diffusion zones used were also comparable, with the exception of one country (Italy) assigning a more sensitive breakpoint for resistance to ciprofloxacin.

Four MSs, Austria, Estonia, Slovenia and Spain, tested at least 10 isolates for the full range of antimicrobials included in the human data collection for *C. jejuni*, and these isolates were included in the multi-drug resistance analysis. Overall, 18.4 % (N=1,299) of the human *C. jejuni* isolates were susceptible to all six antimicrobials, with particularly low levels of susceptibility reported from Spain (1.2 %; N=161) and Estonia (2.2 %; N=45) (Table CA4). Multi-drug resistance was, on average, high in the four MSs (23.2 %; N=1,299; country average 31.3 %). There was large variation in the level of multi-resistance between countries ranging from 14.8 % (N=393) in Austria to 55.3 % (N=161) in Spain (Table CA4). The proportions of *C. jejuni* isolates susceptible to all or resistant (non-susceptible) to any one up to six antimicrobials by MS are presented in Figure CA4. Isolates resistant to up to five antimicrobials were reported from two MSs and isolates resistant to up to all six antimicrobials in one MS. Few isolates exhibited co-resistance to both ciprofloxacin and erythromycin in the three MSs (1.2 %; N=1,299) (Table CA4).

Table CA3. Antimicrobial resistance in* Campylobacter jejuni *from humans per country in 2011, using clinical breakpoints

Country	Amoxicillin		Ampicillin		Ciprofloxacin		Erythromycin		Gentamicin		Nalidixic Acid		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	393	0	393	28.0	393	65.4	393	0.3	393	0.5	393	64.4	393	30.0
Estonia	58	10.3	59	37.3	183	58.5	183	2.2	62	1.6	23	47.8	150	29.3
France	4,278	0	4,279	32.1	4,278	51.3	4,278	1.6	4,278	0	4,279	49.4	-	-
Hungary	-	-	-	-	27	59.3	-	-	-	-	-	-	-	-
Italy	-	-	91	70.3	162	69.8	189	6.3	104	1.9	103	75.7	136	59.6
Lithuania	-	-	-	-	260	83.1	296	0.3	-	-	-	-	-	-
Luxembourg	-	-	-	-	623	51.8	623	0.6	-	-	623	52.5	-	-
Malta	-	-	-	-	147	69.4	149	0.7	-	-	-	-	-	-
Slovakia	-	-	74	18.9	868	20.9	962	0.5	4	NA	-	-	937	7.9
Slovenia	701	5.3	882	39.9	882	67.2	882	1.0	882	0.2	701	58.2	881	18.4
Spain	166	10.8	166	56.6	166	87.3	166	4.8	161	3.1	175	94.9	166	80.1
United Kingdom	1	NA	3	NA	658	44.1	687	2.2	6	NA	568	45.4	83	34.9
Total (12 MSs)	**5,597**	**1.1**	**5,947**	**34.2**	**8,647**	**52.5**	**8,808**	**1.5**	**5,890**	**0.2**	**6,865**	**52.7**	**2,746**	**23.3**
Iceland	-	-	-	-	120	45.8	121	0	-	-	-	-	-	-

N = number of isolates tested.

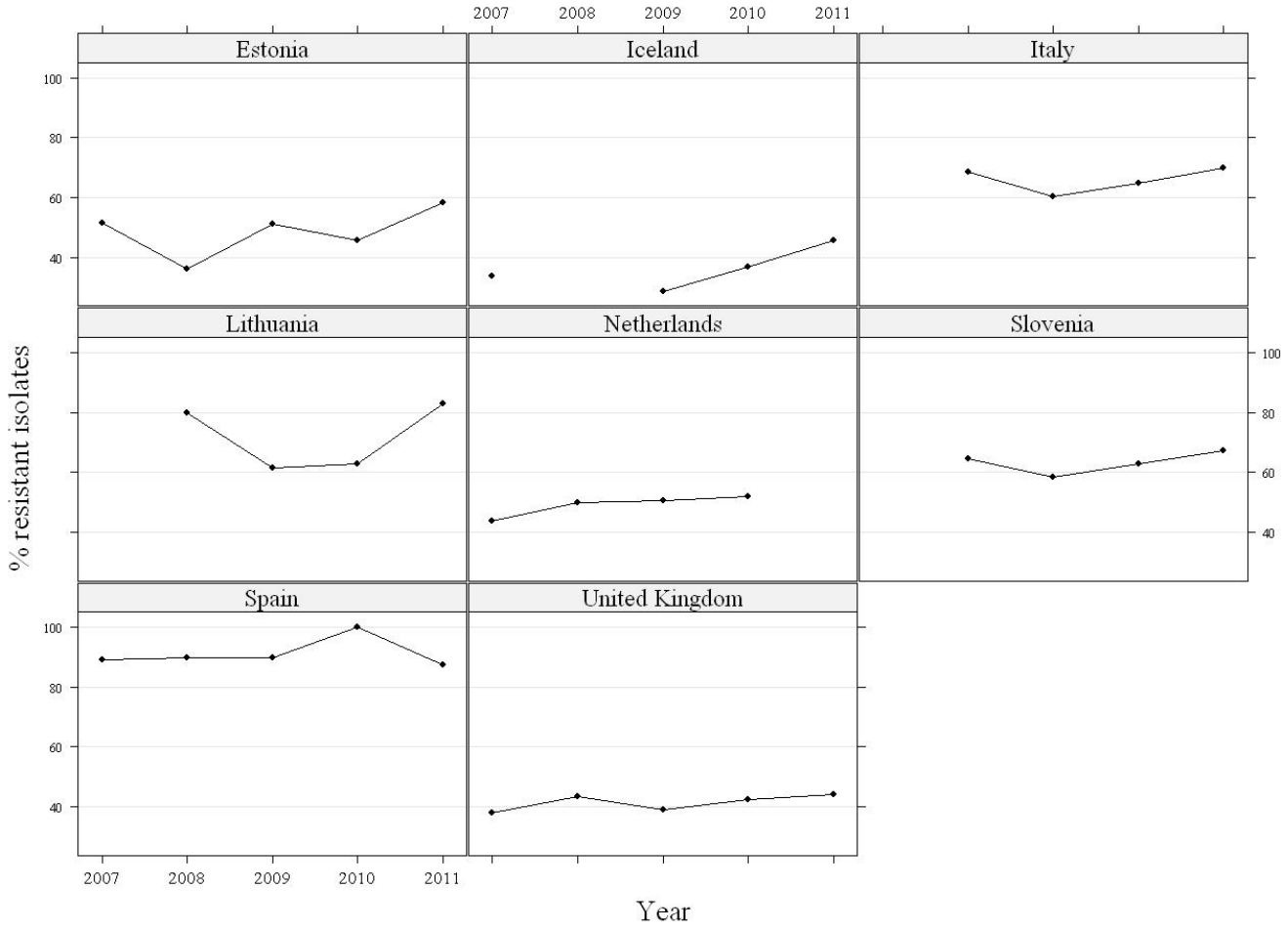
% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable; if fewer than 20 isolates were tested, resistance was not calculated.

Figure CA2. Resistance to ciprofloxacin in* C. jejuni *in humans in reporting MSs in the EU, 2007-2011, using clinical breakpoints

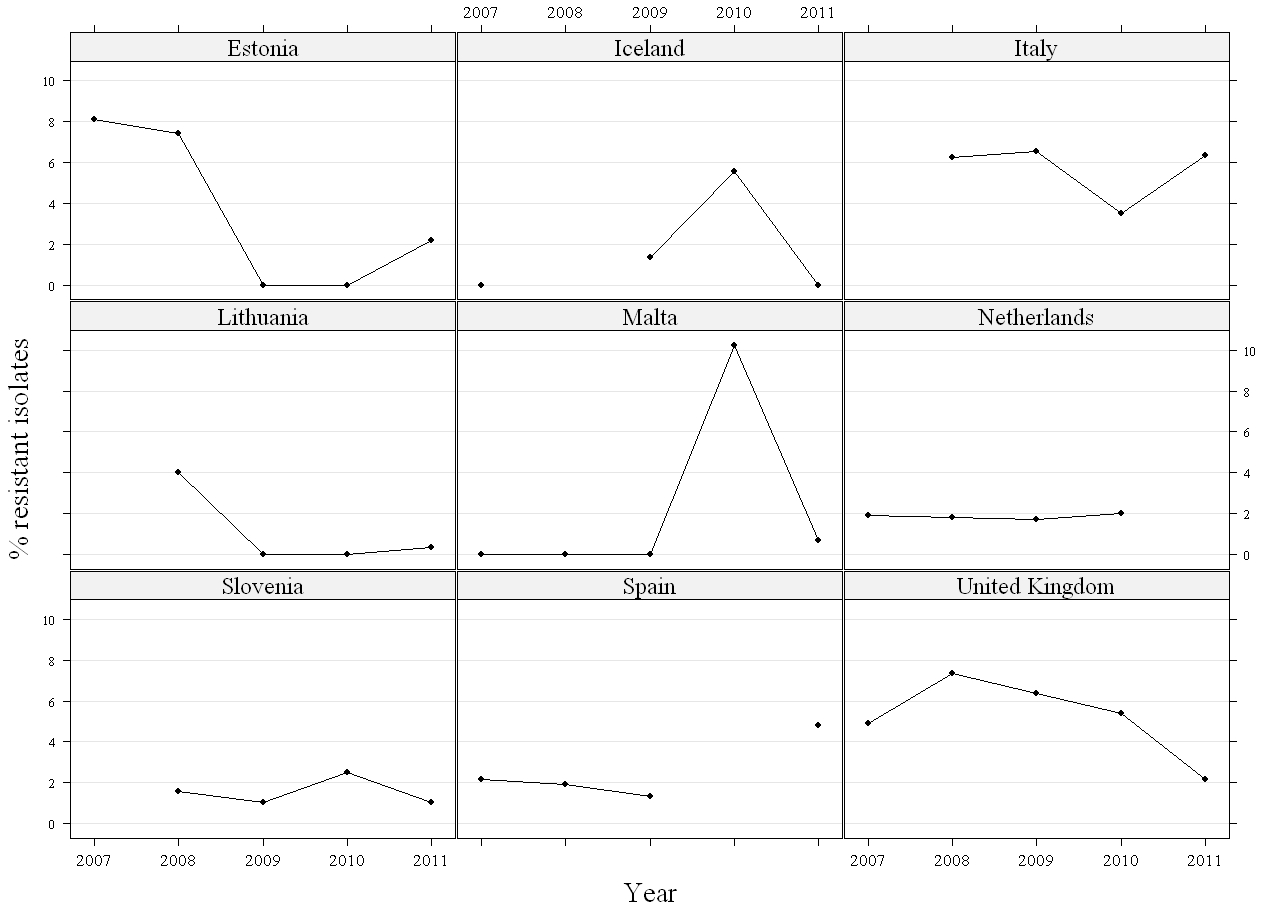
Direct comparisons between countries should be avoided owing to the use of different interpretative criteria[1]



1. Guidelines used for AST: Estonia (CLSI dilution, SRGA-M disc diffusion), Lithuania (BSAC), Italy (CLSI), the Netherlands (unspecified), Slovenia (CLSI dilution, CA-SFM disc diffusion), UK (modified BSAC). See also Table MM2.

Figure CA3. Resistance to erythromycin in C. jejuni in humans in reporting MSs in the EU, 2007-2011, using clinical breakpoints

Direct comparisons between countries should be avoided owing to the use of different interpretative criteria[1]



1. Guidelines used for AST: Estonia (SRGA-M), Lithuania (BSAC), Italy (CLSI), Malta (CA-SFM), the Netherlands (unspecified), Slovenia (CLSI dilution, CA-SFM disc diffusion), UK (CLSI). See also Table MM2.

Table CA4. Complete susceptibility, multi-resistance and co-resistance (non-susceptibility) in ciprofloxacin and erythromycin, as determined by clinical breakpoints, in* C. jejuni *from humans by MS, 2011

Country	Susceptible to all (%)	Multi-resistant (%)	Co-resistant to CIP and ERY (%)
Austria (N=393)	1.2	14.8	0.3
Estonia (N=45)	2.2	35.6	6.7
Slovenia (N=700)	17.9	19.7	0.6
Spain (N=161)	1.2	55.3	5.0
Total (4 MSs) (N=1,299)	**18.4**	**23.2**	**1.2**

N = total number of isolates tested for susceptibility against the whole common antimicrobial set for *Campylobacter*.

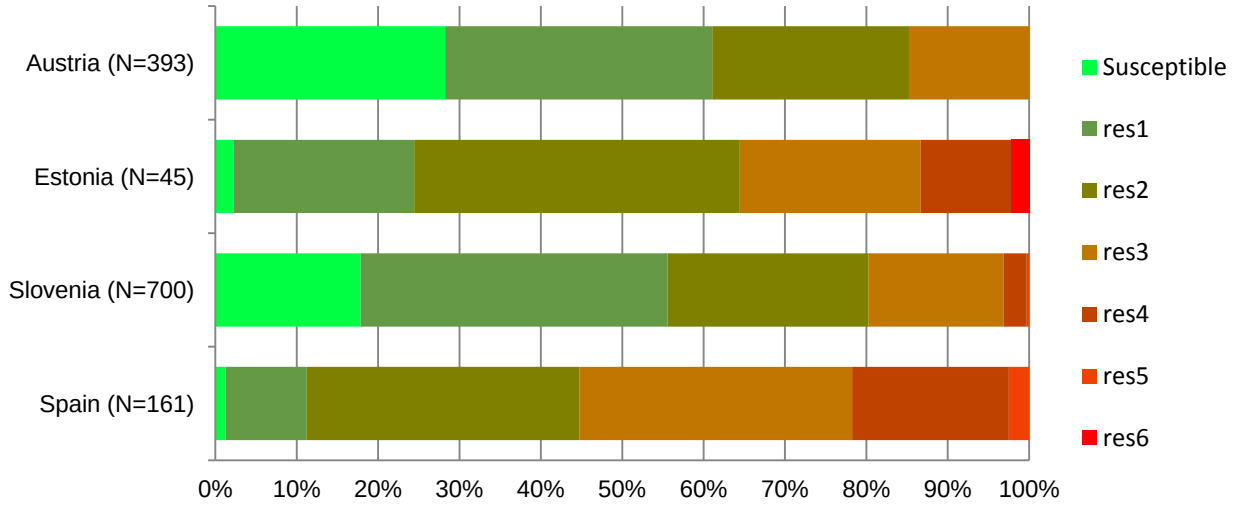
CIP = ciprofloxacin; ERY = erythromycin.

Susceptible to all = proportion of isolates susceptible to all antimicrobial substances of the ECDC common set for *Campylobacter*.

Multi-resistant = proportion of isolates resistant to at least three different antimicrobial substances, belonging to any three antimicrobial families from the ECDC common antimicrobial set for *Campylobacter.*

Co-resistant to CIP and ERY = proportion of isolates not susceptible to both CIP and ERY.

Figure CA4. Frequency distribution of completely susceptible isolates and resistant isolates to from one to six antimicrobials, as determined by clinical breakpoints, in* C. jejuni *from humans by MS, 2011



N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances for *C. jejuni*.

Susceptible = total number of isolates susceptible to all antimicrobial substances of the common set for *C. jejuni*.

res1/res6 = total number of isolates resistant to between one and six antimicrobial substances of the common set for *C. jejuni*.

5.3.3. Antimicrobial resistance in *C. coli* in humans

The number of reported isolates of *C. coli* tested for antimicrobial susceptibility in 2011 varied from 152 tested for tetracyclines to 1,116 tested for erythromycin out of the 5,473 confirmed reported human cases of campylobacteriosis due to *C. coli* in the EU. In 2011, eight MSs reported data on antimicrobial resistance on ≥20 isolates (ranging from three MSs for tetracyclines to eight MSs for ciprofloxacin (Table CA5)).

The highest percentage of resistance among *C. coli* isolates was observed for nalidixic acid (69.2 %; N=1,018) followed by ciprofloxacin (59.6 %; N=1,115) and tetracyclines (48.7 %; N=152) (Table CA5). The percentage of resistance to ciprofloxacin was highly correlated with resistance to nalidixic acid in each of the six countries which tested both antimicrobials. The percentage of human *C. coli* isolates resistant to erythromycin was 10.3 % (N=1,116), which was considerably higher than for *C. jejuni* (1.4 %). The highest levels of resistance to erythromycin were reported from Spain (33.3 %; N=51) and Luxembourg (23.3 %; N=60), but the number of isolates tested was low in each case (Table CA5).

Country-specific trends in resistance to erythromycin over the years 2007–2011 were relatively stable, except for a peak observed in the United Kingdom in 2009, when only 3 isolates were tested (Figure CA6). A notable trend of decreasing *C. coli* resistance to erythromycin was observed in Italy, although only a small number of isolates were tested (N=19-22).

There were few similarities in resistance trends for ciprofloxacin between countries over the years 2007–2011. The trends in resistance to ciprofloxacin during 2007–2011 were less stable among *C. coli* isolates than among *C. jejuni* isolates across three countries (Italy, Lithuania and the United Kingdom), although this may be explained by the small number of *C. coli* isolates tested. In Slovenia and Spain, the trend was more stable and was similar to that for *C. jejuni*. An increasing trend of resistance was observed in the Netherlands, although data for 2011 were not reported (Figure CA5).

Three MSs, Austria, Slovenia and Spain tested at least 10 isolates for the full range of antimicrobials included in the human data collection for *C. coli* and these isolates were included in the multi-drug resistance analysis. Overall, only 13.4 % (N=119) of the human *C. coli* isolates were susceptible to all six antimicrobials, with particularly low levels of susceptibility reported in Spain (4.1 %; N=49) and higher levels of susceptibility reported in Austria (25.0 %; N=36) (Table CA6). On average, the level of multi-drug resistance was high (26.1 %; N=119) (Table CA6). The proportions of *C. coli* isolates susceptible to all or resistant (non-susceptible) to any one up to six antimicrobials by MS are presented in Figure CA7. Isolates resistant to up to five antimicrobials were reported from two MSs, however no isolates were found to be resistant to all six antimicrobials. The overall level of co-resistance to both ciprofloxacin and erythromycin was medium across these three countries (16.0 %; N=119) (Table CA4).

Table CA5. Antimicrobial resistance in* Campylobacter coli *from humans per country in 2011, using clinical breakpoints

Country	Amoxicillin		Ampicillin		Ciprofloxacin		Erythromycin		Gentamicin		Nalidixic Acid		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	36	0	36	16.7	36	69.4	36	8.3	36	0	36	69.4	36	33.3
Estonia	1	NA	1	NA	1	NA	-	-	1	NA	1	NA	-	-
France	759	0	760	27.4	759	57.8	759	7.8	759	0.1	760	68.8	-	-
Hungary	-	-	-	-	5	NA	-	-	-	-	-	-	-	-
Italy	-	-	8	NA	18	NA	19	NA	13	NA	11	81.8	18	NA
Lithuania	-	-	-	-	39	74.4	45	2.2	-	-	-	-	-	-
Luxembourg	-	-	-	-	60	75.0	60	23.3	-	-	60	76.7	-	-
Malta	-	-	-	-	40	55.0	40	7.5	-	-	-	-	-	-
Romania	-	-	-	-	3	NA	3	NA	3	NA	3	NA	3	NA
Slovenia	34	2.9	42	35.7	42	52.4	42	7.1	42	2.4	34	58.8	42	21.4
Spain	51	3.9	51	35.3	51	78.4	51	33.3	49	8.2	57	89.5	51	80.4
United Kingdom	1	NA	-	-	61	47.5	61	14.8	3	NA	56	53.6	2	NA
Total (12 MSs)	**882**	**0.3**	**898**	**27.8**	**1,115**	**59.6**	**1,116**	**10.3**	**906**	**0.9**	**1,018**	**69.2**	**152**	**48.7**

N = number of isolates tested.

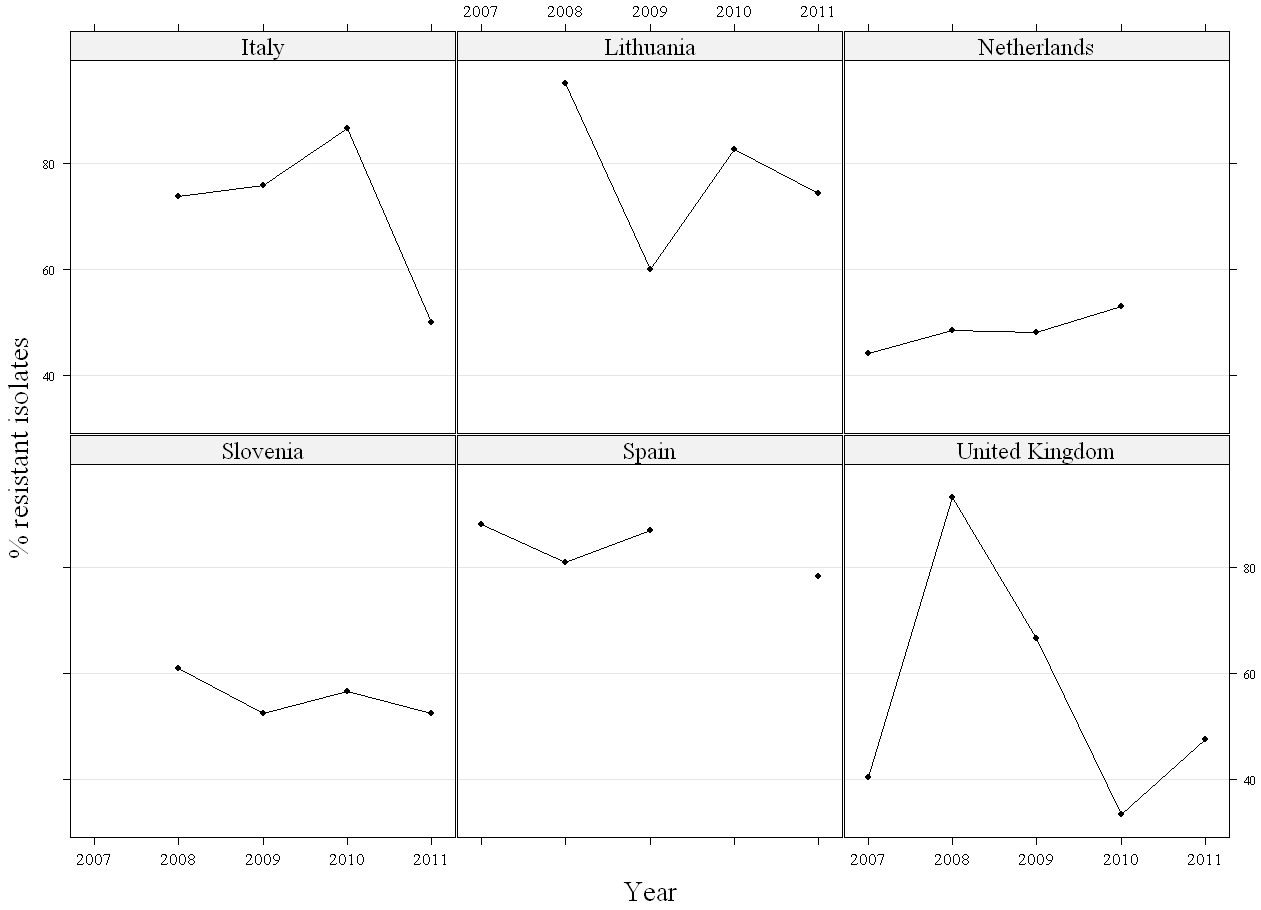
% Res = percentage of resistant isolates.

– = no data reported.

NA = not applicable; if fewer than 20 isolates were tested, resistance was not calculated.

Figure CA5. Resistance to ciprofloxacin in C. coli in humans in reporting MSs in the EU, 2007-2011, using clinical breakpoints

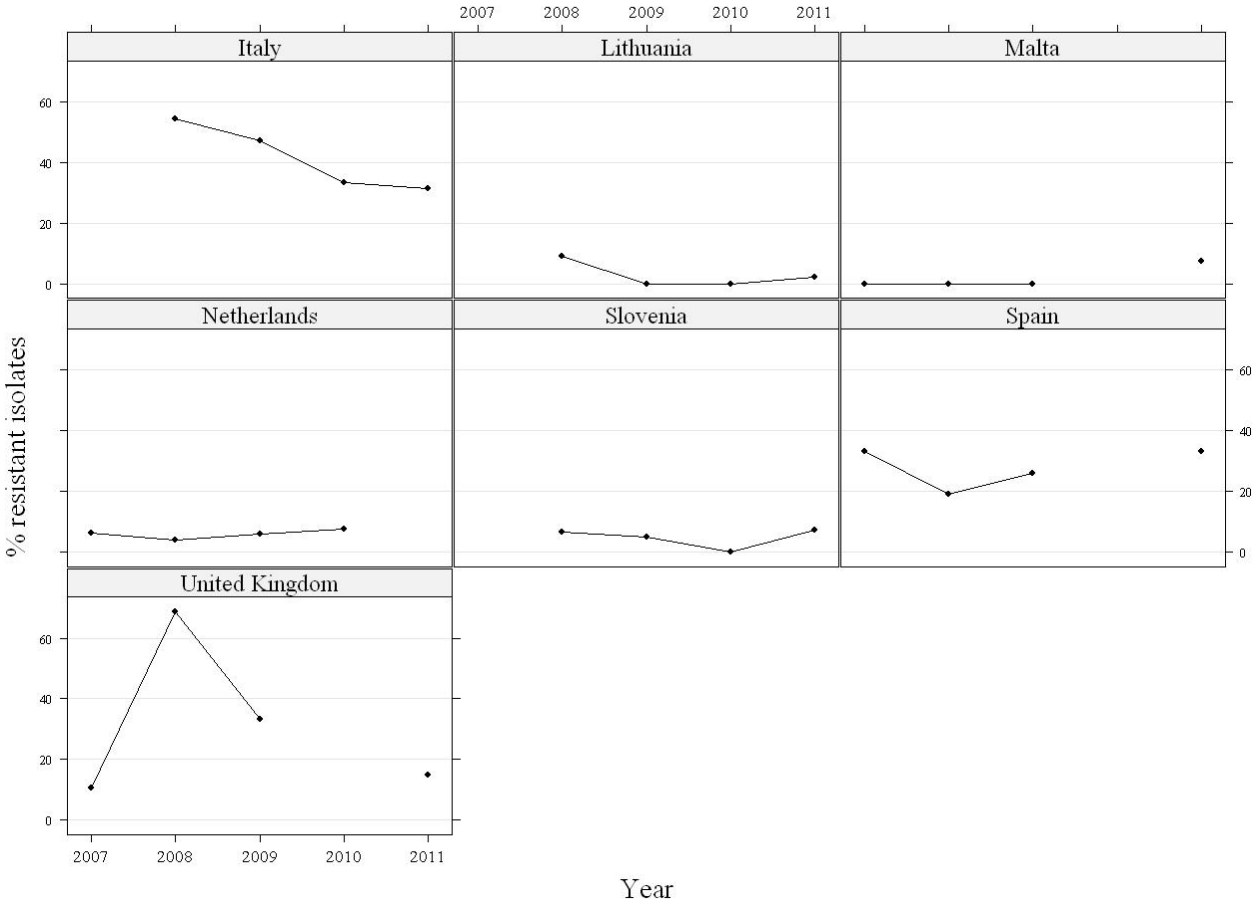
Direct comparisons between countries should be avoided owing to the use of different interpretive criteria[1]



1. Guidelines used for AST: Estonia (CLSI dilution, SRGA-M disc diffusion), Lithuania (BSAC), Italy (CLSI), the Netherlands (unspecified), Slovenia (CLSI dilution, CA-SFM disc diffusion), UK (modified BSAC). See also Table MM2.

Figure CA6. Resistance to erythromycin in C. coli in humans in reporting MSs in the EU, 2007-2011, using clinical breakpoints

Direct comparisons between countries should be avoided owing to the use of different interpretive criteria[1]



1. Guidelines used for AST: the Netherlands (unspecified), Slovenia (CLSI dilution, CA-SFM disc diffusion). See also Table MM2.

Table CA6. Complete susceptibility, multi-resistance and co-resistance (non-susceptibility) in ciprofloxacin and erythromycin, as determined by clinical breakpoints, in C. coli from humans by MS, 2011

Country	Susceptible to all (%)	Multi-resistant (%)	Co-resistant to CIP and ERY (%)
Austria (N=36)	25.0	8.3	5.6
Slovenia (N=34)	14.7	11.8	11.8
Spain (N=49)	4.1	49.0	26.5
Total (3 MSs) (N=119)	**13.4**	**26.1**	**16.0**

N = total number of isolates tested for susceptibility against the whole common antimicrobial set for *Campylobacter*.

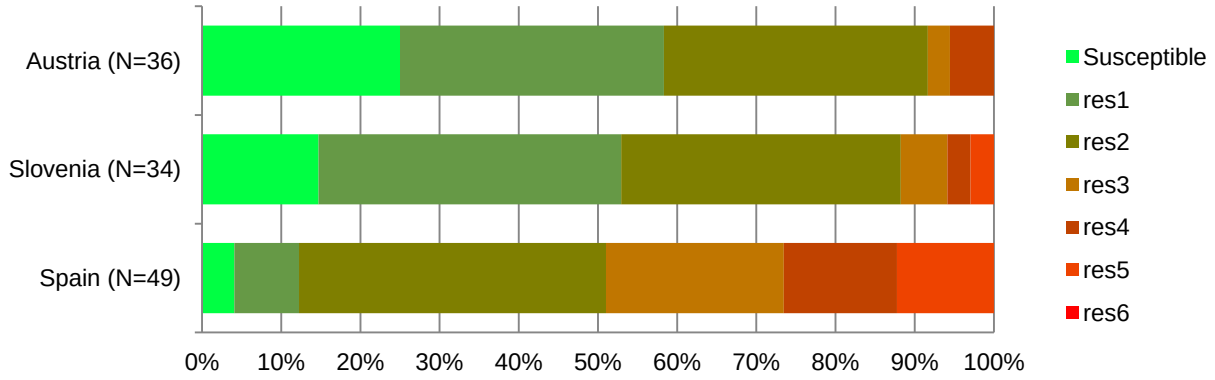
CIP = ciprofloxacin; ERY = erythromycin.

Susceptible to all = proportion of isolates susceptible to all antimicrobial substances of the ECDC common set for *Campylobacter*.

Multi-resistant = proportion of isolates resistant to at least three different antimicrobial substances, belonging to any three antimicrobial families from the ECDC common antimicrobial set for *Campylobacter.*

Co-resistant to CIP and ERY = proportion of isolates not susceptible to both CIP and ERY.

Figure CA7. Frequency distribution of C. coli isolates completely susceptible or resistant to one to six antimicrobials, as determined by clinical breakpoints, from humans by MS, 2011



N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances for *C. coli*.

Susceptible = total number of isolates susceptible to all antimicrobial substances of the common set for *C. coli*.

res1/res6 = total number of isolates resistant to between one and six antimicrobial substances of the common set for *C. coli*.

5.3.4. Antimicrobial resistance in *Campylobacter* spp. from humans by geographical region

Travel-associated isolates were more often tested for any antimicrobial resistance than isolates from cases reported as domestically acquired (59.4 % vs. 25.0 %). Varying levels of resistance were observed among *Campylobacter* spp. infections acquired from different geographical regions around the world (Table CA7). Data on resistance to four antimicrobials (ciprofloxacin, erythromycin, nalidixic acid and tetracyclines) were reported for ≥10 isolates from infections acquired in three geographical regions (EU/EEA, Africa and Asia). Of the isolates tested for resistance to these antimicrobials, less than 3 % came from geographical regions other than the EU/EEA.

The highest frequency of resistance to all four antimicrobials was observed among isolates that had been acquired in Asia, with resistance being highest to nalidixic acid (84.0 %; N=50) and ciprofloxacin (84.4 %; N=90). In all three regions the proportion of isolates resistant to ciprofloxacin was comparable to the proportion resistant to nalidixic acid. The level of resistance to erythromycin was comparable in isolates acquired in Asia (8.8 %; N=91) and Africa (10.3 %; N=39) but notably lower in isolates from the EU/EEA (4.6 %; N=9,423) (Table CA7).

An insufficient number of isolates from cases acquired in non-EU/EEA European countries, Northern and Central America, South America or Oceania were tested to allow these data to be included in the analysis (Table CA7).

Table CA7. Antimicrobial resistance in* Campylobacter *spp. reported to be acquired within the EU and in other geographical regions in 2011, using clinical breakpoints

Country	Amoxicillin		Ampicillin		Ciprofloxacin		Erythromycin		Gentamicin		Nalidixic Acid		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Europe (EU/EEA Countries)	1,280	1.9	1,472	34.2	9,864	46.6	9,423	4.6	1,411	0.6	3,379	49.9	4,499	26.4
Europe (non-EU/EEA Countries)	2	NA	3	NA	7	NA	7	NA	2	NA	No Observations		3	NA
Africa	1	NA	2	NA	40	67.5	39	10.3	2	NA	21	57.1	11	54.5
Asia	4	NA	7	NA	90	84.4	91	8.8	6	NA	50	84.0	15	46.7
Northern & Central America	No Observations		No Observations		9	NA	9	NA	No Observations		4	NA	No Observations	
South America	No Observations		No Observations		5	NA	5	NA	No Observations		2	NA	1	NA
Oceania	No Observations		No Observations		7	NA	7	NA	No Observations		1	NA	3	NA

N = number of isolates tested.

% Res = percentage of resistant isolates.

NA = not applicable; if fewer than 10 isolates were tested, resistance was not calculated.

5.4. Antimicrobial resistance in *Campylobacter* isolates from animals and food

The total number of *Campylobacter* isolates from animals and food for which quantitative MIC tests have been performed in 2011 by MSs and non-MSs was 36,064. Table CA1 presents the countries reporting on C*ampylobacter* resistance, and the animal and food sampling origins, in 2011. Antimicrobials selected by the different MSs and non-MSs for susceptibility testing of *C. jejuni* and *C. coli* are shown in Chapter 11, Materials and Methods, Table MM6.

In this chapter, resistance to ciprofloxacin, erythromycin, gentamicin, nalidixic acid and tetracyclines is described in detail. Tables of the occurrence of resistance were generated, and multi-resistance analysis was performed, if four or more countries reported quantitative data for a given *Campylobacter* species and sampling origin. In addition, only data relating to 10 or more isolates per country, per sampling origin, per year are included in the report.

Where the minimum criteria were met, temporal trend graphs were generated, showing percentage resistance to different antimicrobials among *Campylobacter* isolates from animals and food over the period 2005–2011, by year of sampling. Only countries which had reported on four or more years in the 2005–2011 period were included. In the particular case of quinolones, such as ciprofloxacin and nalidixic acid, mutations in the *gyrA* gene are frequently responsible for quinolone resistance, with or without the additional effect of efflux pumps, and this mechanism of resistance usually confers resistance to both quinolones and fluoroquinolones in *Campylobacter*. Because this is the commonest mechanism of resistance, the level of resistance to nalidixic acid and ciprofloxacin is generally similar for a given group of isolates. In the light of this known correlation between resistance to one and decreased susceptibility to the other agent, temporal trends are illustrated with trellis graphs combining data on these two antimicrobial substances.

The spatial distributions of ciprofloxacin and erythromycin resistance rates in *C. jejuni* from *Gallus gallus* and *C. coli* from pigs are presented. For countries where resistance level figures for 2011 were not available, 2010 figures were used instead. For cattle, the number of reporting countries was lower than in the case of the other animal species monitored and, therefore, no spatial distribution maps were generated.

Where the minimum criteria for detailed analysis were met, multi-resistance was analysed in the isolate-based dataset of *Campylobacter* isolates tested for the full harmonised set of five antimicrobials (ciprofloxacin, erythromycin, gentamicin, streptomycin and tetracyclines) belonging to different classes. Multi-resistance was defined as non-susceptibility to at least three different antimicrobial classes. The proportions of isolates susceptible to all and resistant (non-susceptible) to any one up to nine antimicrobials are presented. Co-resistance to ciprofloxacin and erythromycin was also estimated as these two antimicrobials are of particular interest in human medicine in the treatment of severe campylobacteriosis. The interpretative ECOFFs used to address co-resistance to ciprofloxacin and erythromycin were, for *C. jejuni*, CIP >1 mg/L and ERY >4 mg/L and, for *C. coli*, CIP >1 mg/L and ERY >16 mg/L. These values may be considered as very similar to clinical breakpoints.

Further information on reported MIC distributions and numbers of *C. jejuni* and *C. coli* isolates resistant to amoxicillin, ampicillin chloramphenicol, ciprofloxacin, clarithromycin, colistin, erythromycin, gentamicin, imipenem, nalidixic acid, neomycin, streptomycin, sulfonamides, tetracyclines and tulathromycin can be found in the Level 3 tables published on the EFSA website.

Antimicrobial resistance in *Campylobacter* isolates from food

5.4.1.1. Meat from broilers (*Gallus gallus*)

In reporting MSs, data on antimicrobial resistance in *Campylobacter* isolates from meat from broilers were derived from active monitoring programmes based on the random collection of samples of broiler meat performed at the slaughterhouse, at the processing plant or at retail outlets. In Austria every business was sampled once a year. In Hungary, samples were randomly collected at processing plants as part of a monitoring scheme. In Poland, sampling of broiler meat was performed at processing plants, while in Denmark sampling was carried out at wholesale or retail outlets. In Belgium, *Campylobacter* isolates derived from carcasses (neck skin samples) were collected at the slaughterhouse and isolates from fresh meat and meat preparations were collected at the processing plant.

Resistance levels among *C. jejuni*

In 2011, nine MSs provided quantitative antimicrobial resistance data for *C. jejuni* isolates from broiler meat (Table CA8). For tetracyclines the proportion of resistant isolates for all reporting MSs was high, at 46.9 %. Resistance ranged from low in Denmark (9.8 %) to extremely high in Italy (76.9 %). Resistance to gentamicin and erythromycin was low, at 1.7 % and 3.1%, respectively. Romania reported the highest level of resistance to gentamicin and erythromycin, at 17.3 % and 9.6 %, respectively.

For all reporting MSs, the proportion of resistance to quinolones was very high (59.2 % for ciprofloxacin and 56.9 % for nalidixic acid). For individual MSs, resistance to ciprofloxacin and nalidixic acid ranged from moderate in Denmark (11.5 %) to extremely high in Poland (90.2 % and 89.7 %, respectively).

Table CA8. Resistance (%) to ciprofloxacin, erythromycin, gentamicin, nalidixic acid and tetracyclines among* Campylobacter jejuni *from meat from broilers in MSs reporting MIC data in 2011, using harmonised epidemiological cut-off values

Country	Ciprofloxacin		Erythromycin		Gentamicin		Nalidixic acid		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	84	53.6	84	0	84	0	84	50.0	84	23.8
Belgium	259	36.7	259	7.7	259	1.9	259	39.0	259	49.0
Denmark	61	11.5	61	0	61	0	61	11.5	61	9.8
Germany	188	64.9	188	0.5	188	0	188	58.5	188	46.3
Hungary	33	84.8	33	0	33	6.1	-	-	33	54.5
Italy	13	76.9	13	0	13	0	13	61.5	13	76.9
Netherlands	83	63.9	83	3.6	83	0	83	63.9	83	49.4
Poland	174	90.2	174	0	174	0	174	89.7	174	56.9
Romania	52	84.6	52	9.6	52	17.3	52	82.7	52	69.2
Total (9 MSs)	**947**	**59.2**	**947**	**3.1**	**947**	**1.7**	**914**	**56.9**	**947**	**46.9**

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

Multi-resistance among *C. jejuni* isolates in meat from broilers

In 2011, four MSs provided isolate-based data regarding resistance in *C. jejuni* from meat from broilers. Analysis of the multi-resistance showed that, among the reporting MSs, isolates exhibiting complete susceptibility accounted for about 27.7 % of isolates in Germany, 40.5 % in Austria and Italy and 86.9 % in Denmark. Only Germany detected any multi-resistance, i.e. isolates exhibiting reduced susceptibility to at least three different antimicrobial substances of the common set, at a level of 2.7 % (Table CA9). Very few isolates were resistant to both ciprofloxacin and erythromycin.

Table CA9. Complete susceptibility, multi-resistance and index of diversity in C. jejuni *from meat from broilers in MSs reporting isolate-based data, 2011*

Country	Susceptible to all		Multi-resistant		Index of diversity	Co-resistant to CIP and ERY	
	n	%	n	%		n	%
Austria (N=84)	34	40.5	0	0	0.199	0	0
Denmark (N=61)	53	86.9	0	0	0.156	0	0
Germany (N=188)	52	27.7	5	2.7	0.270	1	0.5
Italy (N=13)	1	7.7	0	0	0.182	0	0

N = total number of isolates tested for susceptibility against the whole common antimicrobial set for *Campylobacter*.

n = number of isolates per category of complete susceptibility or multiple resistance.

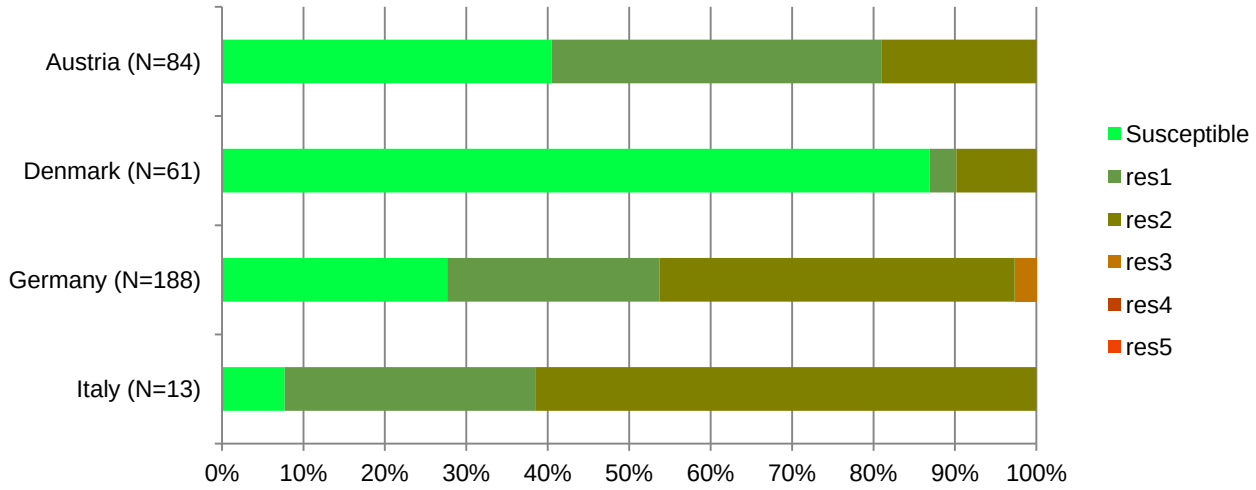
Susceptible to all = isolate susceptible to all antimicrobial substances of the EFSA common set for *Campylobacter*.

Multi-resistant = resistant to at least three different antimicrobial substances, belonging to any three antimicrobial families from the common antimicrobial set.

Index of diversity = see definition in section 11.4.2.1 of Materials and Methods.

Co-resistant to CIP and ERY = the frequencies and percentages of *C. jejuni* isolates not susceptible to ciprofloxacin concentrations >1 mg/L and erythromycin concentrations >4 mg/L.

Figure CA8. Frequency distribution of C. jejuni *isolates completely susceptible and resistant to one to five antimicrobials, in meat from broilers in MSs reporting isolate-based data, 2011*



N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances for *Campylobacter*.

Susceptible = susceptible to all antimicrobial substances of the common set for *Campylobacter*.

res1/res5 = resistance to one antimicrobial substance/resistance to five antimicrobial substances of the common set for *Campylobacter*.

Resistance levels among *C. coli*

Quantitative antimicrobial resistance data for *C. coli* isolates from broiler meat were provided by eight MSs for 2011 (Table CA10). For tetracyclines, resistance was extremely high for the MS group (71.5 %) and ranged from very high in Austria (53.2 %) to extremely high in Germany (85.4 %). Resistance to gentamicin was low for the MS group, at 1.8 %. The range of resistance observed in MSs varied less for gentamicin, from 0 % in four MSs to moderate in Romania (10.2 %).

Overall, resistance to ciprofloxacin and nalidixic acid was extremely high in the reporting MS group (77.7 % and 72.2 %, respectively). Resistance to ciprofloxacin ranged from very high in Austria (55.3 %) to extremely high in Hungary (90.2 %). Similarly, resistance to nalidixic acid ranged from high in Italy (50.0 %) to extremely high in Germany (81.7 %). For erythromycin, resistance was low at 9.8% for the MS group, and resistance ranged in the reporting MSs from very low in Poland (0.6 %) to very high in Italy (50.0 %).

Table CA10. Resistance (%) to ciprofloxacin, erythromycin, gentamicin, nalidixic acid and tetracyclines among* Campylobacter coli *from meat from broilers in MSs reporting MIC data in 2011, using harmonised epidemiological cut-off values

Country	Ciprofloxacin		Erythromycin		Gentamicin		Nalidixic acid		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	47	55.3	47	2.1	47	0	47	55.3	47	53.2
Belgium	81	63.0	81	11.1	81	1.2	81	51.9	81	72.8
Germany	82	86.6	82	17.1	82	0	82	81.7	82	85.4
Hungary	61	90.2	61	3.3	61	3.3	-	-	61	63.9
Italy	14	71.4	14	50.0	14	0	14	50.0	14	78.6
Netherlands	42	78.6	42	21.4	42	2.4	42	78.6	42	66.7
Poland	157	82.2	157	0.6	157	0	157	80.9	157	70.7
Romania	59	79.7	59	16.9	59	10.2	59	78.0	59	76.3
Total (8 MSs)	**543**	**77.7**	**543**	**9.8**	**543**	**1.8**	**482**	**72.2**	**543**	**71.5**

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

Multi-resistance among *C. coli* isolates in meat from broilers

As only three MSs reported resistance isolate-based data on 10 or more isolates of *C. coli* from broiler meat, the corresponding multi-resistance analysis is not presented in this report.

Antimicrobial resistance in *Campylobacter* isolates from animals

5.4.1.2. Fowl (*Gallus gallus*)

In this section, data on antimicrobial resistance in *Campylobacter* isolates from fowl (*Gallus gallus*) are derived from broilers, with the exception of four isolates reported by Italy.[15] The majority of samples were collected at the slaughterhouse, with the exception of Italy, where sampling also took place at farm level. For the majority of MSs specifying details of the sampling strategy, sampling was randomised throughout the year. In Finland, sampling was more intense over the summer months, which corresponds to the period at risk, and in Spain sampling was carried out between May and December. Only one representative sample of caecal content per flock/batch, derived from either a unique carcass or a number of carcasses, was gathered to account for clustering. Typically, given the relatively high prevalence of *Campylobacter* in broilers, representative subsets of *C. jejuni* and *C. coli* isolates recovered from caecal samples, each representing one flock, were randomly selected at the laboratory for susceptibility testing.

Resistance levels among *C. jejuni*

For 2011, quantitative data on *C. jejuni* from *Gallus gallus* were provided by 11 MSs and two non-MSs (Table CA11). Tetracycline resistance in the reporting MS group was high, at 40.6 %, ranging from 0 % in Finland to extremely high in Spain (87.0 %). For gentamicin, reported resistance was very low (0.9 %) at MS group level. Resistance varied slightly for gentamicin among reporting MSs. Only 2 of the 11 reporting MSs detected resistance to gentamicin at low levels, Hungary (5.6 %) and Spain (7.3 %). The remaining MSs did not detect any *C. jejuni* isolates from *Gallus gallus* that were resistant to gentamicin.

Overall, for both ciprofloxacin and nalidixic acid, very high levels of resistance were reported by the MS group (57.2 % and 55.5 %, respectively). For both quinolones resistance varied greatly between MSs, from 0 % in Finland to 94.5 % in Spain. For erythromycin, although the resistance reported was low (1.6 %) among the MS group, the levels of resistance to erythromycin varied importantly among reporting MSs. Five

[15] Two of the Italian samples are *C. coli* isolates, one from a laying hen and one of unspecified origin, and two are *C. jejuni* isolates of an unspecified sampling origin.

of the MSs that submitted data for erythromycin did not detect any resistance, while levels among the six remaining MSs ranged from very low in Ireland (0.9 %) to moderate in Italy (20.0 %).

Table CA11. Resistance (%) to ciprofloxacin, erythromycin, gentamicin, nalidixic acid and tetracyclines among* Campylobacter jejuni *from* Gallus gallus *(mainly broilers[1]) in countries reporting MIC data in 2011, using harmonised epidemiological cut-off values

Country	Ciprofloxacin		Erythromycin		Gentamicin		Nalidixic acid		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	116	69.0	116	0	116	0	116	60.3	116	17.2
Czech Republic	57	54.4	57	0	57	0	57	54.4	57	14.0
Denmark	43	23.3	43	0	43	0	43	23.3	43	18.6
Finland	40	0	40	0	40	0	40	0	40	0
France	51	56.9	51	0	51	0	51	60.8	51	66.7
Germany	59	62.7	59	3.4	59	0	59	57.6	59	50.8
Hungary	36	86.1	36	5.6	36	5.6	36	83.3	36	38.9
Ireland	114	40.4	114	0.9	114	0	114	39.5	114	49.1
Italy	10	60.0	10	20.0	10	0	10	60.0	10	80.0
Netherlands	104	67.3	104	1.9	104	0	104	68.3	104	51.0
Spain	55	94.5	55	3.6	55	7.3	55	94.5	54	87.0
Total (11 MSs)	**685**	**57.2**	**685**	**1.6**	**685**	**0.9**	**685**	**55.5**	**684**	**40.6**
Norway	48	4.2	48	0	48	0	48	6.3	48	2.1
Switzerland	150	40.7	150	5.3	150	1.3	150	42.0	150	20.7

N = number of isolates tested.

% Res = percentage of resistant isolates.

1. All data relate to isolates from broilers, with the exception of two isolates reported by Italy. One of these was from a laying hen, and for the other the production level was not specified. Both isolates were sensitive to all antimicrobials tested.

Resistance levels among *C. coli*

Quantitative data on *C. coli* isolates from *Gallus gallus* were submitted by eight MSs and one non-MS in 2011 (Table CA12).

Considering the reporting MS group overall, levels of resistance for tetracyclines were extremely high, at 74.6 %. Resistance to tetracyclines varied greatly between MSs, from high resistance reported by the Czech Republic (25.0 %) to extremely high resistance reported by Spain (98.8 %). Regarding gentamicin, the level of resistance observed at the level of the reporting MS group overall was low (3.8 %). Six of the eight reporting MSs did not detect any resistance, while the remaining two MSs reported resistance at low (the Czech Republic 4.2 %) and moderate (Spain 14.8 %) levels.

Overall, resistance to ciprofloxacin was higher than resistance to nalidixic acid in the reporting MS group (76.6 % and 70.2 %, respectively). This was also the case in 2010, when resistance was 84 % for ciprofloxacin and 76 % for nalidixic acid. Resistance to ciprofloxacin ranged from 40.6 % in Ireland to 93.8 % in Spain, with the majority of MSs reporting extremely high resistance levels. For nalidixic acid, resistance varied between 43.8 % in Ireland and 85.7 % in Hungary, again, with the majority of MSs reporting levels that were extremely high. For erythromycin, resistance was moderate in the reporting MS group (15.5 %) overall, with levels of resistance ranging from none detected in Hungary (0 %) to high in Germany and Spain (32.0 % and 33.3 %, respectively).

Table CA12. Resistance (%) to ciprofloxacin, erythromycin, gentamicin, nalidixic acid and tetracyclines among* Campylobacter coli *from* Gallus gallus *(mainly broilers[1]) in countries reporting MIC data in 2011, using harmonised epidemiological cut-off values

Country	Ciprofloxacin		Erythromycin		Gentamicin		Nalidixic acid		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	48	79.2	48	6.3	48	0	48	79.2	48	62.5
Czech Republic	24	87.5	24	4.2	24	4.2	24	83.3	24	25.0
France	79	67.1	79	13.9	79	0	79	51.9	79	93.7
Germany	25	92.0	25	32.0	25	0	25	80.0	25	80.0
Hungary	35	85.7	35	0	35	0	35	85.7	35	68.6
Ireland	32	40.6	32	3.1	32	0	32	43.8	32	40.6
Netherlands	18	44.4	18	11.1	18	0	18	44.4	18	44.4
Spain	81	93.8	81	33.3	81	14.8	81	85.2	81	98.8
Total (8 MSs)	**342**	**76.6**	**342**	**15.5**	**342**	**3.8**	**342**	**70.2**	**342**	**74.6**
Switzerland	10	20.0	10	0	10	10.0	10	20.0	10	30.0

N = number of isolates tested.

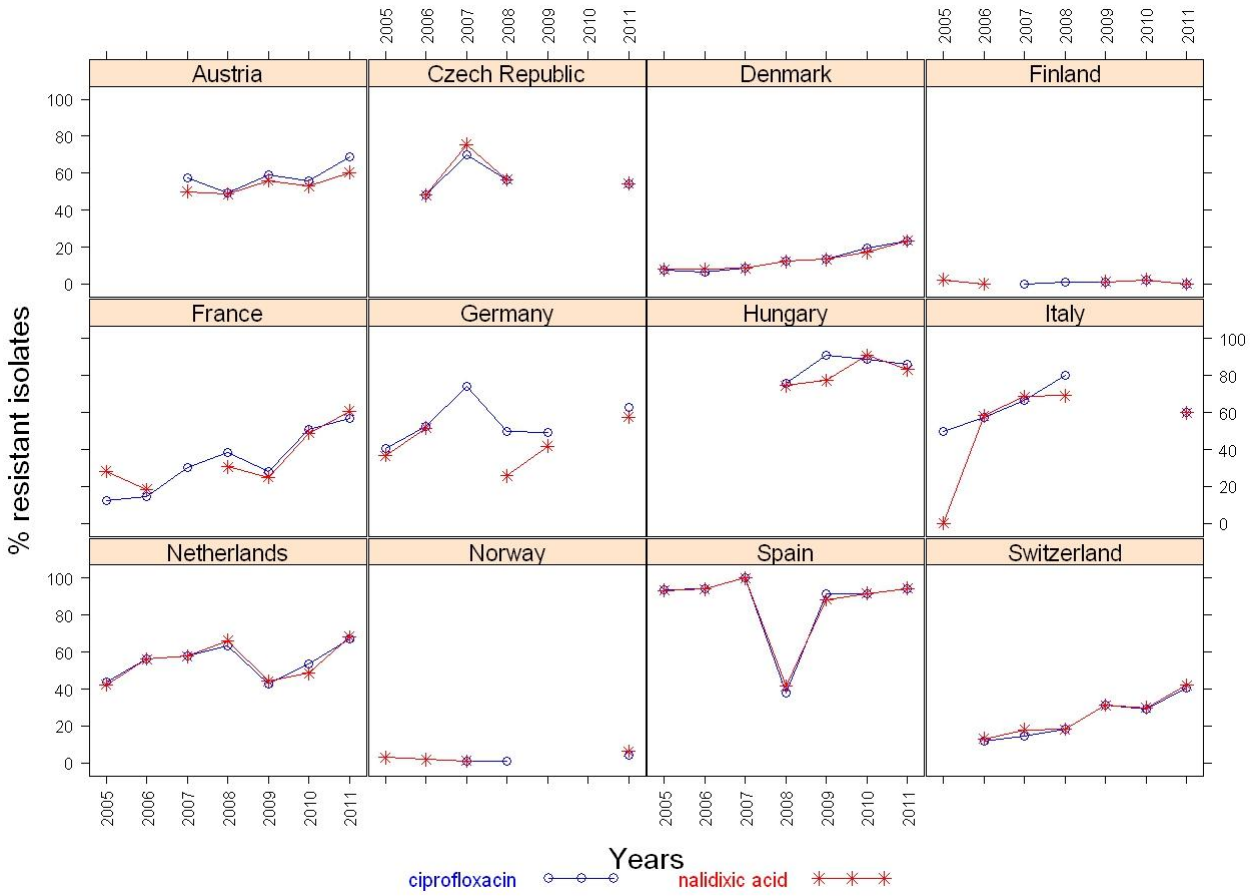
% Res = percentage of resistant isolates.

1. All data relate to isolates from broilers, with the exception of two isolates reported by Italy. For both isolates the production level was not specified. One of the unspecified isolates was resistant to ciprofloxacin, nalidixic acid and tetracycline.

Temporal trends in resistance among *C. jejuni*

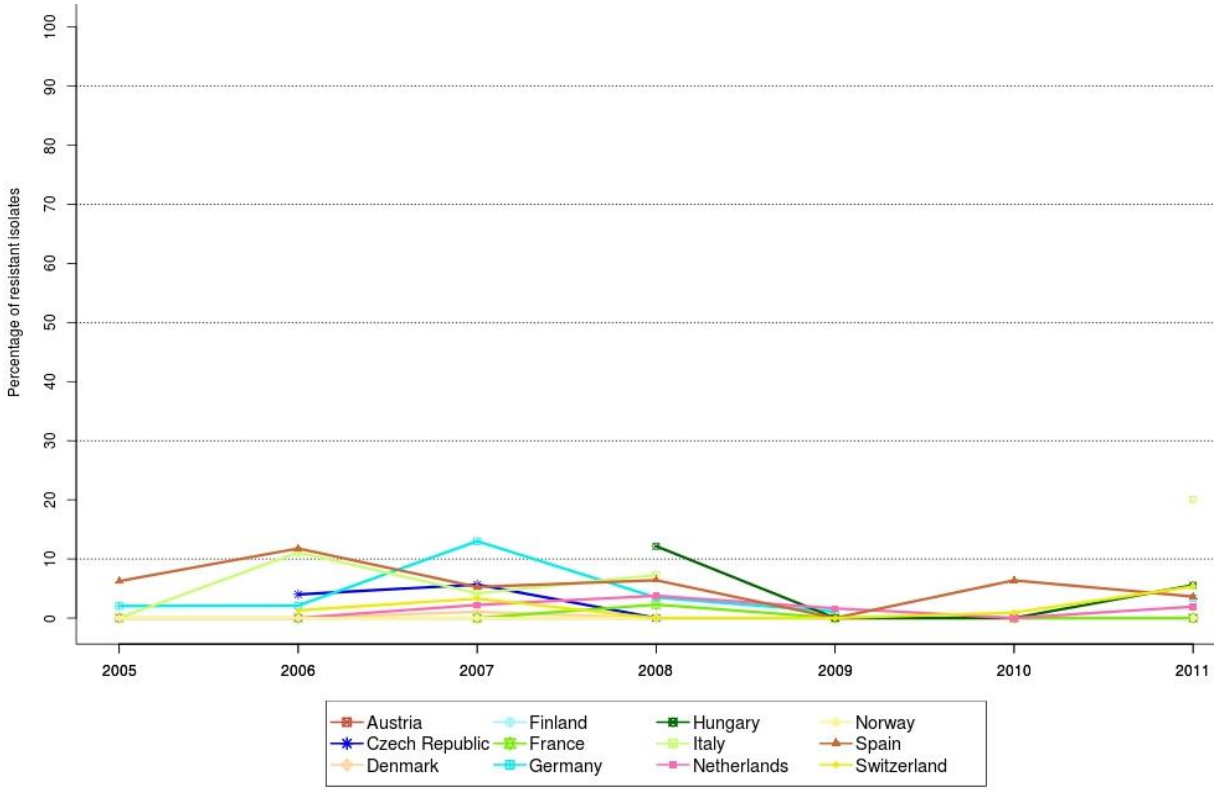
Figures CA9–CA12 present the observed temporal trends in antimicrobial resistance in *C. jejuni* isolates from *Gallus gallus* over the period 2005–2011. As in previous years, resistance to tetracyclines, ciprofloxacin and nalidixic acid varied greatly among reporting MSs in 2011 (Figures CA9 and CA12). When considering resistance to ciprofloxacin and nalidixic acid, statistically significant increasing trends were observed in Denmark, France, Italy, the Netherlands, Spain and Switzerland for five or more years. For Austria, a statistically significant increasing trend was observed for ciprofloxacin alone (Figure CA9). For erythromycin levels of resistance remained absent or very low over the period 2005–2011, with the exception of Italy in 2011, which reported a moderate level of resistance. No statistically significant trends in erythromycin resistance were detected over the reporting period. With regards to gentamicin, statistically significant decreasing trends were observed in France and Germany. For tetracyclines, a statistically significant increase was seen in Denmark, France, Italy and Spain over the period 2005–2011.

Figure CA9. Trends in ciprofloxacin and nalidixic acid resistance in* Campylobacter jejuni *from* Gallus gallus *in reporting MSs and non-MSs, 2005–2011, quantitative data



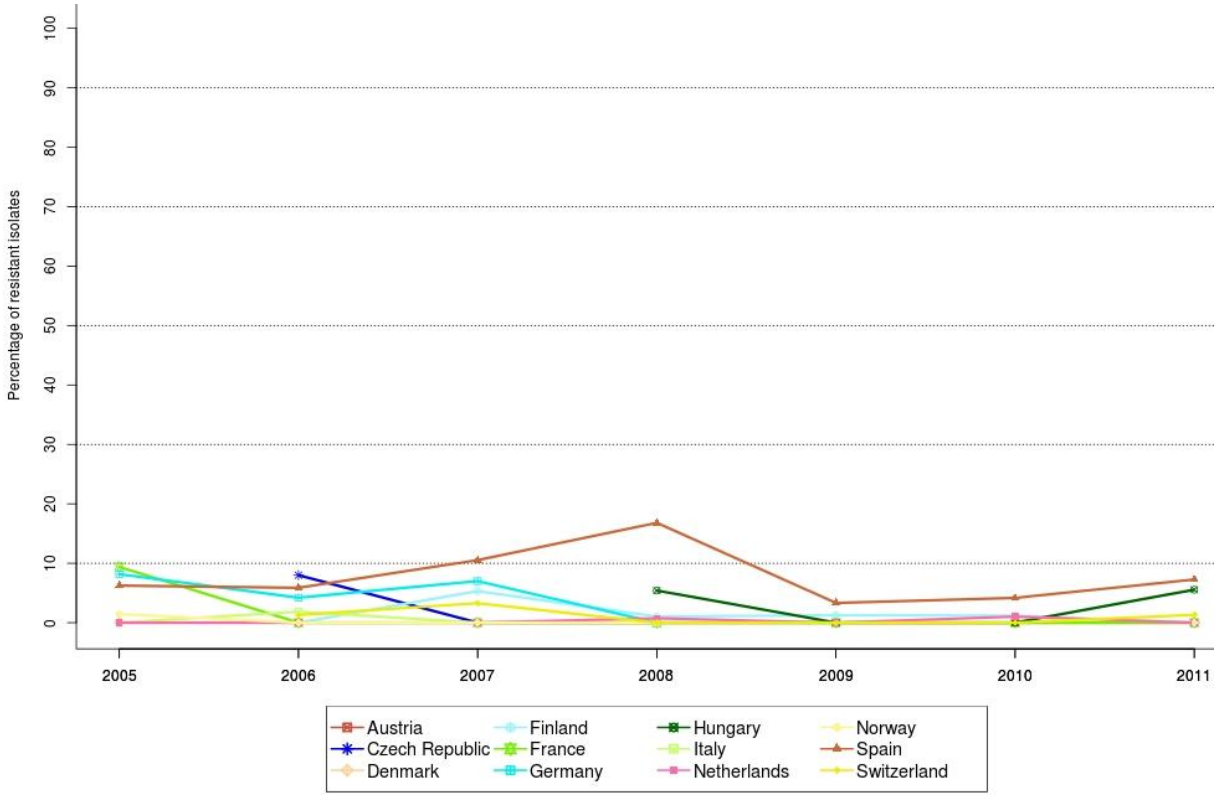
Note: A statistically significant increasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Denmark (↑), France (↑), Italy (↑), the Netherlands (↑), Spain (↑) and Switzerland (↑) for both ciprofloxacin and nalidixic acid and in Austria (↑) for ciprofloxacin.

Figure CA10. Trends in erythromycin resistance in* Campylobacter jejuni *from* Gallus gallus *in reporting MSs and non-MSs, 2005–2011, quantitative data



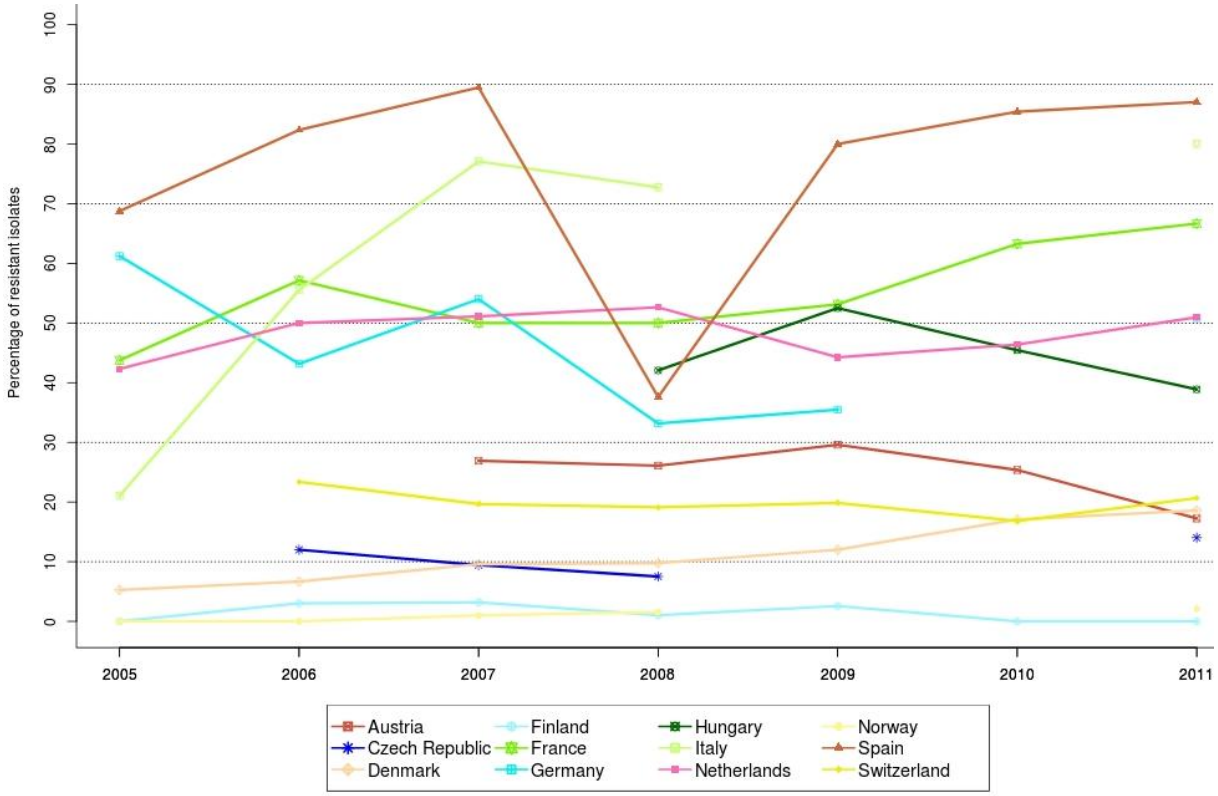
Note: No statistically significant trends over five or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in any of the reporting countries.

Figure CA11. Trends in gentamicin resistance in* Campylobacter jejuni *from* Gallus gallus *in reporting MSs and non-MSs, 2005–2011, quantitative data



Note: A statistically significant decreasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in France (↓) and Germany (↓).

Figure CA12. Trends in tetracycline resistance in* Campylobacter jejuni *from* Gallus gallus *in reporting MSs and non-MSs, 2005–2011, quantitative data



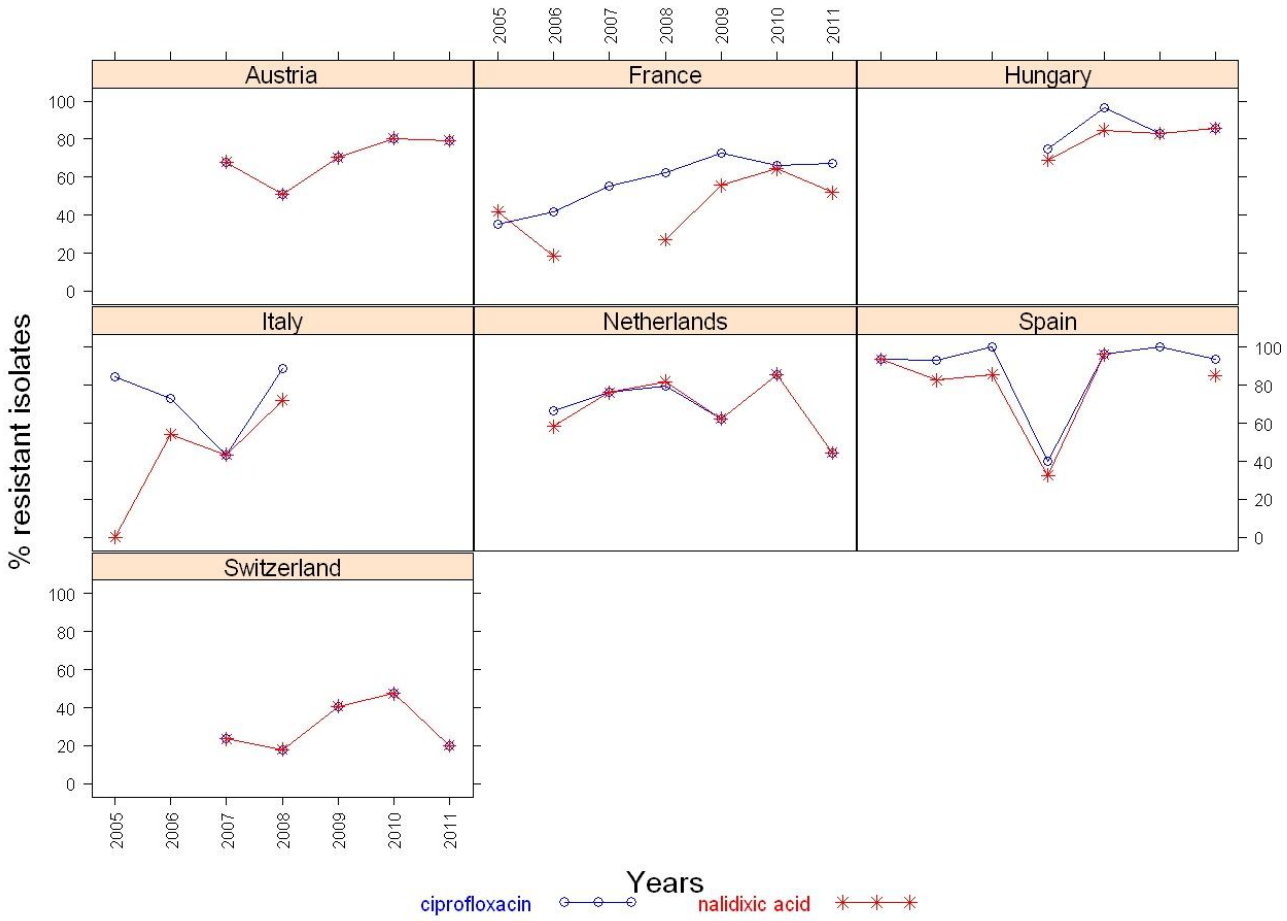
Note: A statistically significant increasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Denmark (↑), France (↑), Italy (↑) and Spain (↑).

Temporal trends in resistance among *C. coli*

Figures CA13–CA16 present observed trends in antimicrobial resistance in *C. coli* from *Gallus gallus*. In 2011, as was the case in previous years, a high degree of variation was observed in levels of resistance to ciprofloxacin, nalidixic acid and tetracyclines among reporting MSs.

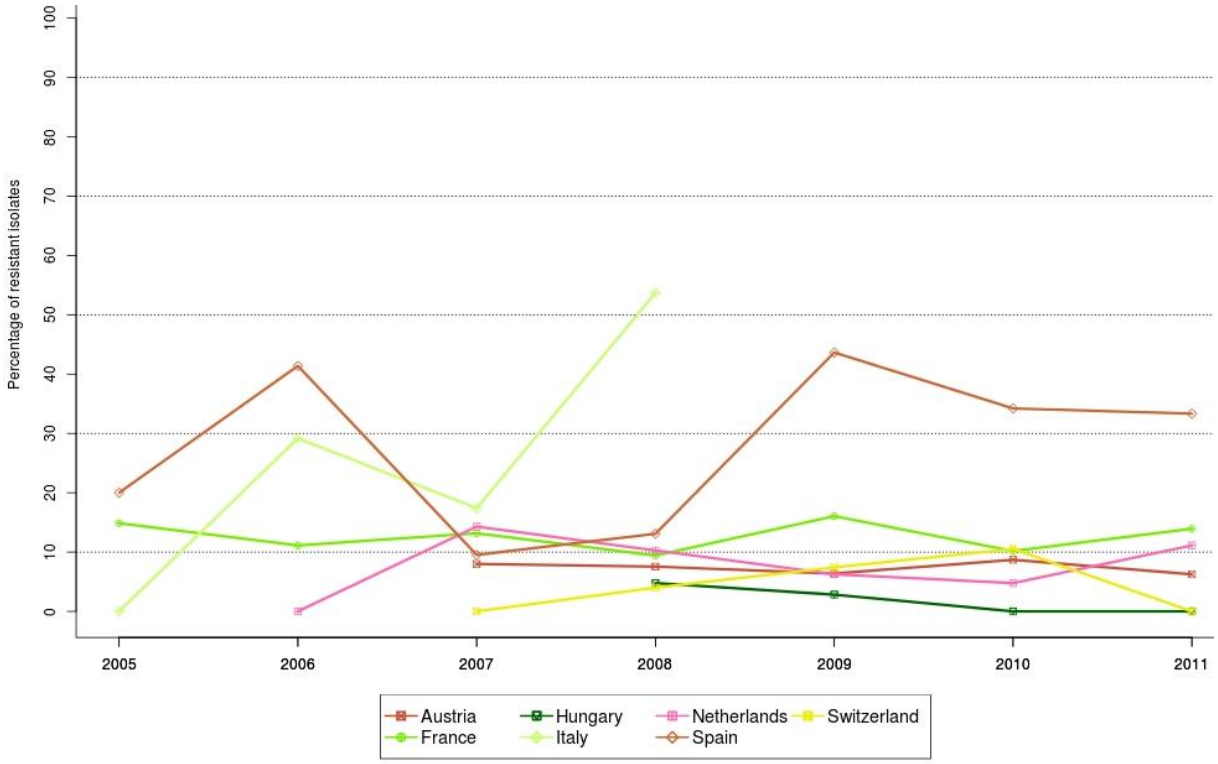
For ciprofloxacin and nalidixic acid, statistically significant increasing trends for the last five or more years were observed in Austria, France and Spain (Figure CA13). France and Spain also exhibited statistically increasing trends in resistance to tetracyclines. For erythromycin and gentamicin, resistance was generally lower over the reporting period than for the other antimicrobials presented. In Spain, resistance to erythromycin and gentamicin increased significantly over the seven years presented, while a statistically significant increase was also seen in France and Switzerland for gentamicin.

Figure CA13. Trends in ciprofloxacin and nalidixic acid resistance in* Campylobacter coli *from* Gallus gallus *in reporting MSs and one non-MS, 2005–2011, quantitative data



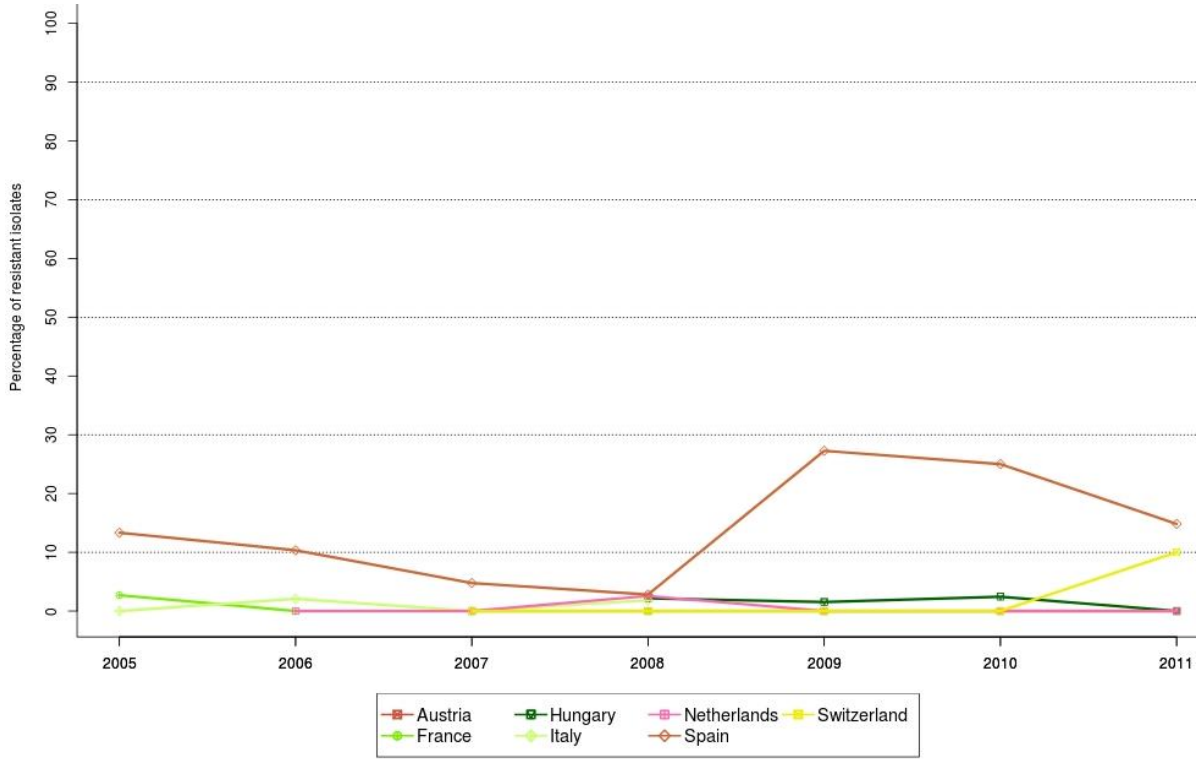
Note: A statistically significant increasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Austria (↑), France (↑) and Spain (↑) for both ciprofloxacin and nalidixic acid.

Figure CA14. Trends in erythromycin resistance in* Campylobacter coli *from* Gallus gallus *in reporting MSs and one non-MS, 2005–2011, quantitative data



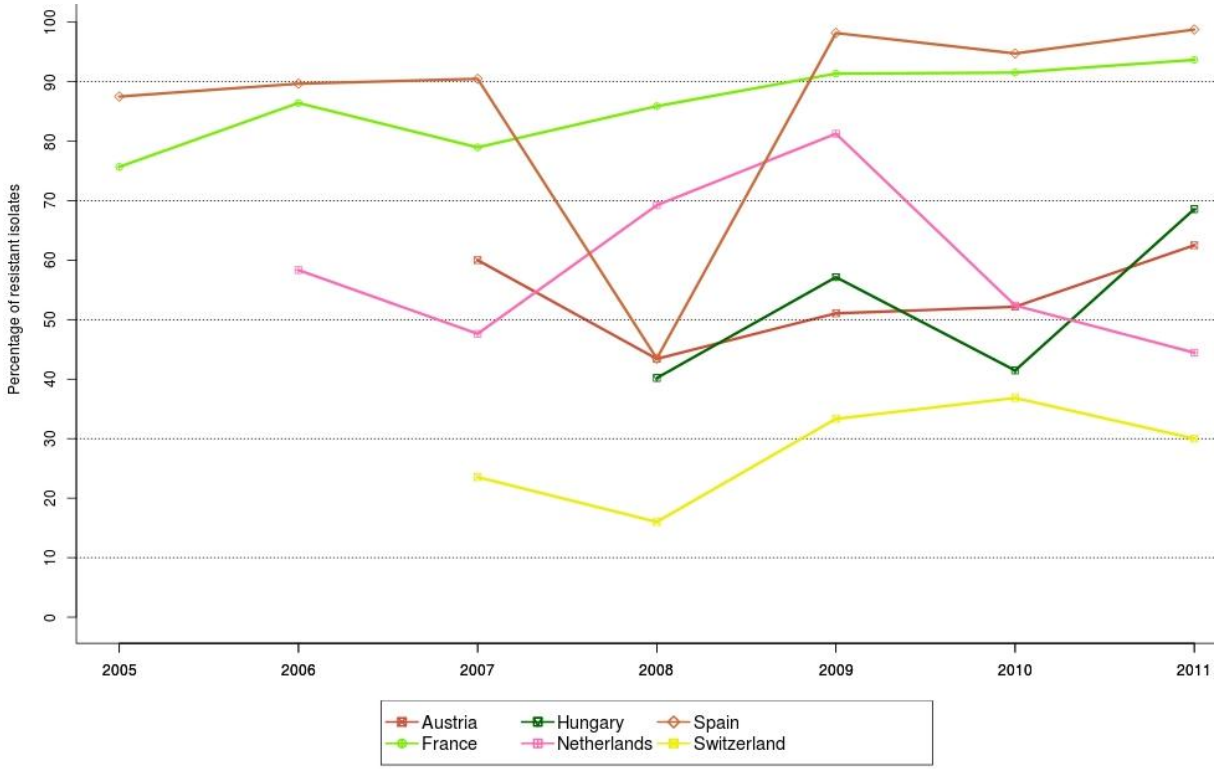
Note: A statistically significant increasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Spain (↑).

Figure CA15. Trends in gentamicin resistance in* Campylobacter coli *from* Gallus gallus *in reporting MSs and one non-MS, 2005–2011, quantitative data



Note: Statistically significant increasing and decreasing trends over five or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in France (↓), Spain (↑) and Switzerland (↑).

Figure CA16. Trends in tetracycline resistance in* Campylobacter coli *from* Gallus gallus *in reporting MSs and one non-MS, 2005–2011, quantitative data

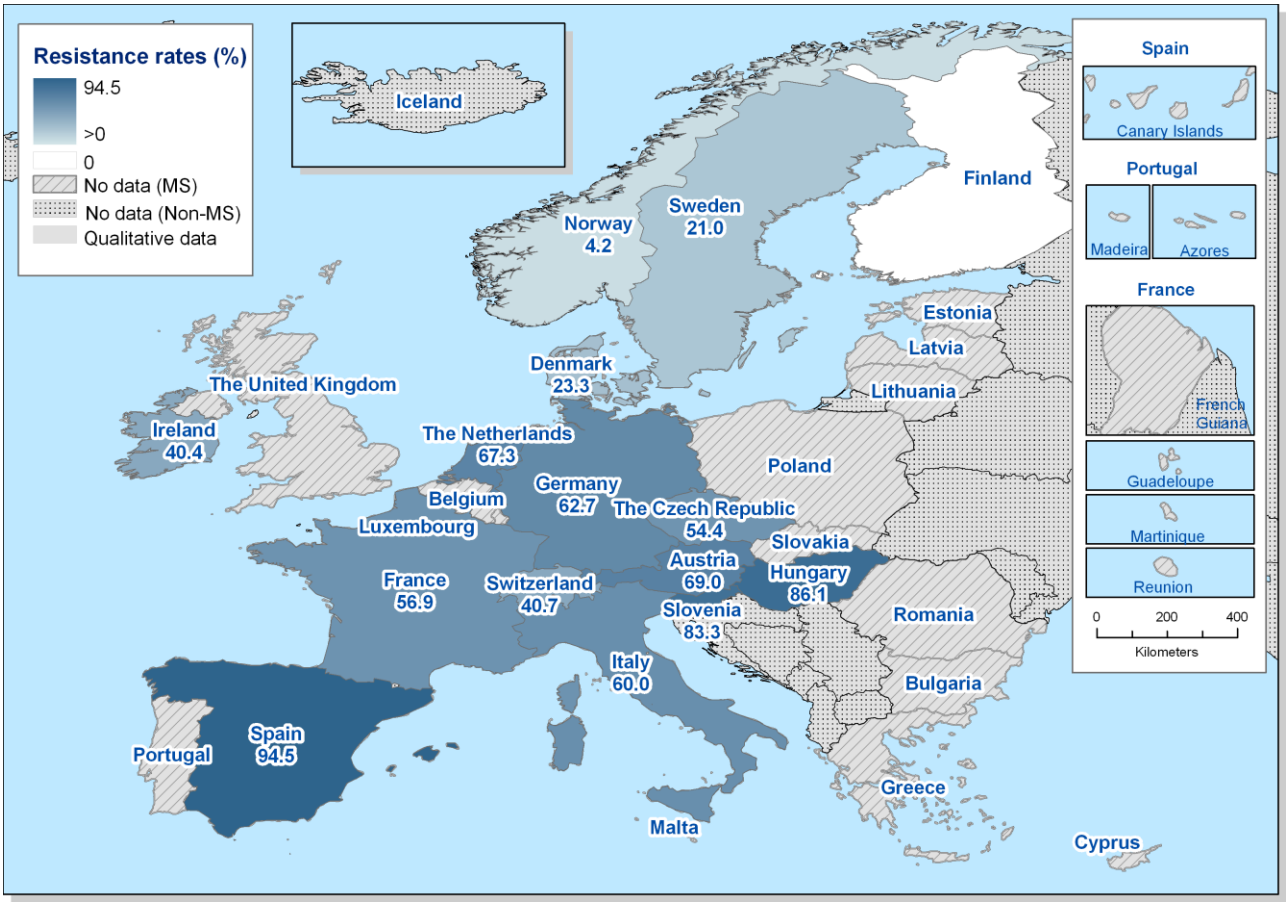


Note: A statistically significant increasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in France (↑) and Spain (↑).

Spatial distribution of resistance among *C. jejuni*

Figures CA17 and CA18 show the spatial distributions of ciprofloxacin and erythromycin resistance in *C. jejuni* from *Gallus gallus*. For both antimicrobials, overall resistance was lower among the reporting Nordic countries than in the rest of the European reporting countries.

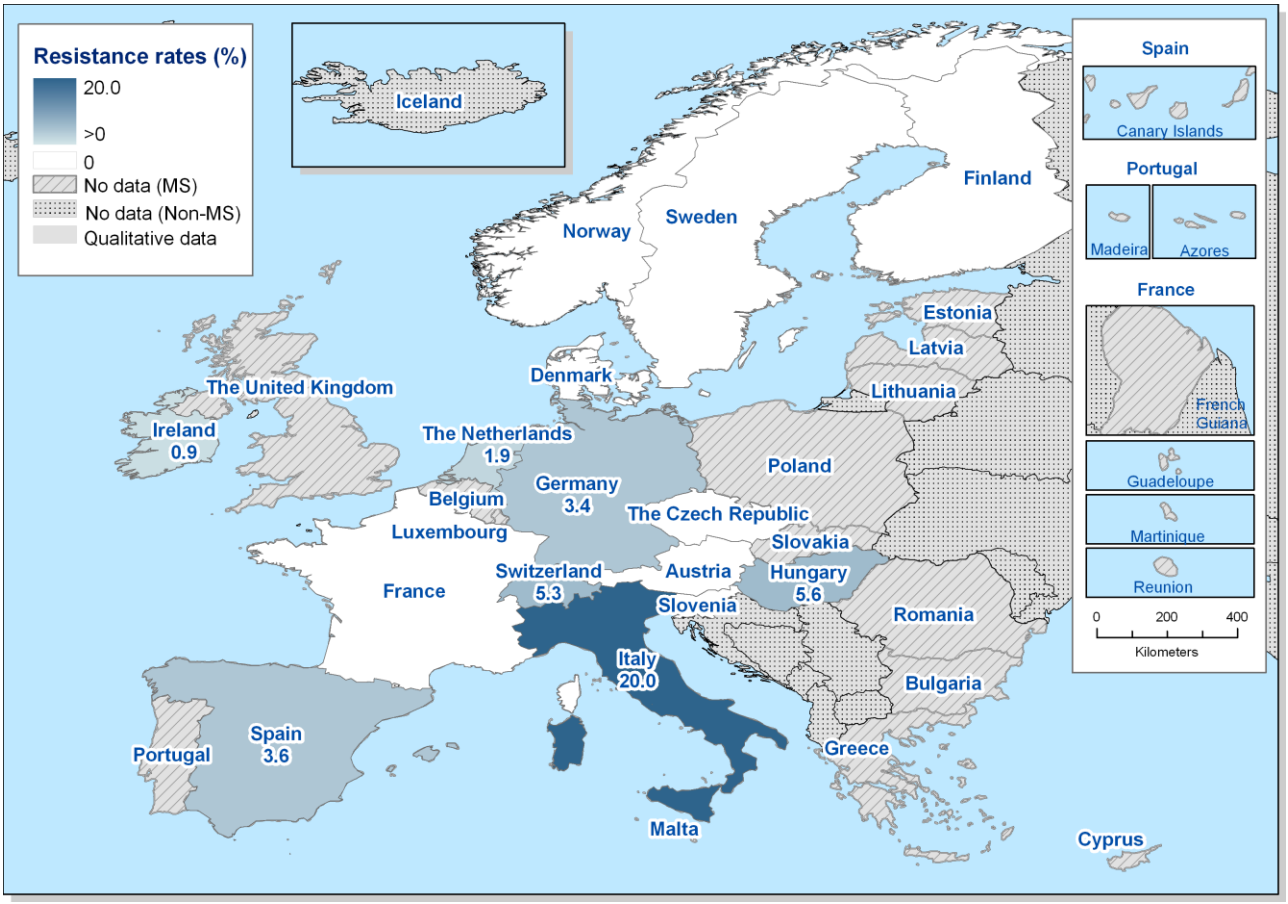
Figure CA17. Spatial distribution of ciprofloxacin resistance among* Campylobacter jejuni *from* Gallus gallus *in countries reporting MIC data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data have been used instead.

1. For Slovenia and Sweden, 2010 data were used.

***Figure CA18. Spatial distribution of erythromycin resistance among* Campylobacter jejuni *from* Gallus gallus *in countries reporting MIC data in 2011*[1]**



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data have been used instead.

1. For Slovenia and Sweden, 2010 data were used.

Multi-resistance among C. jejuni *isolates from broilers*

In 2011, five MSs and two non-MSs reported isolate-based data on resistance in *C. jejuni* from broilers. Among the reporting MSs, complete susceptibility was generally found in more than 20 % of the isolates tested, and reached up to 74.4 % in Denmark and 91.7 % in Norway. The only exception was Spain, which reported a level of complete susceptibility of 3.8 %. Multi-resistance was not recorded or was detected at low levels in most reporting countries, although in Spain 15.1 % of isolates exhibited multi-resistance (reduced susceptibility to three or more antimicrobial classes) (Table CA13). The frequency distributions (Figure CA19) showed that most of the other reporting countries detected multi-resistance to two or three antimicrobial classes (Table CA13). Very few isolates were resistant to both ciprofloxacin and erythromycin.

Table CA13. Complete susceptibility, multi-resistance and index of diversity in C. jejuni *from broilers in MSs and non-MSs reporting isolate-based data, 2011*

Country	Susceptible to all		Multi-resistant		Index of diversity	Co-resistant to CIP and ERY	
	n	%	n	%		n	%
Austria (N=116)	33	28.5	0	0	0.172	0	0
Denmark (N=43)	32	74.4	1	2.3	0.318	0	0
Germany (N=59)	12	20.3	3	5.1	0.321	2	3.4
Ireland (N=114)	38	33.3	1	0.9	0.245	1	0.9
Spain (N=53)	2	3.8	8	15.1	0.388	2	3.8
Norway (N=48)	44	91.7	0	0	0	NA	NA
Switzerland (N=150)	71	47.3	6	4.0	0.391	2	1.3

N = total number of isolates tested for susceptibility against the whole common antimicrobial set for *Campylobacter*.

n = number of isolates per category of complete susceptibility or multiple resistance.

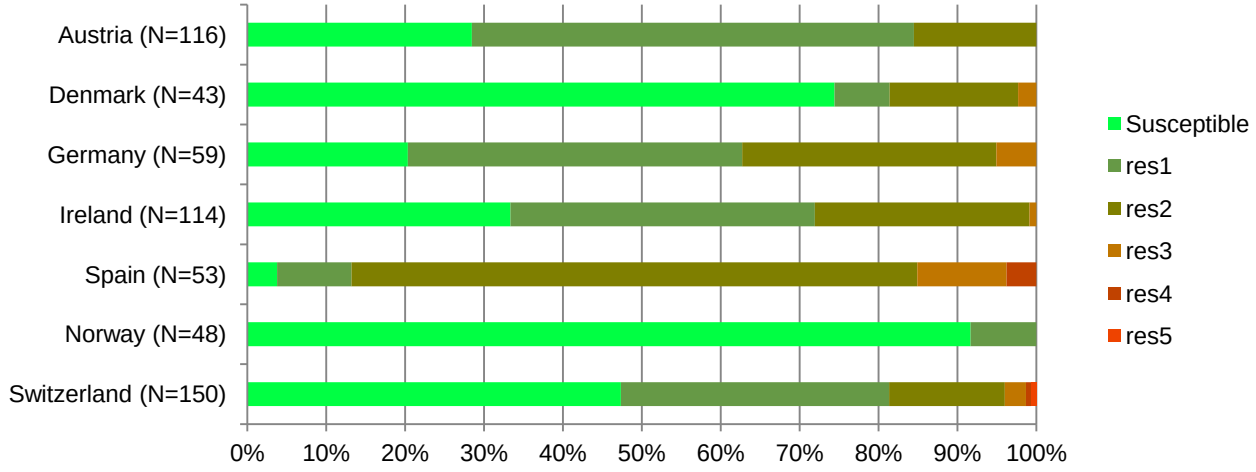
Susceptible to all = isolate susceptible to all antimicrobial substances of the EFSA common set for *Campylobacter*.

Multi-resistant = resistant to at least 3 different antimicrobial substances, belonging to any three antimicrobial families from the common antimicrobial set.

Index of diversity = see definition in section 11.4.2.1 of Materials and Methods.

Co-resistant to CIP and ERY = the frequencies and percentages of *C. jejuni* isolates not susceptible to ciprofloxacin concentrations >1 mg/L and erythromycin concentrations >16 mg/L.

Figure CA19. Frequency distribution of C. jejuni *isolates completely susceptible and resistant to one to five antimicrobials in broilers in MSs and non-MSs reporting isolate-based data, 2011*



N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances for *Campylobacter*.

Susceptible = susceptible to all antimicrobial substances of the common set for *Campylobacter*.

res1/res5 = resistance to one antimicrobial substance/resistance to five antimicrobial substances of the common set for *Campylobacter*.

Multi-resistance among C. coli *isolates from broilers*

In 2011, four MSs and one non-MS provided isolate-based data regarding resistance in *C. coli* from broilers. Analysis of the multi-resistance showed that there was a large variation in the levels of complete susceptibility among the reporting countries. Isolates exhibiting complete susceptibility accounted for 40.6 % in Ireland and 50.0 % in Switzerland, but only 6.3 % in Austria, and in Germany and Spain none of the isolates tested were completely susceptible (Table CA14). Multi-resistance was low in Ireland (3.1 %), moderate in Switzerland and Austria (10.0 % and 12.5 %, respectively) and high in Germany (32.0 %) and Spain (70.5 %). The frequency distributions (Figure CA20) showed an important diversity between the reporting countries, Germany, Switzerland and Spain reporting isolates displaying reduced susceptibility to up to four or five different classes of antimicrobials. In addition, important co-resistance to ciprofloxacin and erythromycin was observed in isolates from Germany and Spain.

Table CA14. Complete susceptibility, multi-resistance and index of diversity in C. coli *from broilers in MSs and one non-MS reporting isolate-based data, 2011*

Country	Susceptible to all		Multi-resistant		Index of diversity	Co-resistant to CIP and ERY	
	n	%	n	%		n	%
Austria (N=48)	3	6.3	6	12.5	0.371	3	6.3
Germany (N=25)	0	0	8	32.0	0.583	7	28.0
Ireland (N=32)	13	40.6	1	3.1	0.305	1	3.1
Spain (N=78)	0	0	55	70.5	0.821	25	32.1
Switzerland (N=10)	5	50.0	1	10.0	0.480	0	0

N = total number of isolates tested for susceptibility against the whole common antimicrobial set for *Campylobacter*.

n = number of isolates per category of complete susceptibility or multiple resistance.

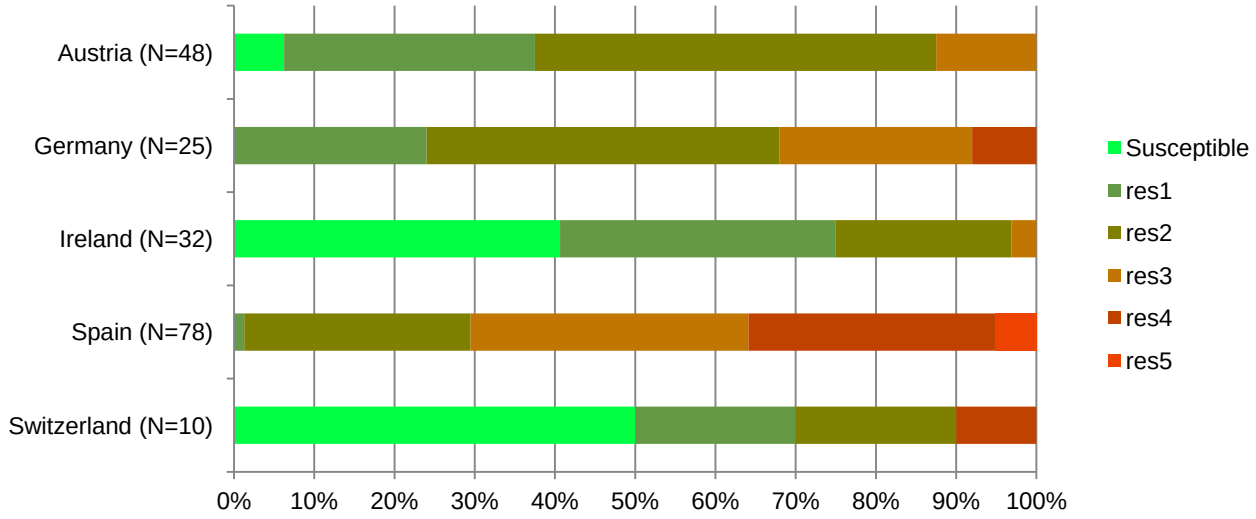
Susceptible to all = isolate susceptible to all antimicrobial substances of the EFSA common set for *Campylobacter*.

Multi-resistant = resistant to at least three different antimicrobial substances, belonging to any three antimicrobial families from the common antimicrobial set.

Index of diversity = see definition in section 11.4.2.1 of Materials and Methods.

Co-resistant to CIP and ERY = the frequencies and percentages of *C. coli* isolates not susceptible to ciprofloxacin concentrations >1 mg/L and erythromycin concentrations >16 mg/L.

Figure CA20. Frequency distribution of C. coli *isolates completely susceptible and resistant to one to five antimicrobials, in broilers in MSs and one non-MS reporting isolate-based data, 2011*



N = total number of isolates tested for susceptibility against the whole common antimicrobial set for *Campylobacter*.

Susceptible = susceptible to all antimicrobial substances of the common set for *Campylobacter* for *Campylobacter*.

res1/res5 = resistance to one antimicrobial substance/resistance to five antimicrobial substances of the common set for *Campylobacter*.

5.4.1.3. Pigs

In the reporting MSs, antimicrobial resistance monitoring in *Campylobacter* isolates from pigs was based on active monitoring plans based on random sampling of healthy pig carcasses at the slaughterhouse. The sampling plan was typically stratified per slaughterhouse, by allocating the number of samples collected per slaughterhouse in proportion with the annual throughput of the slaughterhouse. An approximately equal distribution of the collected samples over the year enabled the different seasons to be covered. Only one representative faecal sample per epidemiological unit (batch/farm), either derived from a unique carcass or pooled from a number of carcasses, was gathered to account for clustering. In the reporting MSs, antimicrobial resistance monitoring in *Campylobacter* spp. in pigs focused on *C. coli*, as this is the more prevalent *Campylobacter* species in pigs. Because of the very low *C. jejuni* prevalence in pigs, the number of samples required to be collected to achieve a sufficient number of *C. jejuni* isolates would have been too large to be really cost-effective. In some reporting countries, representative subsets of *C. coli* isolates recovered from faecal samples were randomly selected at the laboratory for susceptibility testing, whereas, in some others, all *C. coli* isolates were tested for susceptibility.

Resistance levels among *C. coli*

In 2011, quantitative data were provided by six MSs and one non-MS (Switzerland) for *C. coli* isolates from pigs (Table CA15).

For the reporting MS group overall, the highest level of resistance was observed for tetracyclines (64.8 %). As seen in 2010, the range of resistance reported among the MSs varied greatly in 2011. Sweden reported the absence of resistance (0 %) and Denmark reported moderate resistance (14.7 %), while all the other reporting MSs recorded extremely high levels of resistance. Regarding gentamicin resistance, the overall level within the reporting MS group was low (7.2 %). Four of the six MSs did not detect any resistant isolates, while resistance was low in Hungary (7.9 %) but high in Spain (44.4 %).

For both ciprofloxacin and nalidixic acid, resistance was high in the reporting MS group overall (35.5 % and 32.8 %, respectively). The spread of resistance reported among individual MSs was similar for both antimicrobials, ranging from a low level of resistance reported by Denmark (6.9 %) to an extremely high level of resistance reported by Spain (90.1 %). Erythromycin resistance also varied widely among the reporting MS group. Overall, a high level of resistance was reported (24.5 %), with individual levels ranging from no resistance reported in Sweden (0 %) to a very high level reported by Spain (63.0 %).

Table CA15. Resistance (%) to ciprofloxacin, erythromycin, gentamicin, nalidixic acid and tetracyclines among* Campylobacter coli *from pigs[1] in countries reporting MIC data in 2011, using harmonised epidemiological cut-off values

Country	Ciprofloxacin		Erythromycin		Gentamicin		Nalidixic acid		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Denmark	102	6.9	102	6.9	102	0	102	6.9	102	14.7
France	82	46.3	82	45.1	82	0	82	30.5	82	95.1
Hungary	76	52.6	76	15.8	76	7.9	76	48.7	76	88.2
Netherlands	156	10.9	156	22.4	156	0	156	10.9	156	86.5
Spain	81	90.1	81	63.0	81	44.4	81	90.1	81	100
Sweden	83	37.3	83	0	83	0	83	37.3	83	0
Total (6 MSs)	**580**	**35.5**	**580**	**24.5**	**580**	**7.2**	**580**	**32.8**	**580**	**64.8**
Switzerland	185	41.1	185	7.6	185	1.1	185	41.6	185	30.3

N = number of isolates tested.

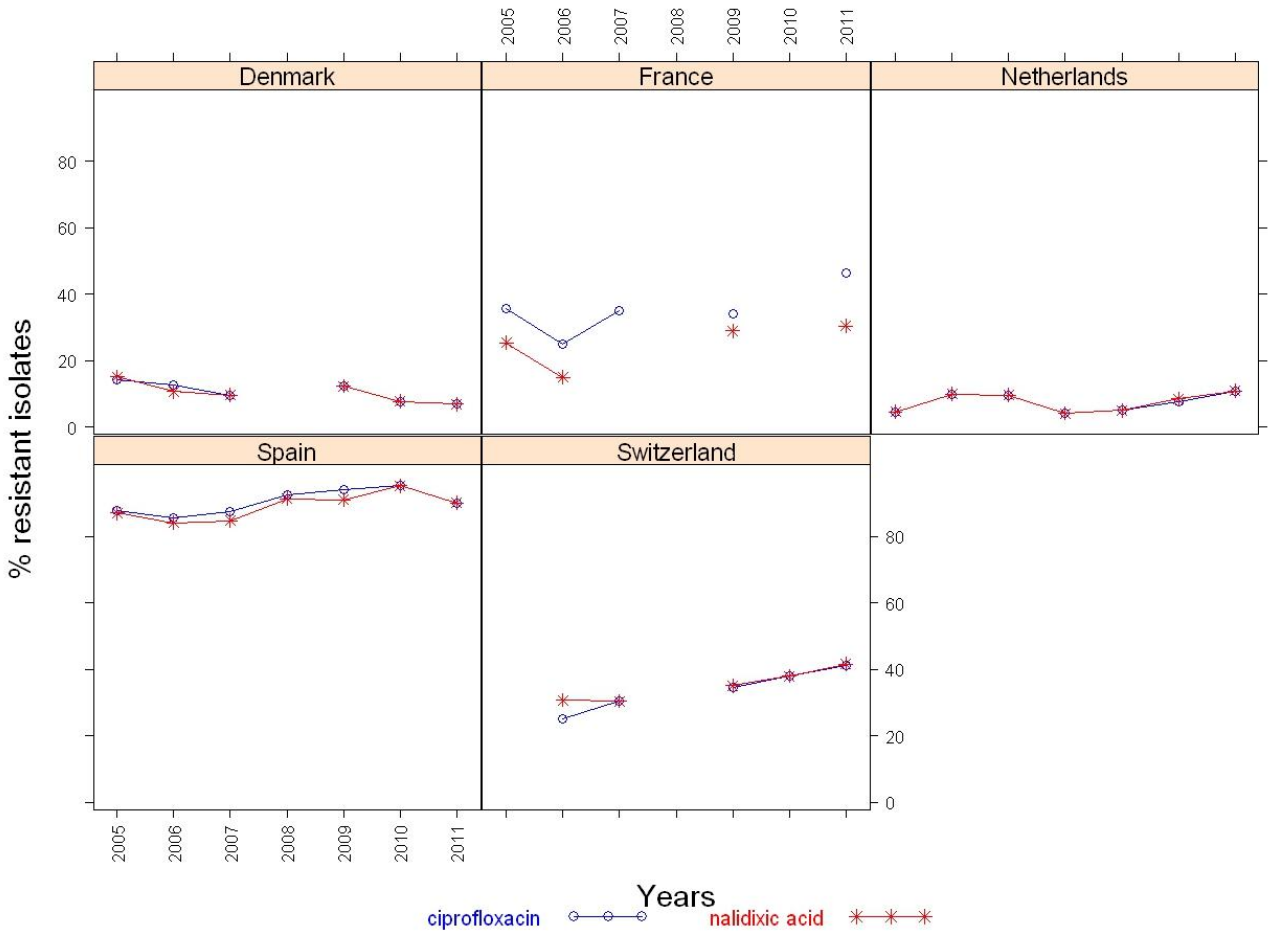
% Res = percentage of resistant isolates.

1. For Denmark, the Netherlands, Spain and Switzerland, the origin of the *C. coli* isolates was from fattening pigs. For France and Hungary, the production level was not specified.

Temporal trends in resistance among *C. coli*

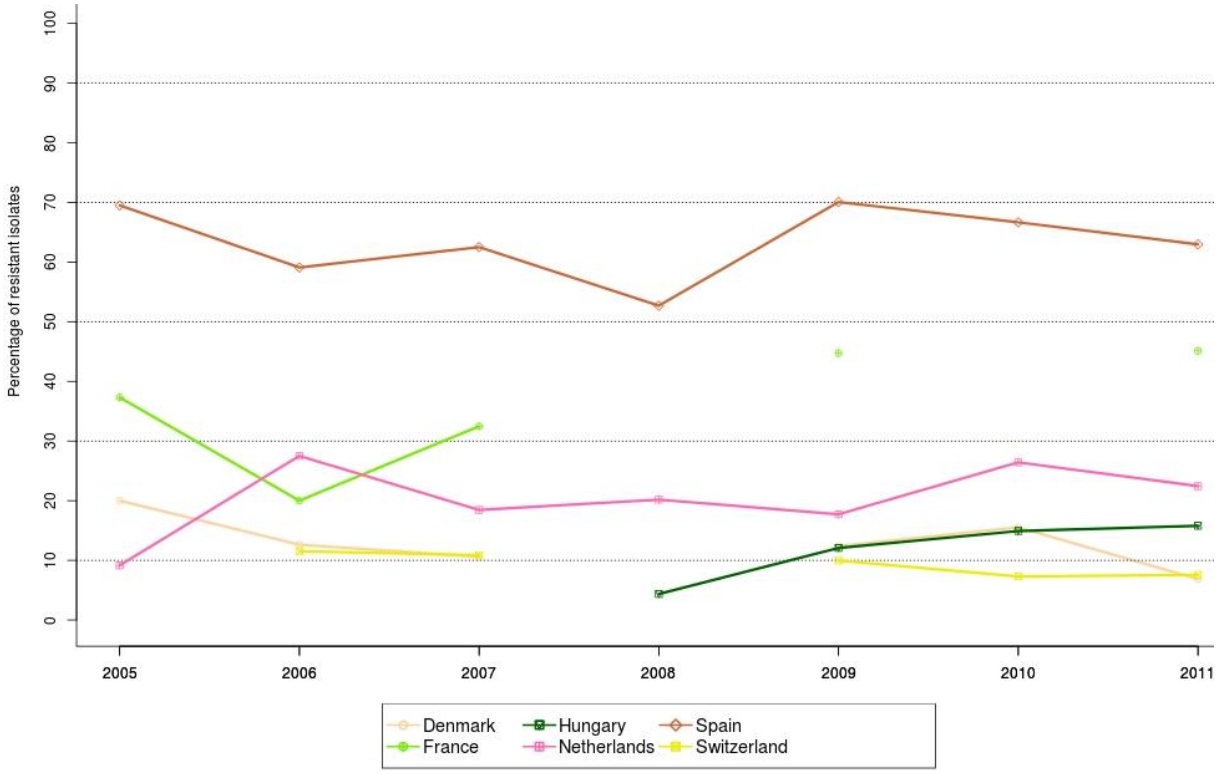
Figures CA21–CA23 show the trends in antimicrobial resistance observed in *C. coli* from pigs over the period 2005–2011. For all of the antimicrobials considered, levels of resistance have remained relatively stable between 2005 and 2011. For ciprofloxacin and nalidixic acid, a statistically significant increasing trend was seen for Spain, while France and Switzerland also reported significantly increasing levels of resistance to ciprofloxacin over the reporting period. Levels of erythromycin resistance increased significantly in France and the Netherlands and, for gentamicin, resistance increased significantly in Spain. When considering tetracyclines, a significantly increasing trend was observed in Denmark and France between 2005 and 2011.

Figure CA21. Trends in ciprofloxacin and nalidixic acid resistance in* Campylobacter coli *from pigs in reporting MSs and one non-MS, 2005–2011, quantitative data



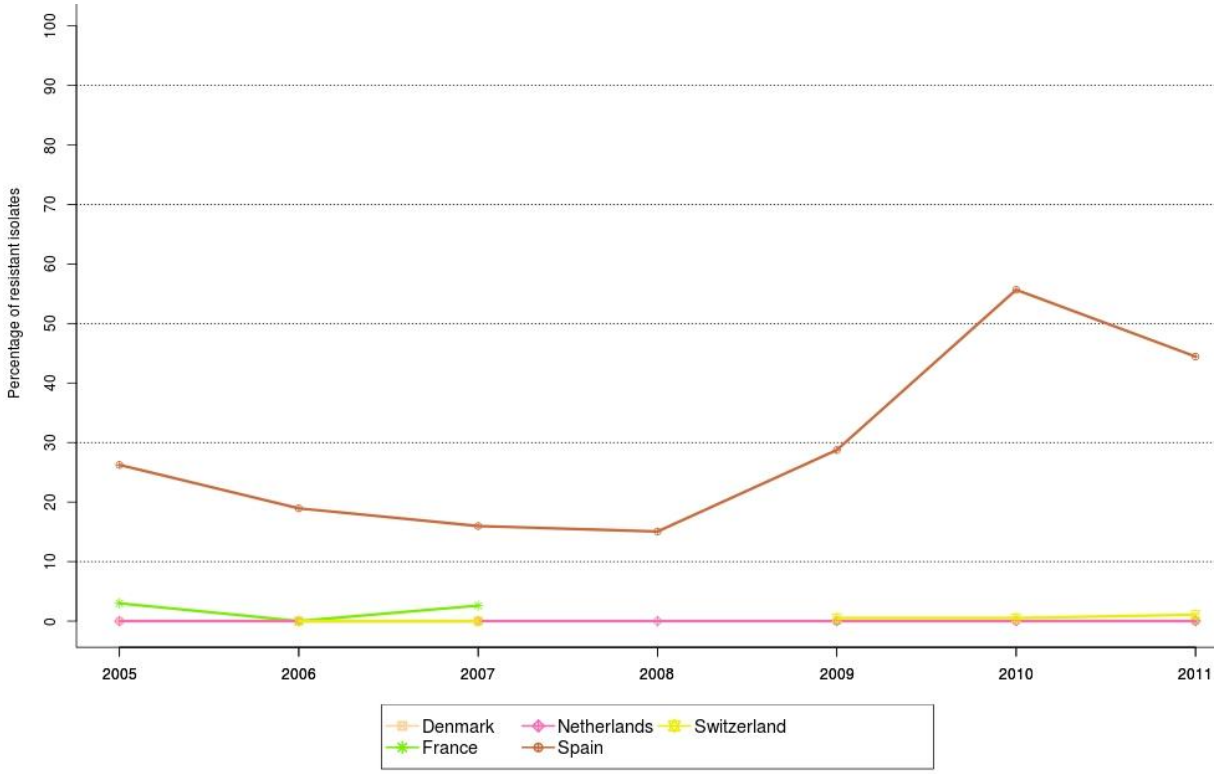
Note: A statistically significant increasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Spain (↑) for both ciprofloxacin and nalidixic acid and in France (↑) and Switzerland (↑) for ciprofloxacin.

Figure CA22. Trends in erythromycin resistance in* Campylobacter coli *from pigs in reporting MSs and one non-MS, 2005–2011, quantitative data



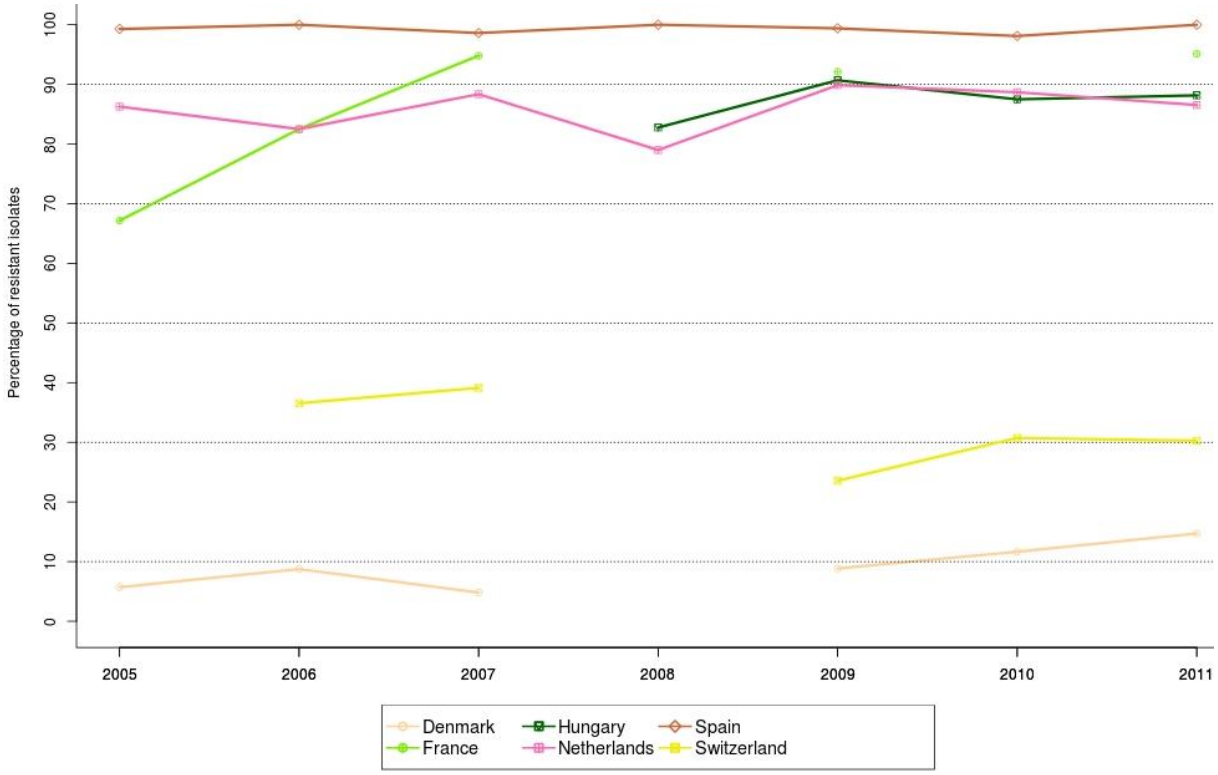
Note: A statistically significant increasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in France (↑) and the Netherlands (↑).

Figure CA23. Trends in gentamicin resistance in* Campylobacter coli *from pigs in reporting MSs and one non-MS, 2005–2011, quantitative data



Note: A statistically significant increasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Spain (↑).

Figure CA24. Trends in tetracycline resistance in* Campylobacter coli *from pigs in reporting MSs and one non-MS, 2005–2011, quantitative data

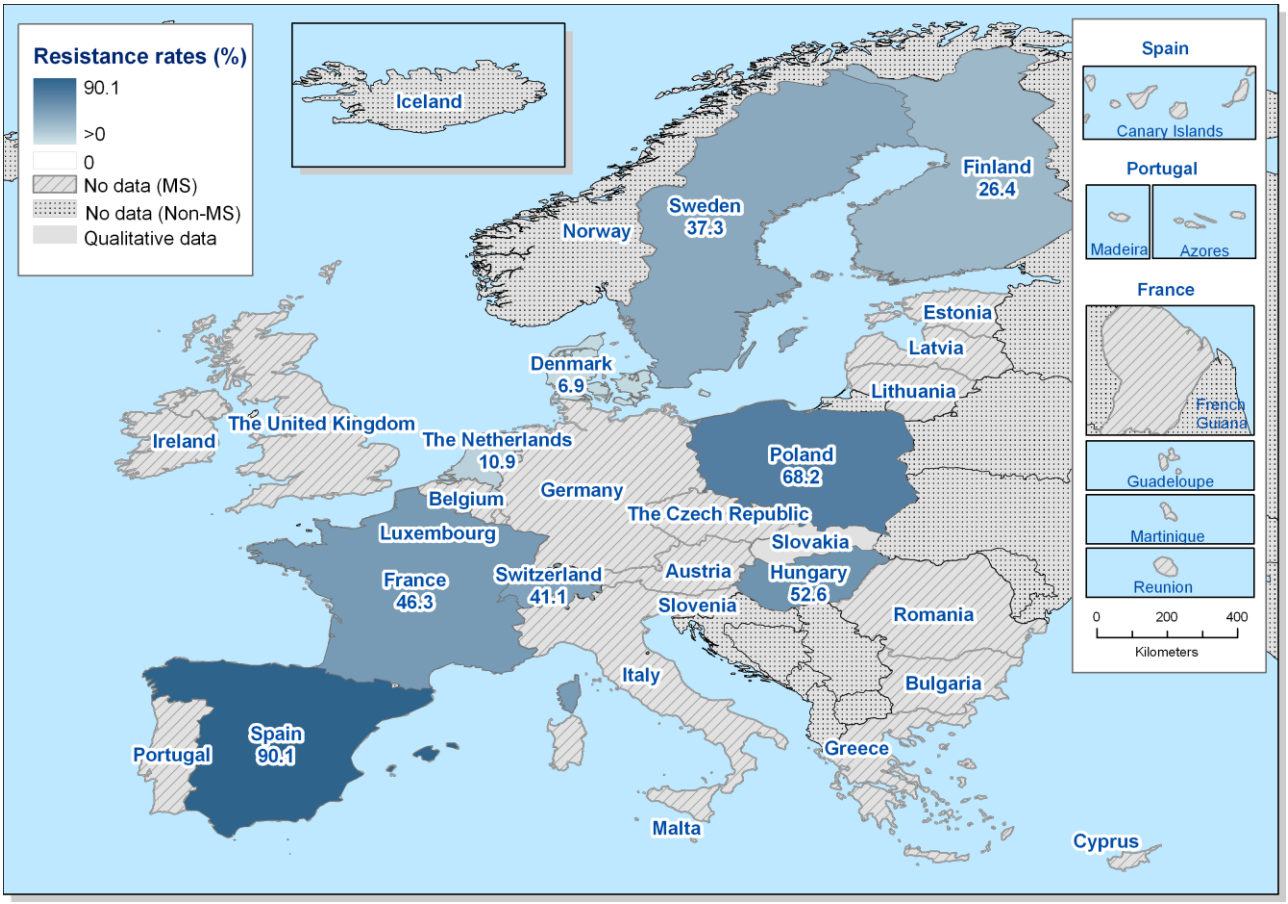


Note: A statistically significant increasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Denmark (↑) and France (↑).

Spatial distribution of resistance among *C. coli*

Figures CA25 and CA26 show the spatial distributions of ciprofloxacin and erythromycin resistance in *C. coli* from pigs. For both erythromycin and ciprofloxacin, the highest levels of resistance were reported by southern countries, while northern countries reported lower levels.

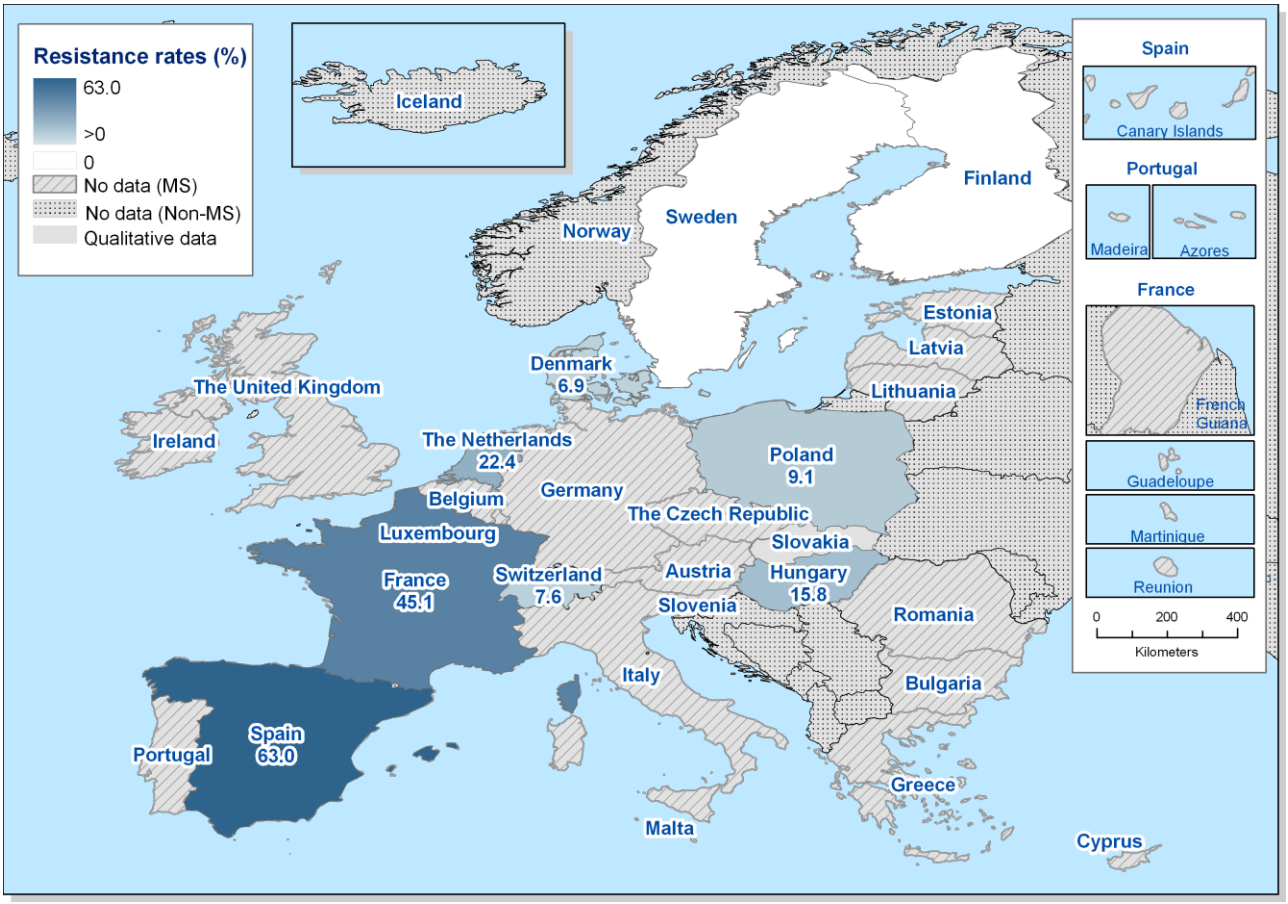
Figure CA25. Spatial distribution of ciprofloxacin resistance among* Campylobacter coli *from pigs in countries reporting MIC data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data have been used instead.

1. For Finland and Poland, 2010 data were used.

Figure CA26. Spatial distribution of erythromycin resistance among* Campylobacter coli *from pigs in countries reporting MIC data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data have been used instead.

1. For Finland and Poland, 2010 data were used.

Multi-resistance among *C. coli* isolates from pigs

The multi-resistance analysis for *C. coli* in pigs was not presented in this report as fewer than four MSs reported multi-resistance isolate-based data on more than 10 isolates from this animal species.

5.4.1.4. Cattle (bovine animals)

In 2011, data on antimicrobial resistance among *C. jejuni* isolates from cattle include samples collected both at the slaughterhouse (Austria, Denmark and Spain) and at farm level (Italy and the Netherlands). Slaughterhouse sampling programmes were randomised over the year and stratified by the number of slaughtered animals by abattoirs across the MS. Sampling in Italy was carried out by active monitoring on a voluntary basis. The sampling was evenly distributed throughout the year or a significant part of the year to account for a possible seasonal effect. Only one faecal sample per bovine animal carcass was collected. In some reporting countries, representative subsets of *Campylobacter* isolates recovered from animal samples were randomly selected at the laboratory for susceptibility testing, while, in some others, all isolates were tested for susceptibility.

Resistance levels among *C. jejuni*

For 2011, five MSs provided quantitative data on *C. jejuni* isolates from cattle (Table CA16).

For tetracyclines, the overall level of resistance in the reporting MS group was also high (32.4 %), but the range of resistance reported among individual MSs was greater than was seen for the quinolones. Tetracycline resistance varied from a low level in Denmark (4.2 %) to extremely high in Spain (73.7 %). The overall level of resistance to gentamicin in the reporting MS group was very low, at 0.8 %. For gentamicin, however, the majority of MSs reported no resistant isolates (0 %), while two MSs reported a very low (Austria, 0.6 %) and a low (Spain, 3.9 %) level of resistance.

For both ciprofloxacin and nalidixic acid, the overall levels of resistance were high, at 38.8 % and 39.2 %, respectively. For both antimicrobials, the range of resistance ranged from moderate in Denmark (20.0 %) to very high in Spain (60.5 %). When considering erythromycin, the overall level of resistance in the reporting MS group was very low (0.8 %). Most MSs reported low or very low levels resistance to erythromycin.

Table CA16. Resistance (%) to ciprofloxacin, erythromycin, gentamicin, nalidixic acid and tetracyclines among* Campylobacter jejuni *from cattle[1] in countries reporting MIC data in 2011, using harmonised epidemiological cut-off values

Country	Ciprofloxacin		Erythromycin		Gentamicin		Nalidixic acid		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Veal calves (under 1 year)										
Netherlands	67	55.2	67	1.5	67	0	67	56.7	67	79.1
Young meat production animals (1-2 years)										
Austria	57	29.8	57	0	57	0	57	28.1	57	10.5
Spain	76	60.5	76	1.3	76	3.9	76	60.5	76	73.7
Total (2 MSs)	**133**	**47.4**	**133**	**0.8**	**133**	**2.3**	**133**	**46.6**	**133**	**46.6**
Adult cattle (over 2 years)										
Austria	109	35.8	109	0.9	109	0.9	109	34.9	109	15.6
Dairy cows										
Netherlands	41	22.0	41	0	41	0	41	24.4	41	19.5
Unspecified cattle type										
Denmark	95	20.0	95	0	95	0	95	20.0	95	4.2
Italy	45	51.1	45	2.2	45	0	45	55.6	45	35.6
Total (2 MSs)	**140**	**30.0**	**140**	**0.7**	**140**	**0**	**140**	**31.4**	**140**	**14.3**
All types of cattle										
Austria	170	33.5	170	0.6	170	0.6	170	32.4	170	13.5
Denmark	95	20.0	95	0	95	0	95	20.0	95	4.2
Italy	48	52.1	48	2.1	48	0	48	56.3	48	35.4
Netherlands	108	42.6	108	0.9	108	0	108	44.4	108	56.5
Spain	76	60.5	76	1.3	76	3.9	76	60.5	76	73.7
Total (5 MSs)	**497**	**38.8**	**497**	**0.8**	**497**	**0.8**	**497**	**39.2**	**497**	**32.4**

N = number of isolates tested.

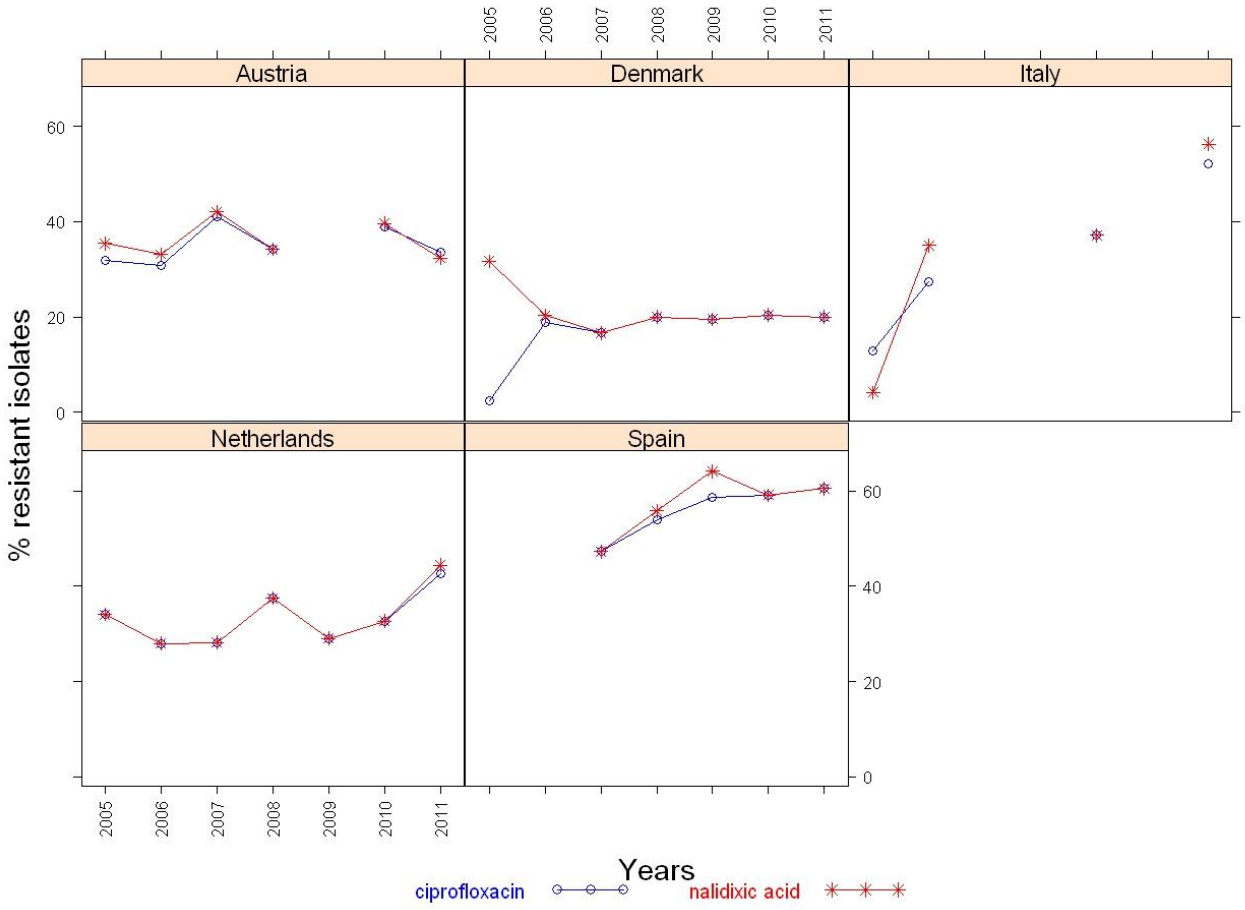
% Res = percentage of resistant isolates.

1. Data presented in this table were derived from a variety of production types. These include adult cattle over 2 years (Austria), meat production animals (Austria and Spain), veal calves (Netherlands), dairy cows (Italy and the Netherlands) and production type unspecified (Denmark and Italy).

Temporal trends in resistance among *C. jejuni*

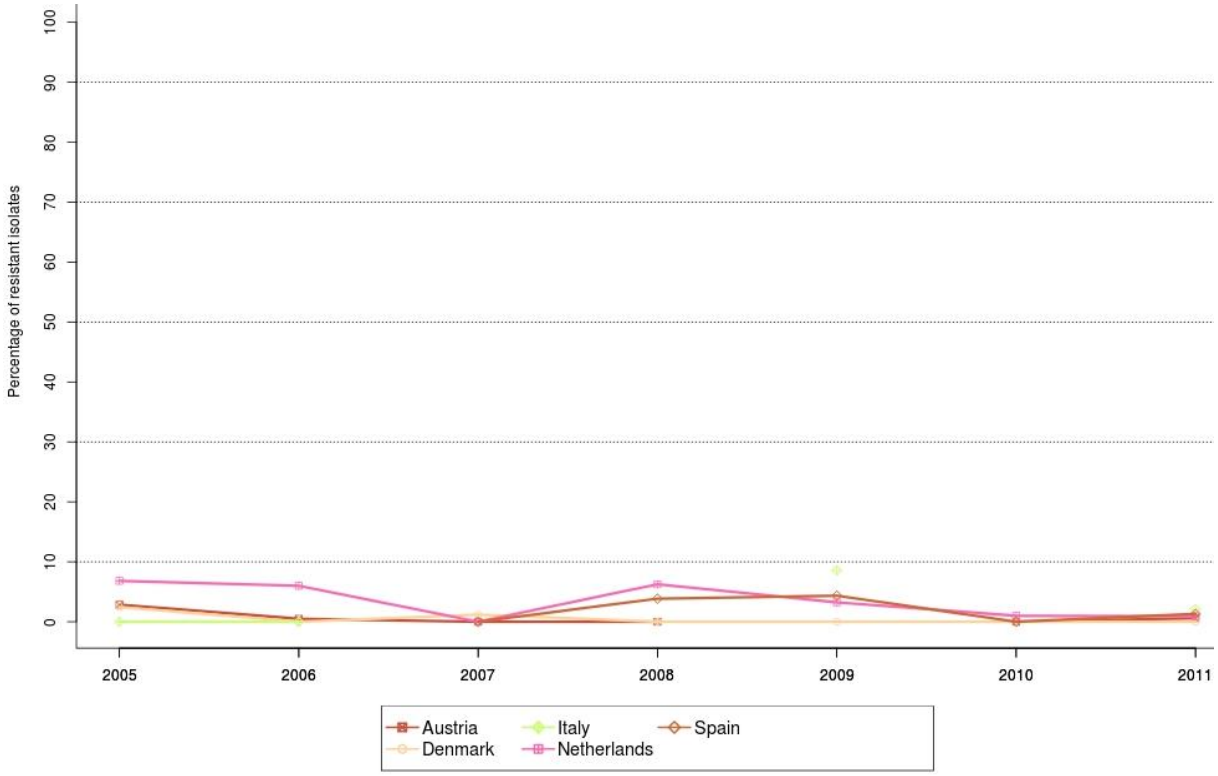
Figures CA27–CA29 show the temporal trends in resistance for *C. jejuni* in cattle. As seen in *C. coli* in pigs, levels of resistance for *C. jejuni* in cattle have remained relatively stable over the 2005–2011 reporting period for individual MSs. Resistance to ciprofloxacin, nalidixic acid and tetracyclines is relatively higher than levels of resistance to erythromycin and gentamicin for the reporting MSs. When considering trends in ciprofloxacin, nalidixic acid and gentamicin resistance, no significant changes were observed over the reporting period. For erythromycin, a significantly decreasing trend was observed in Austria and the Netherlands when tested by a logistic regression model, and for tetracyclines a significantly decreasing trend was observed in Austria only.

Figure CA27. Trends in ciprofloxacin and nalidixic acid resistance in* Campylobacter jejuni *from cattle in reporting MSs and one non-MS, 2005–2011, quantitative data



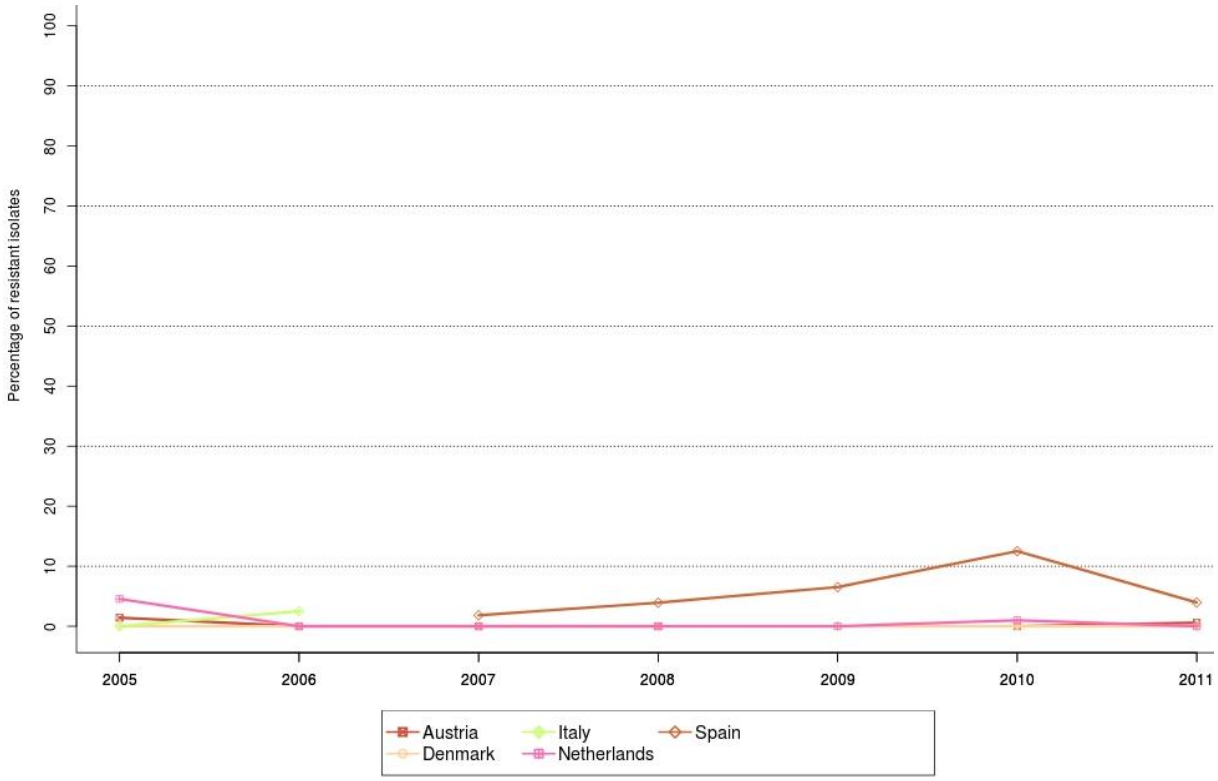
Note: No statistically significant trends over five or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in any of the reporting countries.

Figure CA28. Trends in erythromycin resistance in* Campylobacter jejuni *from cattle in reporting MSs, 2005–2011, quantitative data



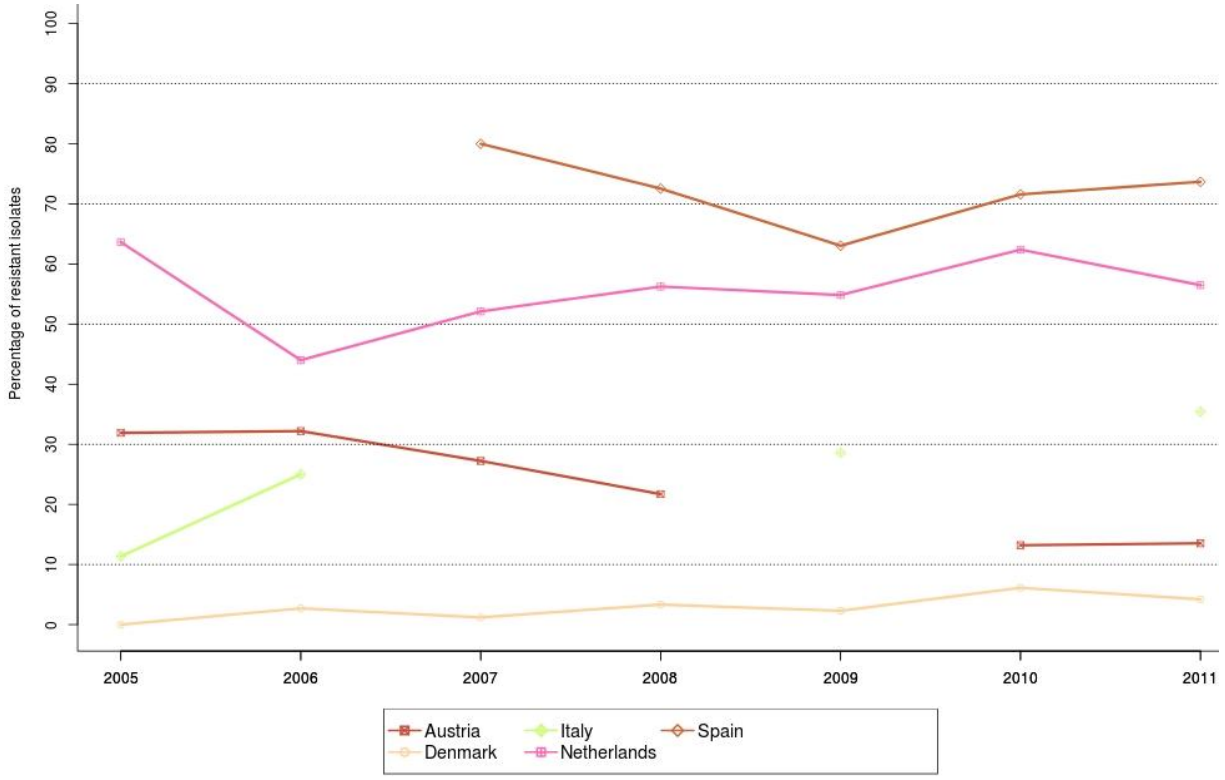
Note: A statistically significant decreasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Austria (↓) and the Netherlands. (↓)

Figure CA29. Trends in gentamicin resistance in* Campylobacter jejuni *from cattle in reporting MSs, 2005–2011, quantitative data



Note: No statistically significant trends over five or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in any of the reporting countries.

Figure CA30. Trends in tetracycline resistance in* Campylobacter jejuni *from cattle in reporting MSs, 2005–2011, quantitative data



Note: A statistically significant decreasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Austria (↓).

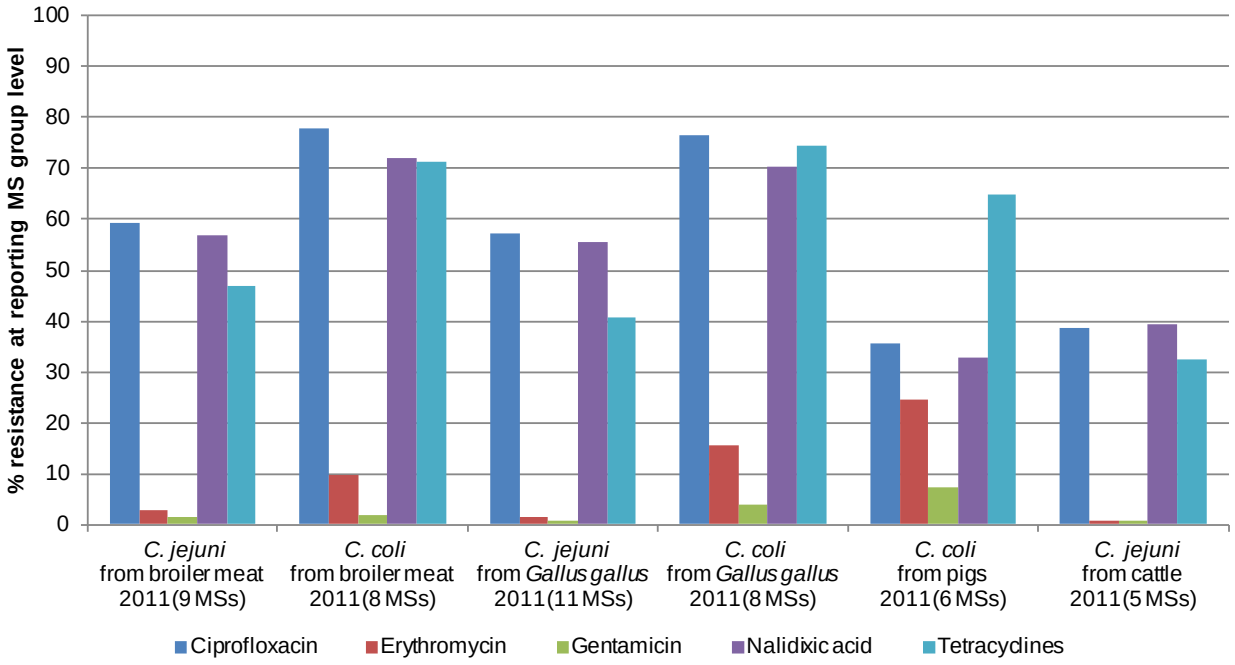
Multi-resistance among *C. jejuni* isolates from cattle

As too few MSs reported resistance isolate-based data on 10 or more isolates of *C. jejuni* from cattle, multi-resistance are not presented in this report.

5.5. Overview of the findings on antimicrobial resistance in *Campylobacter* at reporting MS group level, 2011

Figure CA31 shows the resistance levels in the reporting MS group based on the quantitative data submitted in 2011 for the various animal species and meat derived from those animal species. These data may derive from different MS groups, which needs to be considered when interpreting the figure. As was the case in previous years, *C. coli* isolates tend to be more resistant than *C. jejuni* isolates. Direct comparisons of the levels of resistance in *Campylobacter* from *Gallus gallus* and in broiler meat may not be entirely appropriate because different MSs have reported different types and proportions of isolates tested from meat and live fowl.

Figure CA31. Resistance to ciprofloxacin, erythromycin, gentamicin, nalidixic acid and tetracyclines in* Campylobacter jejuni *and* Campylobacter coli *from fowl, pigs and cattle at reporting MS group level in 2011



5.6. Discussion

Campylobacter causes a large number of human cases of gastro-enteritis and has been the most frequently reported cause of human food-borne zoonoses in the EU since 2004 (EFSA and ECDC, 2013). Resistance to antimicrobials in *Campylobacter* is of concern because of the large numbers of cases of human infection and the fact that some of these require treatment. *Campylobacter* can also cause invasive infections, although the numbers of such cases are usually extremely low.

In 2011, information on antimicrobial resistance in *Campylobacter* isolates from human cases of campylobacteriosis was reported by 13 MSs and one non-MS (Iceland). The data submitted by these countries represented isolates from 16 % of the human campylobacteriosis cases reported within the EU in 2011. There was a large variation in the guidelines used for interpreting the susceptibility tests for human *Campylobacter* isolates, both among and also within countries. Although the clinical breakpoints used for the dilution test for *Campylobacter* were less variable than those for *Salmonella*, the breakpoints for disc diffusion differed significantly depending on the guidelines used, and disc diffusion was still the most common method of testing for antimicrobial susceptibility in human isolates. The disc diffusion method and clinical breakpoints established by EUCAST in 2012 are therefore much welcomed and will be recommended by the ECDC in its work on harmonisation of antimicrobial susceptibility testing for human *Campylobacter* isolates.

There was also a large variation with regard to the number of antimicrobials tested among the reporting countries, which reflects the variation in the clinical importance of the antimicrobials. Erythromycin was the antimicrobial for which the greatest number of human *Campylobacter* spp. isolates were tested. The levels of resistance in human *Campylobacter* isolates to the clinically important antimicrobial erythromycin was overall low, but moderately high in *C. coli*, although the number of tested isolates for this bacterial species was small. High resistance levels to ciprofloxacin continued to be reported in human *Campylobacter* isolates, with increasing trends observed in some MSs.

In order to assess the importance of travel-associated infections, antimicrobial resistance was also analysed based on the most likely country of infection reported. Human isolates acquired in Asia had the highest frequency of resistance to the tested antimicrobials, with resistance to both erythromycin and ciprofloxacin among these isolates being twice as high as in isolates acquired within the EU/EEA. The number of cases associated with travel outside of the EU/EEA was however low (3 % overall in the reporting countries).

Human antimicrobial susceptibility data were available for the full range of antimicrobials only from three MSs for *C. jejuni* and from two MSs for *C. coli*. Overall, only one in six (18.4 %) human *C. jejuni* isolates and one in eight (13.4 %) human *C. coli* isolates were fully susceptible to all antimicrobials. On average, one quarter of both *C. jejuni* and *C. coli* isolates exhibited multi-drug resistance, meaning that they were clinically non-susceptible to at least three different antimicrobial groups. The clinical breakpoints used to interpret the human data were in some cases more sensitive than the ECOFFs when intermediate and resistant results were combined. The human data also covered two penicillins which were not included in the animal/food testing. All these factors could explain the generally higher proportion of multi-resistance observed in humans than in animals, particularly for *C. jejuni*, which was the most common species in humans. Co-resistance to the critically important antimicrobials ciprofloxacin and erythromycin was, on average, low for *C. jejuni* but at a moderate level among *C. coli* isolates, although in the case of *C. coli* few isolates were tested.

The data relating to the susceptibility of *Campylobacter* of food and animal origin reported by MSs were, in general, well harmonised, with almost all MSs reporting the adoption of the EFSA guidelines and recommendations. Some MSs reported qualitative data for *Campylobacter* and did not specify the exact methods used in their submissions to EFSA. For the first time, complete susceptibility and multi-resistance were analysed in isolate-based resistance data reported by the MSs.

Among *Campylobacter* isolates from food-producing animals and meat very to extremely high levels of resistance to one or more antimicrobials were reported by a number of MSs, with the exception of some Nordic countries, particularly when using ECOFFs as interpretative criteria of resistance. In particular, extremely high resistance rates to ciprofloxacin were detected. Overall, in 2011, the highest level of resistance at the reporting MS group level was seen for *C. coli* isolates from meat from broilers, with

resistance to ciprofloxacin being 77.7 %. This figure was remarkably similar to the figure for ciprofloxacin resistance for the reporting MS group for *C. coli* from *Gallus gallus*, although the contributing MSs were not the same. Within a MS, the levels of ciprofloxacin resistance were generally lower in *C. coli* and *C. jejuni* isolates from meat from broilers than in isolates from broilers. Similarly, the levels of complete susceptibility are higher, and of multi-resistance are lower, in *C. jejuni* isolates from broiler meat than in those from broilers. Generally, resistance levels to all antimicrobials were higher in *C. coli* than in *C. jejuni* for the same host species. Similarly, the levels of multi-resistance (reduced susceptibility to at least three different antimicrobial classes) in *C. coli* isolates from broilers were much higher than those detected in *C. jejuni* isolates of the same origin. However, it should be borne in mind that, despite the high levels of resistance/multi-resistance observed, *C. coli* is much less prevalent in poultry than *C. jejuni*.

The number of MSs reporting statistically significant trends in resistance levels over five or more years by the logistic regression model ($p \leq 0.05$) increased in 2011. Significant trends were most frequently seen for ciprofloxacin and nalidixic acid resistance in *C. jejuni* from *Gallus gallus*, with six MSs reporting an increasing trend. Overall, levels of antimicrobial resistance in *Campylobacter* isolates from animals and food were similar to those in 2010.

Over the period 2009–2011, the highest levels of resistance to quinolones and fluoroquinolones were in general detected in *Campylobacter* isolates from *Gallus gallus*. This high level of resistance is of particular concern, since the EFSA BIOHAZ Panel, in its recent scientific opinion on the quantification of the risk of campylobacteriosis posed to humans by broiler meat, estimated that the handling, preparation and consumption of broiler meat may account for 20 % to 30 % of human campylobacteriosis cases, while 50 % to 80 % of cases may be attributed to the chicken (broiler) reservoir as a whole (EFSA, 2010a). However, *Campylobacter* strains from the broiler reservoir may also reach humans via routes other than food (e.g. by the environment or by direct contact).

Regarding resistance to erythromycin, the first-choice drug for the treatment of campylobacteriosis, the levels observed were mostly low to moderate in food and animal isolates. This situation is similar to that observed in 2009 and 2010.

In countries which reported results for *C. coli* from both pigs and *Gallus gallus* and *C. jejuni* from *Gallus gallus* (France, Hungary, the Netherlands, Spain and Switzerland), the level of resistance to erythromycin was invariably highest in *C. coli* isolates from pigs and lower in the isolates from the other sources for each MS. These findings mirror those in 2009 and 2010 and in many previous studies, in which macrolide-resistant isolates of *C. coli* from food animals have mainly been of porcine origin (Gibreel and Taylor, 2006).

THE RECENT REVISION OF EUCAST ECOFFS FOR *CAMPYLOBACTER*

There have been some recent minor revisions to the ECOFFs provided by EUCAST. Thus, the EUCAST ciprofloxacin ECOFF for C. coli *is currently ≤0.5 mg/L, a decline of one log value from the previous ECOFF value of >1 mg/L described on the EUCAST website and recorded in Table MM10. Similarly, the ECOFF values for* C. coli *and erythromycin,* C. coli *and nalidixic acid and* C. jejuni *and both ciprofloxacin and tetracyclines have declined by one dilution step. Conversely, the ECOFF has increased by one log dilution for* C. jejuni *versus gentamicin and streptomycin. Although deviation from wild-type susceptibility is a fixed microbiological characteristic, as greater numbers of bacterial isolates are tested, the wild-type distribution may become better defined and minor changes in the ECOFF might therefore be expected. The breakpoints used in this report to discriminate between 'microbiologically resistant' and wild-type bacteria are identical to those used in previous reports for* Campylobacter *and so there should be no effect of methodological changes when comparisons are made between years. When EFSA's recommendations are revised to include the latest EUCAST ECOFFs and new legislation incorporating those recommendations is subsequently adopted by the European Commission, then the historical data are likely to be re-interpreted, using the new EUCAST ECOFF values. Reference to the MIC distribution tables for* C. coli *and* C. jejuni *which are published in the appendix, shows that the effect of these changes is in most cases likely to be small.*

6. ANTIMICROBIAL RESISTANCE IN INDICATOR *ESCHERICHIA COLI*

6.1. Introduction

Escherichia coli are commensal bacteria normally and naturally present in the intestine of most terrestrial farm animals. Commensal *E. coli* is commonly chosen as an indicator Gram-negative bacterium as it is very commonly present in animal faeces, is relevant to human medicine and can often acquire conjugative plasmids, which can be transferred between enteric bacteria. Commensal *E. coli* present in the intestine of farm animals comprise a reservoir of resistance genes that can spread horizontally to zoonotic and other bacteria occurring in the food chain. Most terrestrial food animals generally carry indicator *E. coli*, and therefore randomised sampling strategies can be developed, allowing for statistical analysis of data and reducing the effect of sampling bias, as well as allowing inference to be made from the representative random sample investigated to the target population from which the sample was derived. Commensal indicator organisms, rather than pathogenic types of *E. coli*, such as enterotoxigenic *E. coli* (ETEC) or verotoxigenic *E. coli* (VTEC), are therefore the target of the monitoring of indicator *E. coli*.

The monitoring of antimicrobial resistance in indicator *E. coli*, isolated from either randomly selected healthy animals or derived carcases and meat thereof, and chosen to be representative of the general population, provides valuable data on the resistance occurring in that population. Determining the occurrence of resistance to antimicrobials in indicator *E. coli* provides data useful for investigating relationship with the selective pressure exerted by the use of antimicrobials on the intestinal population of bacteria in food-producing animals. Indicator *E. coli* are also useful as representatives of the Enterobacteriaceae to monitor the emergence and changes in the proportion of bacteria possessing extended-spectrum beta-lactamases (ESBLs).

The EFSA monitoring guidelines (EFSA, 2008a) recommend that monitoring may be carried out at farm or slaughterhouse level and that at least 90 % of the animal population in a MS should be included in the sampling frame. Samples should be collected randomly from selected holdings or flocks or randomly selected within the slaughterhouse. Samples collected (and subsequently tested) in accordance with the EFSA recommendations should therefore be comparable between MSs.

ANTIMICROBIAL RESISTANCE IN VEROTOXIGENIC *E. COLI*

In 2011, there were a total of 9,478 confirmed cases of verotoxigenic E. coli *in the EU, which was a 159.2 % increase compared with 2010 (N=3,656) (EFSA and ECDC, 2013). However, antimicrobial resistance is not usually considered very significant in infections caused by 'classic' food-borne* E. coli *pathogens such as VTEC; human VTEC infections are also commonly not treated with antimicrobials. Only one country (the Netherlands) submitted data concerning VTEC in 2011, and the results for these organisms are presented in section 10.5 of this report. There are a number of different types and strains of* E. coli *causing a range of infections in humans, ranging from urinary tract infections, through enteritis to bacteraemia and septic shock. The degree to which animals and humans share or exchange the same strains of* E. coli *is currently the subject of active research and debate. Resistance to key therapeutic antimicrobials can seriously compromise treatment of invasive* E. coli *infections as well as urinary tract infections in humans. Infections caused by such antimicrobial-resistant strains are becoming increasingly common worldwide and are posing serious health problems for human medicine (EARSS, 2008).*

6.2. Antimicrobial resistance in indicator *Escherichia coli* isolates from animals and food

In total, 12 MSs and 2 non-MSs (Norway and Switzerland) reported quantitative MIC data on antimicrobial resistance in commensal (indicator) *E. coli* isolates from animals in 2011. In addition, three of these countries provided MIC data on isolates collected from food. The total number of tests performed on *E. coli* isolates from animals and food by MSs and non-MSs and for which quantitative MIC data are available was 123,662. In addition, qualitative data were provided by seven MSs, but no specific subsection has been prepared for these data. Table EC1 shows the countries that reported data concerning indicator *E. coli* in 2011.

Table EC1. Overview of countries reporting MIC and disc inhibition zones on indicator* Escherichia coli *from animals and food in 2011

Method	Origin	Total number of MSs reporting	Countries
Diffusion	*Gallus gallus* (fowl)	4	**MSs**: FR[1], PL[1], SK[2], UK[2]
	Turkeys	3	**MSs:** PL[1], SK[2], UK[2]
	Pigs	4	**MSs:** FR[1], PL[1], SK[2], UK[2]
	Cattle (bovine animals)	3	**MSs:** PL[1], SK[2], UK[2]
	Meat from broilers (*Gallus gallus*)	2	**MSs:** ES[3], HU
	Meat from turkey	1	**MS:** HU
	Meat from pig	1	**MS:** HU
	Meat from bovine animals	3	**MSs:** ES[3], HU, SI[2]
Dilution	*Gallus gallus* (fowl)	10	**MSs:** AT, BE, DE, DK, ES, FI, FR, IE, NL, PL
			Non-MSs: CH, NO
	Turkeys	3	**MSs:** DE, NL, PL
	Pigs	10	**MSs:** AT, BE, DE, DK, EE, ES, FR, NL, PL, SE
			Non-MSs: CH, NO
	Cattle (bovine animals)	7	**MSs:** AT, BE, DE, DK, ES, NL, PL
			Non-MS: CH
	Meat from broilers (*Gallus gallus*)	2	**MSs:** DE, DK
	Meat from pig	3	**MSs:** DE, DK, SE
	Meat from bovine animals	2	**MSs**: DE, DK

1. These data were submitted with no test method specified and this information could not be obtained from the National Zoonoses Reports.
2. These data were submitted with no test method specified but are believed to have been tested by disc diffusion based on information in the National Zoonoses Reports.
3. These data were submitted with the test method listed as dilution but no MIC distribution data were supplied.

Antimicrobials selected by the different MSs and non-MSs for MIC susceptibility testing of indicator *E. coli* are shown in Chapter 11, Materials and Methods, Table MM7. Proportions of resistance to the antimicrobial agents ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, streptomycin, sulfonamides and tetracyclines are described in detail later in this chapter. The tables of occurrence of resistance were generated, and multi-drug resistance analysis was performed, if more than four countries reported quantitative data per sampling origin. In addition, only data where 10 or more isolates were available per country, per sampling origin, per year are included in the report.

In the graphs illustrating trends in the evolution of antimicrobial resistance over time, results for MIC data interpreted using epidemiological cut-off values are shown. Few MSs have reported data for the seven consecutive years from 2005 to 2011, as the monitoring of resistance in indicator *E. coli* is performed on a voluntary basis.

Where the minimum criteria for detailed analysis were met, multi-resistance was analysed in the isolate-based dataset of indicator *E. coli* isolates tested for the full harmonised set of nine antimicrobials belonging to different classes. Multi-resistance was defined as non-susceptibility to at least three different antimicrobial classes. The proportions of isolates susceptible to all and resistant (non-susceptible) to any one up to nine antimicrobials are presented. Co-resistance to cefotaxime and ciprofloxacin was estimated as these two

antimicrobials are of particular interest in human medicine. Co-resistance was addressed using both ECOFFs (CTX >0.25 mg/L and CIP >0.03 mg/L) and clinical breakpoints (CTX >2 mg/L and CIP >1 mg/L).

For further information on reported MIC distributions and numbers of resistant isolates for ampicillin, apramycin, cefotaxime, ceftazidime, ceftiofur, chloramphenicol, ciprofloxacin, colistin, florfenicol, gentamicin, imipenem, kanamycin, nalidixic acid, neomycin, spectinomycin, streptomycin, sulphonamides, tetracyclines and trimethoprim for *E. coli* in 2011, please refer to the Level 3 tables published on the EFSA website.

6.2.1. Antimicrobial resistance in indicator *Escherichia coli* isolates from food

6.2.1.1. Meat

In 2011, Denmark and Germany reported quantitative MIC data for *E. coli* isolates from meat from bovine animals, broilers (*Gallus gallus*) and pigs, and Sweden reported comparable data for meat from pigs. The AMR data in indicator *E. coli* isolates from the three kinds of meat reported by Denmark, Germany and Sweden derived from active and representative monitoring programmes. In Denmark, *E. coli* isolates originated from meat sampled at wholesale and retail outlets, collected randomly in all regions of the country and spread evenly throughout the year, in the framework of three centrally coordinated sampling plans corresponding to each kind of meat.

Resistance levels among *E. coli* isolates in broiler meat

Denmark and Germany tested 122 and 172 *E. coli* isolates from meat from broilers (*Gallus gallus*), respectively. The highest resistance levels in both countries were reported for ampicillin (23.0 % and 67.4 %, respectively) and sulfonamides (22.1 % and 54.7 %, respectively). In addition, Germany reported high resistance to nalidixic acid (48.8 %), streptomycin (44.2 %), tetracyclines (44.2 %) and trimethoprim (44.2 %), while Denmark reported only low or moderate levels of resistance, at 5.7 %, 11.5 %, 18.9 % and 12.3 %, respectively. There was a lower level of resistance to chloramphenicol in both countries, with 16.9 % of isolates in Germany and 1.6 % of isolates in Denmark expressing resistance. Low resistance to gentamicin (4.1 %) was reported by Germany, while all isolates from Denmark were fully susceptible to this antimicrobial. Germany also reported very high resistance to ciprofloxacin (52.3 %), whereas Denmark reported 5.7 % resistance to this antimicrobial. Both countries reported low resistance to cefotaxime (2.5 % in Denmark and 4.7 % in Germany).[16]

Resistance levels among *E. coli* isolates in meat from pigs

Denmark, Germany and Sweden tested for susceptibility 92, 52 and 20 isolates from meat from pigs, respectively. The highest overall resistance levels for all three MSs combined were reported for streptomycin (31.1 %), ampicillin (28.0 %), tetracyclines (28.0 %), sulfonamides (25.0 %) and trimethoprim (22.0 %). Regarding ampicillin, all three countries reported comparable resistance levels. For the other four antimicrobials, Sweden reported relatively lower resistance levels of only 10 % or less compared with the high resistance levels recorded in Denmark and Germany. There was low or very low overall resistance to cefotaxime (0.6 %), chloramphenicol (1.2 %), gentamicin (0.6 %) and nalidixic acid (1.2 %), with only one country reporting one or two resistant isolates for each: Germany reported 3.8 % resistance to nalidixic acid and 1.9 % resistance to cefotaxime and gentamicin, and Denmark reported 2.2 % resistance to chloramphenicol, while all other isolates from the three countries were susceptible to these antimicrobials. Only Denmark and Germany tested ciprofloxacin and both reported low resistance levels (1.1 % and 5.8 %, respectively).[17]

Resistance levels among *E. coli* isolates in meat from bovine animals

Denmark and Germany tested for susceptibility 37 and 68 isolates from meat from bovine animals, respectively. Germany tended to report higher resistance than Denmark, although the difference was not as extreme as for meat from broilers. The highest resistance levels were reported for ampicillin and

[16] In addition, of the other aminoglycosides tested, Denmark reported low resistance to both neomycin (4.1 %) and spectinomycin (1.6 %), while Germany reported full sensitivity to kanamycin. Denmark also reported 2.5 % resistance to ceftiofur.

[17] Moreover, Denmark reported moderate resistance to spectinomycin (15.2 %) but low resistance to neomycin (2.2 %). Germany and Sweden both reported low resistance to kanamycin (9.6 % and 5.0 %, respectively). Denmark found no resistance to ceftiofur.

tetracyclines (5.4 % resistance to both in Denmark and 11.8 % resistance to both in Germany). Germany reported moderate levels of resistance to streptomycin (11.8 %), sulfonamides (16.2 %) and trimethoprim (11.8 %), whereas Denmark reported only 2.7 % resistance to the former and full sensitivity to the last two antimicrobials. Both countries reported low resistance to ciprofloxacin (2.7 % in Denmark and 4.4 % in Germany). Germany also reported low resistance to chloramphenicol (1.5 %), gentamicin (2.9 %) and nalidixic acid (4.4 %), whereas Denmark reported full sensitivity to all three antimicrobials. Neither country reported any resistance to cefotaxime.[18]

Multi-resistance among *E. coli* from food

As too few MSs reported multi-resistance isolate-based data on more than 10 isolates of indicator *E. coli* in food, tables and graphs on multi-resistance are not presented in this report.

6.2.2. Antimicrobial resistance in indicator *Escherichia coli* isolates from animals

6.2.2.1. Fowl (*Gallus gallus*)

In this section, data on antimicrobial resistance in indicator *E. coli* isolates from fowl (*Gallus gallus*) are presented separately for broilers and laying hens. The majority of MSs collected isolates as part of their national monitoring programmes. In all reporting MSs, except Germany, active monitoring programmes were based on random sampling of healthy broilers at the slaughterhouse. The slaughterhouses included in the monitoring programme accounted for a major proportion, typically 80 % or more, of the total production in the country. The sampling plan was stratified per slaughterhouse, the sample size per slaughterhouse being proportional to the annual throughput of animals slaughtered. The sampling was evenly distributed throughout the year or a significant part of the year to account for a possible seasonal effect. Indicator *E. coli* isolates were isolated from caecal contents in Belgium, France, the Netherlands and Sweden, from cloacal swabs in Switzerland, and from faecal samples in the other reporting MSs, by sampling healthy broilers at slaughter. Only one representative sample of caecal content per flock/batch, derived from either a unique or a number of slaughtered animals, was gathered to account for clustering. In Germany, indicator *E. coli* were isolated from faeces sampled from broiler flocks and laying hen flocks on farm. Samples were collected in the framework of a national sampling plan, stratified per federal region, and allocated in proportion with regard to the total number of broilers and laying hens per land, respectively.

Resistance levels among *Escherichia coli*

In 2011, nine MSs and two non-MSs provided quantitative data concerning antimicrobial resistance in *E. coli* from broilers, and two MSs provided comparable data concerning *E. coli* from laying hens; only Germany provided data concerning both production types of fowl (Table EC2).

Regarding broiler flocks, a high or very high level of resistance was observed at the reporting MS group level for ciprofloxacin (53.1 %), ampicillin (54.4 %), sulfonamides (50.8 %), streptomycin (47.2 %), tetracyclines (45.2 %) and nalidixic acid (42.6 %). Resistance levels varied considerably between MSs, for example from 3.8 % (Finland) to 84.8 % (Belgium) for ampicillin. Denmark and Finland tended to have the lowest levels of resistance to these antimicrobials. There was a moderate level of resistance to chloramphenicol at the reporting MS group level (13.2 %). Both Denmark and Finland reported no resistance, while Belgium, Germany and the Netherlands reported high levels of resistance (24.3 %, 23.6 % and 20.5 %, respectively). A low level of resistance was observed to gentamicin overall (4.2 %). Three countries reported full sensitivity to gentamicin among broilers, with all other countries reporting low or very low levels of resistance of between 0.3 % and 7.1 %, except for Spain, which reported 25.7 % resistance.

Regarding ciprofloxacin and nalidixic acid, the overall resistance was also high, at 53.1 % and 42.6 %, respectively. Resistance to cefotaxime at MS group level was low, at 8.2 %. Among reporting MSs, Finland reported no resistance to this antimicrobial among broilers, and most other countries reported low or very low levels of resistance of between 0.4 % and 8.1 %, although Belgium and Spain reported 19.1 % and 20.8 % resistance, respectively.

[18] Denmark also reported full sensitivity to ceftiofur as well as neomycin and spectinomycin, and Germany reported full sensitivity to kanamycin.

Among *E. coli* isolates from laying hens tested in the two reporting MSs, Poland and Germany, only a low or moderate overall resistance was recorded to ampicillin (18.1 %), sulfonamides (14.3 %), streptomycin (9.7 %), tetracyclines (17.1 %), as well as to ciprofloxacin (13.6 %) and nalidixic acid (11.2 %). However, Poland tended to report resistance levels at least twice as high as those recorded in Germany for these antimicrobials, with the difference most extreme for ciprofloxacin (46.8 % vs. 5.6 %) and nalidixic acid (38.3 % vs. 4.7 %). There was low resistance among laying hens to chloramphenicol (3.0 %), and gentamicin (1.6 %), as well as to cefotaxime (1.9 %), with slightly higher resistances recorded by Poland than by Germany.

Table EC2. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, streptomycin, sulfonamides and tetracyclines among indicator* Escherichia coli *from* Gallus gallus *in countries reporting MIC data in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Broilers										
Austria	173	26.6	173	1.7	173	5.2	173	68.8	173	0
Belgium	420	84.8	419	19.1	420	24.3	420	64.0	420	4.0
Denmark	134	20.1	134	0.7	134	0	134	9.0	134	0
Finland	316	3.8	316	0	316	0	-	-	316	0.3
France	192	56.8	192	6.8	192	6.3	192	40.1	192	1.0
Germany	246	77.6	246	7.7	246	23.6	246	48.4	246	6.1
Ireland	154	64.3	154	3.9	154	5.2	154	39.0	154	2.6
Netherlands	283	66.1	283	8.1	283	20.5	283	56.2	283	7.1
Spain	101	70.3	101	20.8	101	19.8	101	89.1	101	25.7
Total (9 MSs)	**2,019**	**54.4**	**2,018**	**8.2**	**2,019**	**13.2**	**1,703**	**53.1**	**2,019**	**4.2**
Norway[1]	244	18.0	244	0.4	244	0.8	-	-	244	0
Switzerland	176	27.8	176	2.3	176	1.7	176	40.3	176	2.3
Laying hens										
Germany	642	14.6	642	1.6	642	2.8	642	5.6	642	1.2
Poland	154	32.5	154	3.2	154	3.9	154	46.8	154	3.2
Total (2 MSs)	**796**	**18.1**	**796**	**1.9**	**796**	**3.0**	**796**	**13.6**	**796**	**1.6**
All types of fowl (*Gallus gallus*)										
Austria	173	26.6	173	1.7	173	5.2	173	68.8	173	0
Belgium	420	84.8	419	19.1	420	24.3	420	64.0	420	4.0
Denmark	134	20.1	134	0.7	134	0	134	9.0	134	0
Finland	316	3.8	316	0	316	0	-	-	316	0.3
France	192	56.8	192	6.8	192	6.3	192	40.1	192	1.0
Germany	888	32.1	888	3.3	888	8.6	888	17.5	888	2.6
Ireland	154	64.3	154	3.9	154	5.2	154	39.0	154	2.6
Netherlands	283	66.1	283	8.1	283	20.5	283	56.2	283	7.1
Poland	154	32.5	154	3.2	154	3.9	154	46.8	154	3.2
Spain	101	70.3	101	20.8	101	19.8	101	89.1	101	25.7
Total (10 MSs)	**2,815**	**44.1**	**2,814**	**6.4**	**2,815**	**10.3**	**2,499**	**40.5**	**2,815**	**3.5**
Norway[1]	244	18.0	244	0.4	244	0.8	-	-	244	0
Switzerland	176	27.8	176	2.3	176	1.7	176	40.3	176	2.3

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

1. Thirty-eight of the isolates tested by Norway were from clinical samples.

Table EC2 (continued). Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, streptomycin, sulfonamides and tetracyclines among indicator* Escherichia coli *from* Gallus gallus *in countries reporting MIC data in 2011, using harmonised epidemiological cut-off values

Country	Nalidixic acid		Streptomycin		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res
Broilers								
Austria	173	65.3	173	41.6	173	30.6	173	26.0
Belgium	420	62.9	419	69.0	420	75.0	420	64.8
Denmark	134	9.0	134	11.2	134	16.4	134	10.4
Finland	316	0.6	316	12.7	316	10.8	316	7.9
France	192	30.7	192	50.0	192	55.7	192	81.3
Germany	246	44.3	246	54.5	246	69.1	246	48.4
Ireland	155	36.8	154	45.5	154	59.1	154	50.6
Netherlands	283	55.8	283	62.2	283	63.3	283	51.6
Spain	101	85.1	101	59.4	101	54.5	101	57.4
Total (9 MSs)	**2,020**	**42.6**	**2,018**	**47.2**	**2,019**	**50.8**	**2,019**	**45.2**
Norway[1]	244	2.9	244	5.7	244	14.3	244	7.0
Switzerland	176	38.6	176	17.6	176	35.8	176	26.1
Laying hens								
Germany	642	4.7	642	8.4	642	12.1	642	14.0
Poland	154	38.3	154	14.9	154	23.4	154	29.9
Total (2 MSs)	**796**	**11.2**	**796**	**9.7**	**796**	**14.3**	**796**	**17.1**
All types of fowl (*Gallus gallus*)								
Austria	173	65.3	173	41.6	173	30.6	173	26.0
Belgium	420	62.9	419	69.0	420	75.0	420	64.8
Denmark	134	9.0	134	11.2	134	16.4	134	10.4
Finland	316	0.6	316	12.7	316	10.8	316	7.9
France	192	30.7	192	50.0	192	55.7	192	81.3
Germany	888	15.7	888	21.2	888	27.9	888	23.5
Ireland	155	36.8	154	45.5	154	59.1	154	50.6
Netherlands	283	55.8	283	62.2	283	63.3	283	51.6
Poland	154	38.3	154	14.9	154	23.4	154	29.9
Spain	101	85.1	101	59.4	101	54.5	101	57.4
Total (10 MSs)	**2,816**	**33.7**	**2,814**	**36.6**	**2,815**	**40.5**	**2,815**	**37.3**
Norway[1]	244	2.9	244	5.7	244	14.3	244	7.0
Switzerland	176	38.6	176	17.6	176	35.8	176	26.1

N = number of isolates tested.

% Res = percentage of resistant isolates.

1. Thirty-eight of the isolates tested by Norway were from clinical samples.

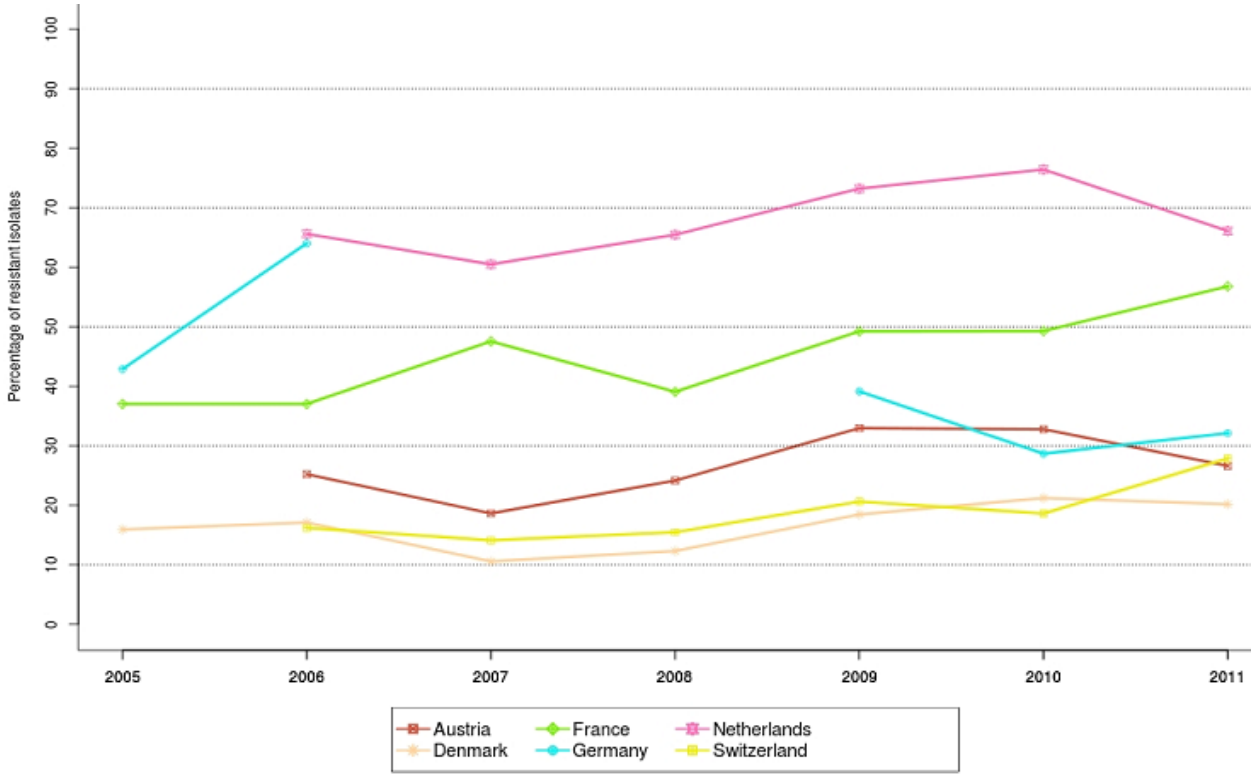
Temporal trends in resistance among indicator *Escherichia coli*

Figures EC1-EC6 display the temporal trends in resistance to the selected antimicrobials in indicator *E. coli* from *Gallus gallus*, data derived from broilers and laying hens being combined. The 2010 and 2011 resistance levels for Germany presented in these figures combine data for broilers and laying hens, while for the other reporting countries resistance data derive from broilers only. The figures illustrate the wide variation in resistance between MSs for many of the antimicrobials. The Netherlands and Spain tended to report relatively high resistance levels for most antimicrobials, although France consistently reported the highest resistance to tetracyclines between 2005 and 2011. Denmark often reported the lowest resistance levels. The resistance to ciprofloxacin reported over the seven-year study period was high to very high for all reporting countries, with the exception of Denmark for the whole period and of Germany for the years 2010 and 2011, which in both cases was below 20 %. There was less variation between countries in the resistance to cefotaxime and chloramphenicol, which, in most countries, was at a moderate or low level. Figure EC4 clearly demonstrates the close similarity in resistance levels for ciprofloxacin and nalidixic acid in most MSs.

In addition, compared with the year 2010, resistance levels observed in 2011 tended to be broadly similar, although there were a few exceptions; for example, in Germany resistance to sulfonamides in broiler flocks increased from 4 % in 2010 to 69.1 % in 2011. Such inter-annual evolutions need to be confirmed by longer-term trends.

Resistance levels for many of the antimicrobials were broadly stable or had shown only gradual increases or decreases. Nevertheless, there was evidence of statistically significant trends in the occurrence of resistance to some of the antimicrobials over five or more years. Austria reported significant increases in resistance to ciprofloxacin, nalidixic acid and streptomycin, and France reported significant increases in resistance to both ampicillin and ciprofloxacin. In contrast, Germany reported significant declines in resistance to many antimicrobials, including ampicillin, ciprofloxacin, nalidixic acid and tetracyclines, but with an increase in resistance to chloramphenicol. Switzerland also reported a decline in resistance to tetracyclines but an increase in resistance to ampicillin. In addition, there were statistically significant increases in resistance to nalidixic acid in the Netherlands, and to tetracyclines in Denmark. There were no significant trends in resistance to cefotaxime in any of the reporting countries.

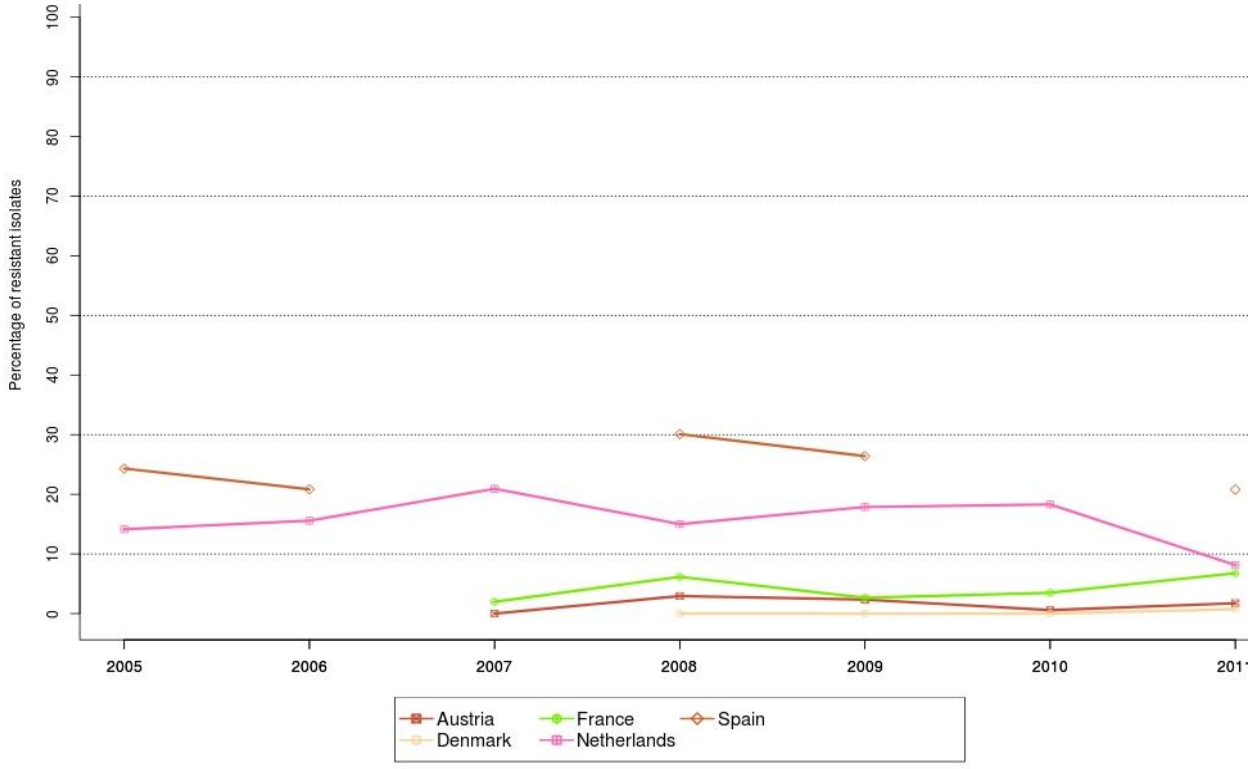
Figure EC1. Trends in ampicillin resistance in indicator* Escherichia coli *from* Gallus gallus[1] *in reporting MSs and one non-MS, 2005–2011, quantitative data



Note: Statistically significant increasing or decreasing trends over five or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in France (↑), Germany (↓) and Switzerland (↑).

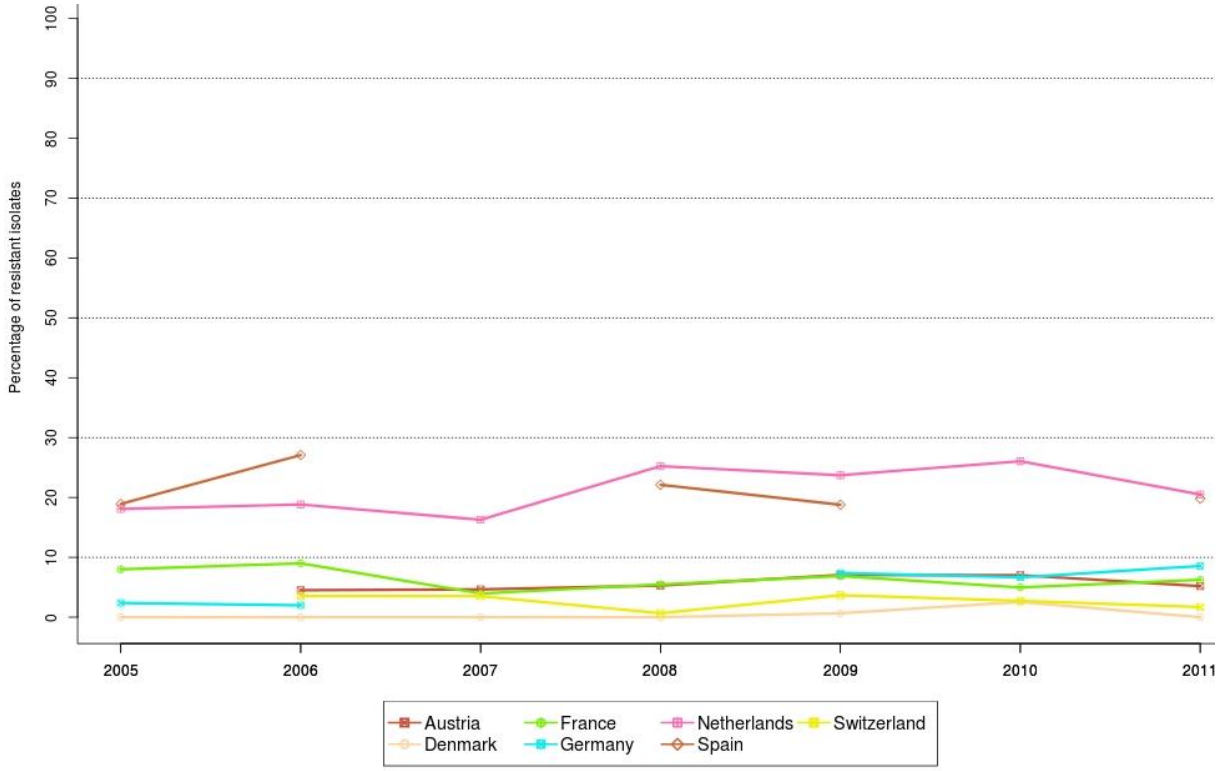
1. The data from Germany in 2010 and 2011 originated from broilers and laying hens.

Figure EC2. Trends in cefotaxime resistance in indicator* Escherichia coli *from* Gallus gallus *in reporting MSs, 2005–2011, quantitative data



Note: No statistically significant increasing or decreasing trends over five or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in any of the reporting countries.

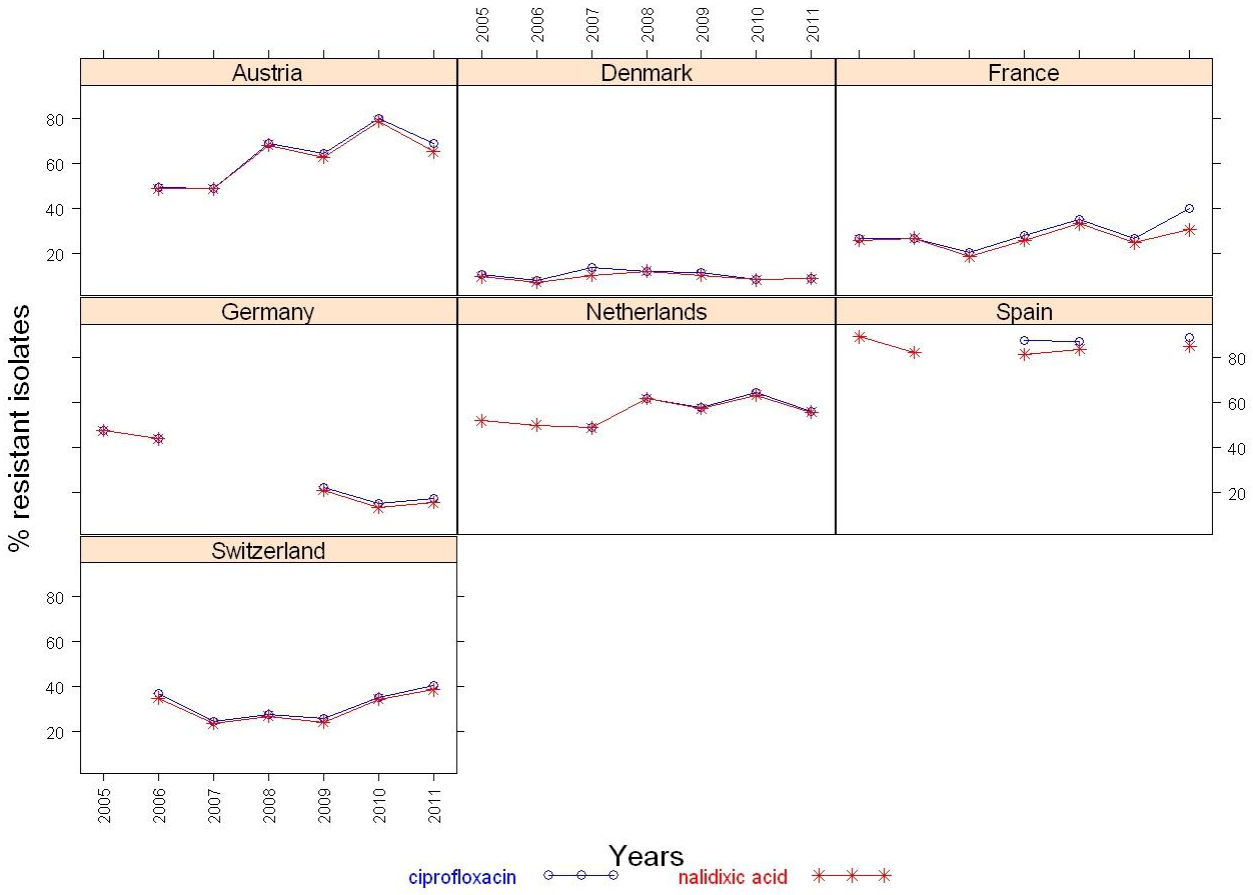
Figure EC3. Trends in chloramphenicol resistance in indicator* Escherichia coli *from* Gallus gallus[1] *in reporting MSs and one non-MS, 2005–2011, quantitative data



Note: A statistically significant increasing trend over five years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Germany (↑).

1. The data from Germany in 2010 and 2011 originated from broilers and laying hens.

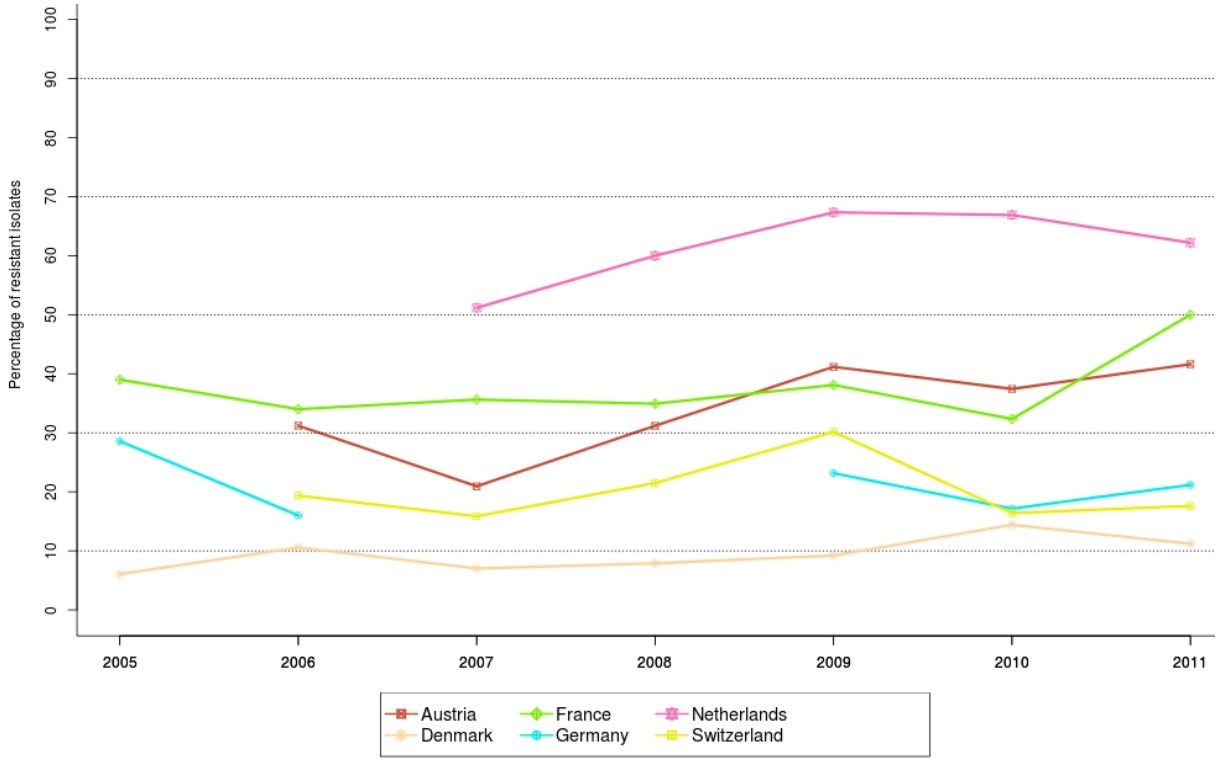
Figure EC4. Trends in ciprofloxacin and nalidixic acid resistance in indicator* Escherichia coli *from* Gallus gallus[1] *in reporting MSs and one non-MS, 2005–2011, quantitative data



Note: Statistically significant increasing or decreasing trends over five or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Austria (↑), France (↑) and Germany (↓) for ciprofloxacin, and in Austria (↑), Germany (↓) and the Netherlands (↑) for nalidixic acid.

1. The data from Germany in 2010 and 2011 originated from broilers and laying hens.

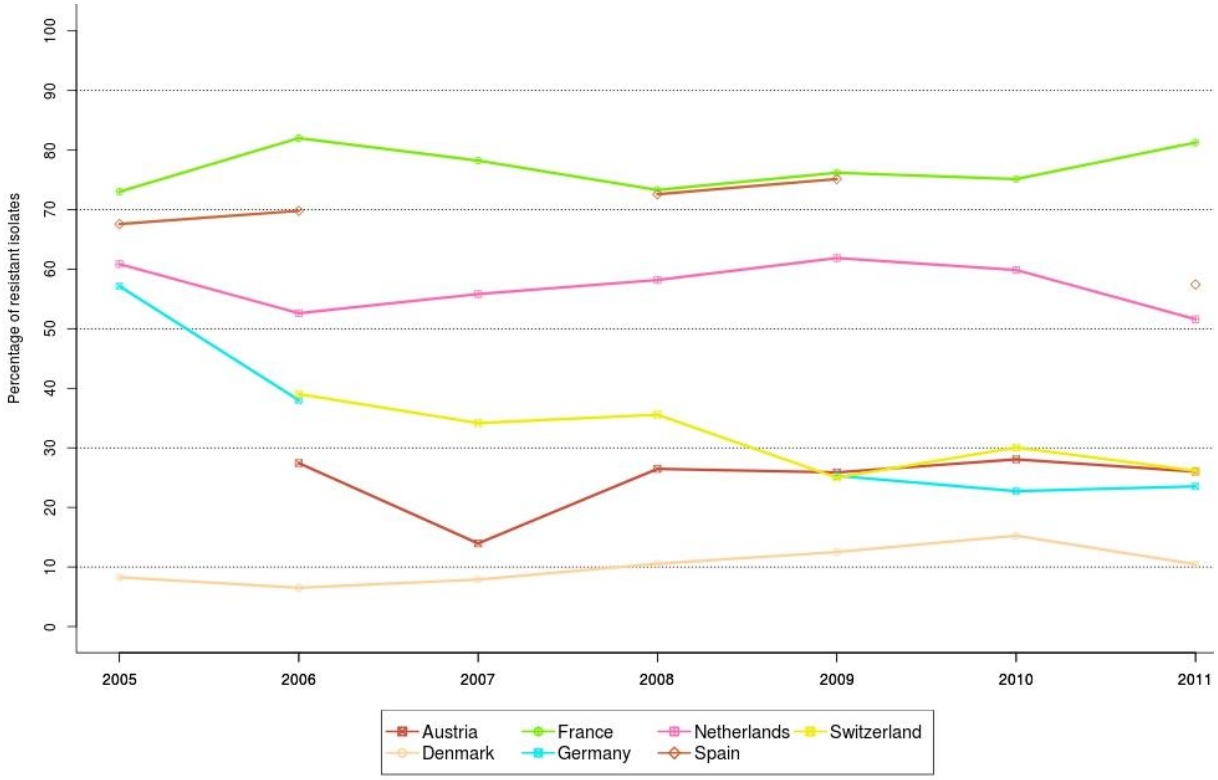
Figure EC5. Trends in streptomycin resistance in indicator* Escherichia coli *from* Gallus gallus[1] *in reporting MSs and one non-MS, 2005–2011, quantitative data



Note: A statistically significant increasing trend over six years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Austria (↑).

1. The data from Germany in 2010 and 2011 originated from broilers and laying hens.

Figure EC6. Trends in tetracycline resistance in indicator* Escherichia coli *from* Gallus gallus[1] *in reporting MSs and one non-MS, 2005–2011, quantitative data



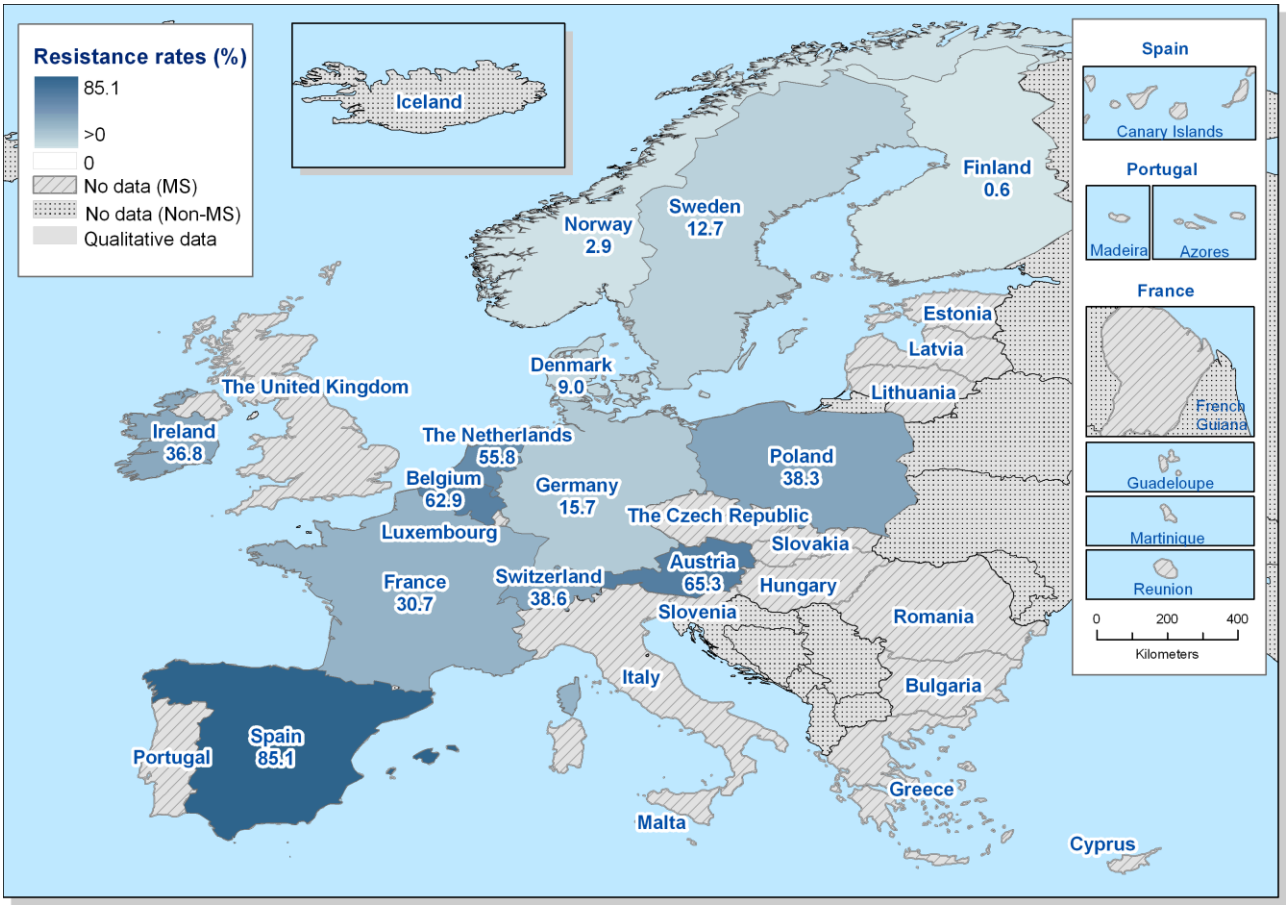
Note: Statistically significant increasing and decreasing trends over five or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Denmark (↑), Germany (↓) and Switzerland (↓).

1. The data from Germany in 2010 and 2011 originated from broilers and laying hens.

Spatial distribution of resistance among indicator *Escherichia coli*

The spatial distributions of nalidixic acid and tetracycline resistance in *E. coli* from *Gallus gallus* are shown in Figures EC7 and EC8. The Nordic countries reported the lowest levels of resistance to both antimicrobials. The highest resistance to tetracyclines tended to be reported by the most western countries. However, the spatial pattern for nalidixic acid was less clear.

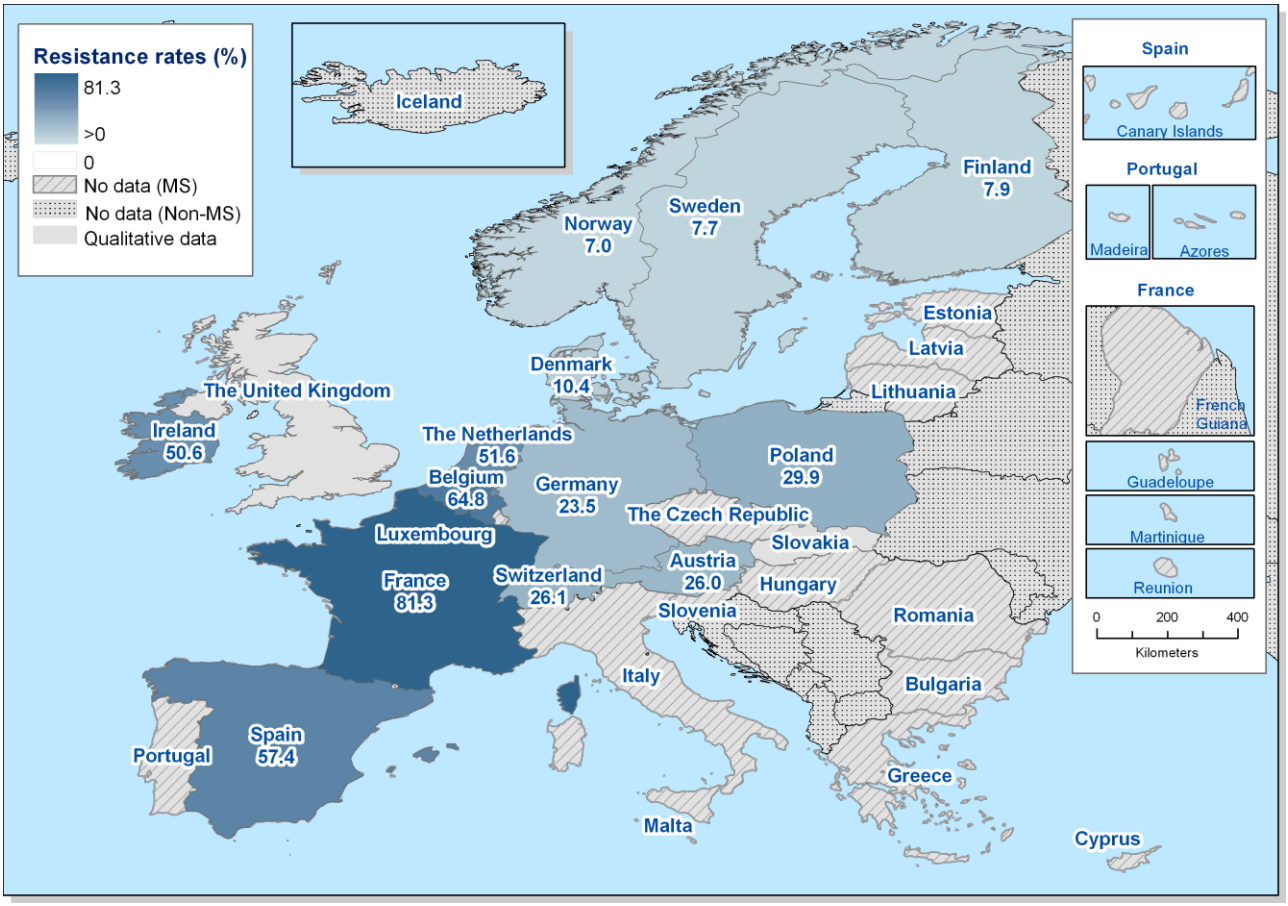
***Figure EC7. Spatial distribution of nalidixic acid resistance among indicator* Escherichia coli *from* Gallus gallus *in countries reporting MIC data in 2011*[1,2]**



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data were used instead.

1. For Sweden, 2010 data were used.
2. For Germany, data from broilers and laying hens have been aggregated.

***Figure EC8. Spatial distribution of tetracycline resistance among indicator* Escherichia coli *from* Gallus gallus *in countries reporting MIC data in 2011*[1,2]**



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data were used instead. The countries labelled as 'qualitative data' therefore include those reporting MIC data for fewer than 10 isolates or purely qualitative data (as proportion of resistant isolates).

1. For Sweden, 2010 data were used.
2. For Germany, data from broilers and laying hens have been aggregated.

Multi-resistance among indicator *E. coli* isolates from broilers

In 2011, four MSs and two non-MSs provided isolate-based data regarding resistance in indicator *E. coli* from broilers. Among the reporting countries, important variations were observed in the percentages of completely susceptible isolates, which varied from 5.9 % in Spain to 56.7 % in Denmark. Although all reporting countries recorded multi-resistant isolates, their proportions differed substantially between countries, reaching up to 74.4 % in Germany and 79.2 % in Spain (Table EC3). The frequency distributions (Figure EC9) showed that isolates resistant to as many as six antimicrobials were reported from all reporting countries, and one MS even reported a few isolates resistant to nine substances. Co-resistance to cefotaxime and ciprofloxacin was undetected or detected at only low levels, with the exception of Spain, where about 20 % of the isolates tested exhibited co-resistance to these substances.

Table EC3. Complete susceptibility, multi-resistance and index of diversity in* E. coli *from broilers in MSs and non-MSs reporting isolate-based data, 2011

Country	Susceptible to all		Multi-resistant		Index of diversity	Co-resistant to CIP and CTX			
	n	%	n	%		n		%	
Austria (N=173)	24	13.9	62	35.8	0.417	2	(0)	1.2	(0)
Denmark (N=134)	76	56.7	12	9.0	0.261	0	(0)	0	(0)
Germany (N=246)	22	8.9	183	74.4	0.683	11	(2)	4.5	(0.8)
Spain (N=101)	6	5.9	80	79.2	0.757	21	(11)	20.8	10.9)
Norway (N=244)	96	39.3	25	10.3	0.248	1	(0)	0.4	(0)
Switzerland (N=176)	44	25.0	49	27.8	0.361	3	(0)	1.7	(0)

N = total number of isolates tested for susceptibility against the whole common antimicrobial set for *E. coli*.

n = number of isolates per category of complete susceptibility or multiple resistance.

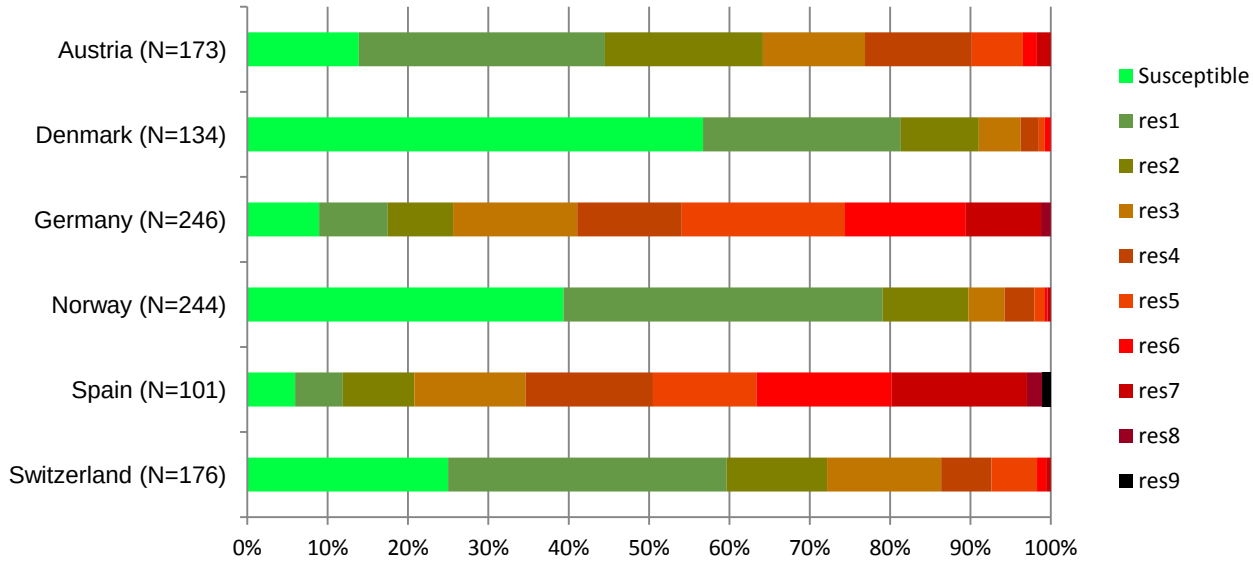
Susceptible to all = isolate susceptible to all antimicrobial substances of the EFSA common set for *E. coli*.

Multi-resistant = resistant to at least 3 different antimicrobial substances, belonging to any three antimicrobial families from the common antimicrobial set for *E. coli.*

Index of diversity = see definition in section 11.4.2.1 of Materials and Methods.

Co-resistant to cefotaxime (CTX) and ciprofloxacin (CIP) = the effectives and percentages of *E. coli* isolates non-susceptible to concentrations greater than ECOFFs (CTX >0.25 mg/L and CIP >0.03 mg/L). Figures in parentheses indicate the occurrence of co-resistance to CIP and CTX determined using clinical breakpoints (CTX >2 mg/L and CIP >1 mg/L).

Figure EC9. Frequency distribution of* E. coli *isolates completely susceptible and resistant to one to nine antimicrobials in broilers in MSs and non-MSs reporting isolate-based data, 2011



N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances for *E. coli*.

Susceptible = susceptible to all antimicrobial substances of the common set for *E. coli*.

res1/res9 = resistance to one antimicrobial substance/resistance to nine antimicrobial substances of the common set for *E. coli*.

6.2.2.2. Pigs

In 2011, ten MSs and two non-MSs (Norway and Switzerland) provided quantitative antimicrobial resistance data on indicator *E. coli* in pigs and were included in the following analysis (Table EC4). These data were not split by production type, as all isolates originated from fattening pigs or the production type was not specified. The majority of MSs collected isolates as part of their national resistance monitoring programmes. The AMR monitoring in indicator *E. coli* isolates from pigs was based on active monitoring plans based on random sampling of healthy slaughter pig carcasses at the slaughterhouse. The slaughterhouses included in the monitoring programme accounted for a major proportion, typically 80 % or more, of the total production in the country. The sampling plan was typically stratified per slaughterhouse by allocating the number of samples collected per slaughterhouse in proportion with the annual throughput of the slaughterhouse. An approximately equal distribution of the collected samples over the year enabled the different seasons to be covered. Only one representative faecal sample per epidemiological unit (batch), either derived from a unique carcass or pooled from a number of carcasses, was gathered to account for clustering.

Resistance levels among *Escherichia coli*

In 2011, resistance to streptomycin and tetracyclines was very high overall in the reporting MS group, at 53.1 % and 57.0 %, respectively (Table EC4). Resistance levels varied considerably between MSs, from 16.2 % to 71.8 % for the former and from 8.4 % to 90.0 % for the latter. There was also a high level of resistance to ampicillin (37.1 %) and sulfonamides (45.8 %). Again, resistance levels differed widely between reporting countries, from 7.8 % to 72.4 % in the case of ampicillin. For all four of these antimicrobials, Spain recorded the highest resistance, while Norway and Sweden reported the lowest levels. Overall, resistance to chloramphenicol was moderate at 14.5 %, with most countries reporting low or moderate levels of resistance to this antimicrobial, and only Belgium, France and Spain recording high resistance. The overall resistance to gentamicin in the reporting MS group was low (2.2 %). Four countries reported full sensitivity to this antimicrobial while all other countries reported low levels of resistance of between 1.1 % and 4.5 %.

At the reporting MS group level, the occurrence of resistance to nalidixic acid was low (4.8 %), with most countries reporting either no resistance or low to very low resistance, although Belgium and Spain reported moderate resistance, at levels of 11.5 % and 20.1 %, respectively. Overall, resistance to ciprofloxacin was low, with only 8.3 % of isolates in the reporting MS group expressing resistance. The majority of countries reported low resistance, although Belgium, Estonia and France reported moderate levels and Spain reported high levels. Cefotaxime resistance was also low at the reporting MS group level (1.7 %). Belgium and Estonia reported the highest level of resistance, at 4.5 %, with all other countries reporting low or very low levels of resistance of between 0.5 % and 1.9 %.

Table EC4. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, streptomycin, sulfonamides and tetracyclines among isolates of indicator* Escherichia coli *from pigs in countries reporting MIC data in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	162	14.8	162	1.2	162	6.2	162	4.3	162	0
Belgium	157	49.0	157	4.5	157	26.8	157	15.3	157	3.8
Denmark	157	26.8	157	1.3	157	4.5	157	1.3	157	0
Estonia	22	36.4	22	4.5	22	13.6	22	13.6	22	4.5
France	184	21.2	184	1.1	184	23.9	184	10.9	184	0
Germany	859	44.7	859	1.9	859	14.6	859	5.9	859	3.1
Netherlands	287	35.5	287	1.7	287	12.2	287	2.1	287	2.1
Poland	172	26.7	172	1.2	172	7.0	172	9.3	172	3.5
Spain	170	72.4	170	0.6	170	31.2	170	30.6	170	2.4
Sweden	167	13.2	167	0.6	167	4.2	-	-	167	1.2
Total (10 MSs)	**2,337**	**37.1**	**2,337**	**1.7**	**2,337**	**14.5**	**2,170**	**8.3**	**2,337**	**2.2**
Norway	192	7.8	192	0.5	192	0.5	-	-	192	0
Switzerland	175	24.6	175	1.1	175	10.3	175	8.0	175	1.1

Country	Nalidixic acid		Streptomycin		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res
Austria	162	3.7	162	49.4	162	25.9	162	54.3
Belgium	157	11.5	157	54.1	157	58.6	157	56.7
Denmark	157	0.6	157	35.7	157	28.0	157	29.3
Estonia	22	0	22	45.5	22	45.5	22	22.7
France	184	1.6	184	57.1	184	51.6	184	73.9
Germany	859	3.7	859	59.4	859	47.7	859	62.5
Netherlands	287	1.0	287	57.8	287	54.7	287	66.9
Poland	172	5.8	172	47.1	172	40.7	172	41.3
Spain	169	20.1	170	71.8	170	72.4	170	90.0
Sweden	167	2.4	167	16.2	167	16.8	167	8.4
Total (10 MSs)	**2,336**	**4.8**	**2,337**	**53.1**	**2,337**	**45.8**	**2,337**	**57.0**
Norway	192	0	192	17.2	192	10.4	192	9.4
Switzerland	175	6.9	175	51.4	175	50.9	175	31.4

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

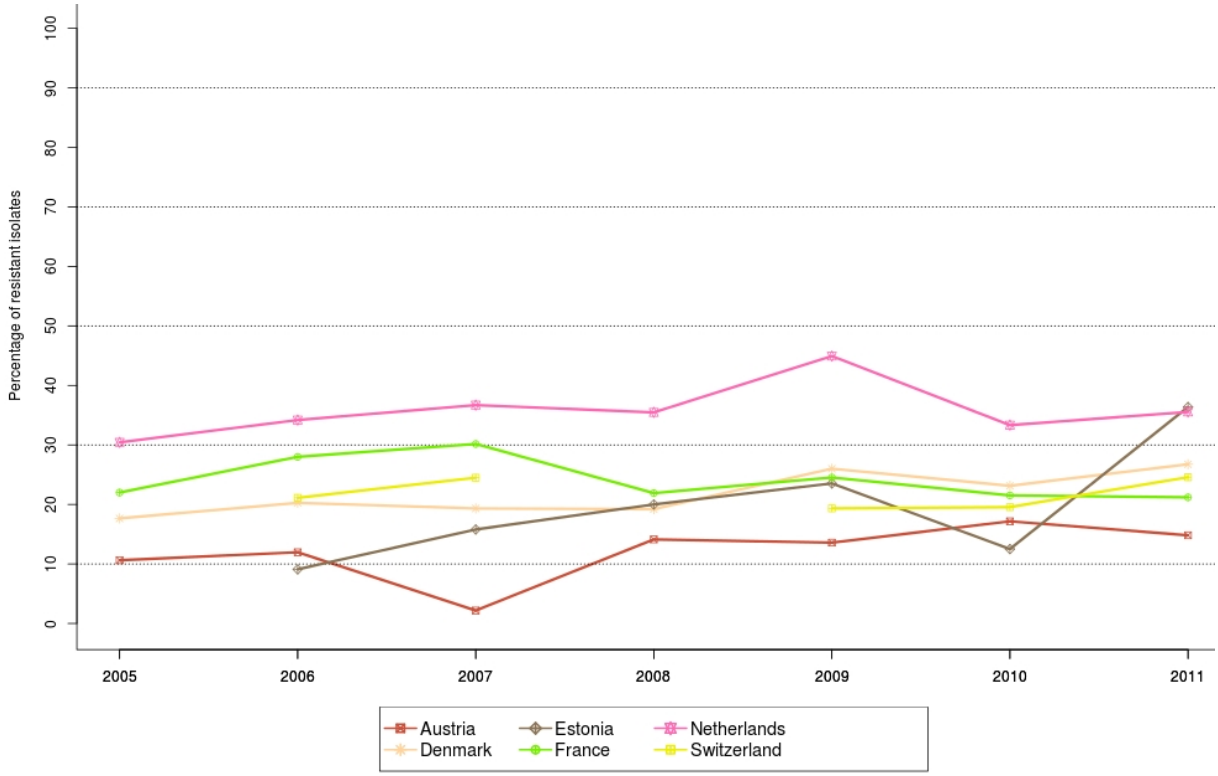
Temporal trends in resistance among indicator *Escherichia coli*

Figures EC10-EC15 display the trends in resistance to selected antimicrobials in indicator *E. coli* from pigs. There was variation in the resistance levels in different MSs, particularly for tetracyclines (Figure EC15). However, the differences between MSs were often not as extreme as was observed for isolates from *Gallus gallus.* In some cases, this was because the resistance levels tended to be lower than those observed in *Gallus gallus* (e.g. ampicillin; Figure EC10), whereas, for others, it was due to the resistance levels all being higher than those recorded in *Gallus gallus* (e.g. streptomycin; Figure EC14). As in the previous year, France, the Netherlands or Spain tended to report the highest occurrence of resistance. Resistance to cefotaxime has been below 5 % in all countries since 2005, and at a lower level than in *Gallus gallus* (Figure EC11). Resistance to both ciprofloxacin and nalidixic acid has also generally been at a low level since 2005 (Figure EC13).

For many of the antimicrobials, the resistance levels were relatively stable with only fairly minor fluctuations or gradual changes. There were fewer statistically significant trends than were observed among isolates from *Gallus gallus*. Austria and Denmark both reported significant increases in resistance to ampicillin and chloramphenicol, with the latter also showing a significant increase in resistance to tetracyclines. There has also been a significant decline in resistance to tetracyclines among isolates from France. No statistically significant trends were observed in resistance to cefotaxime, ciprofloxacin, nalidixic acid or streptomycin.

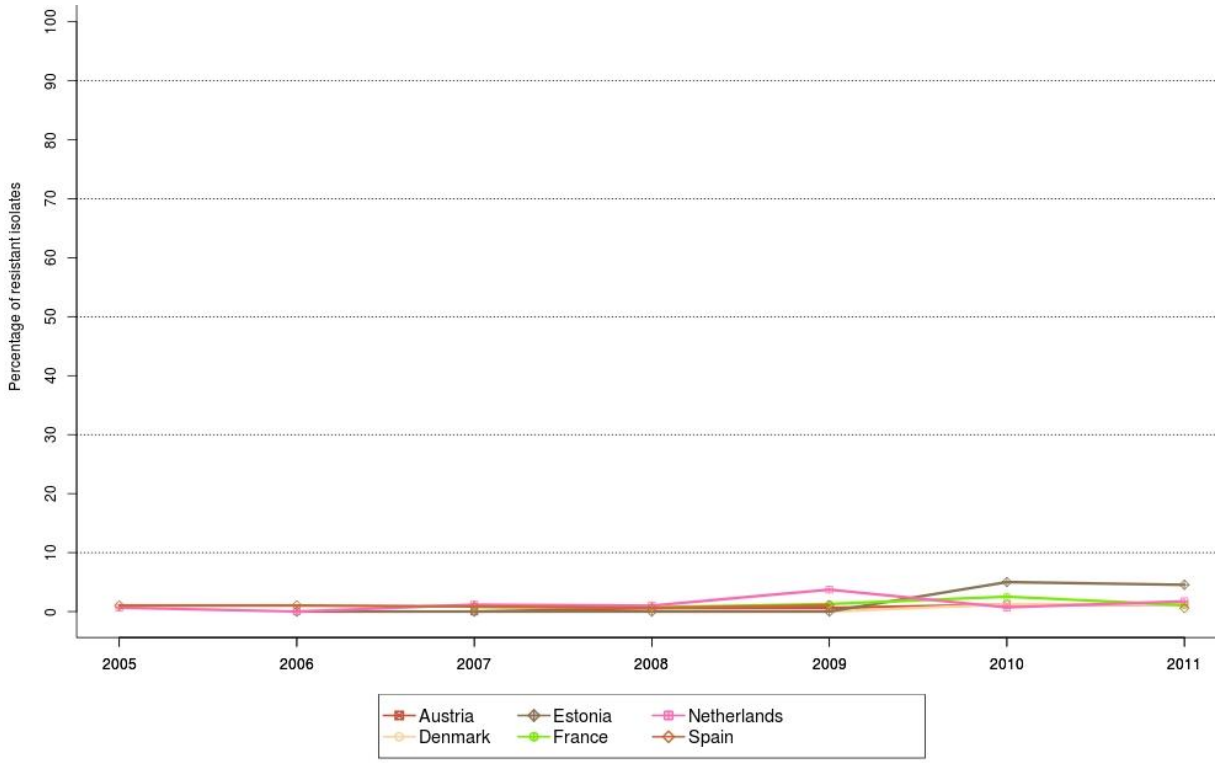
In addition, comparing the last years in certain MSs, there were relatively large increases in resistance to ampicillin and sulfonamides in Estonia between 2010 and 2011, but a large concurrent decline in resistance to gentamicin.

Figure EC10. Trends in ampicillin resistance in indicator* Escherichia coli *from pigs in reporting MSs and one non-MS, 2005–2011, quantitative data



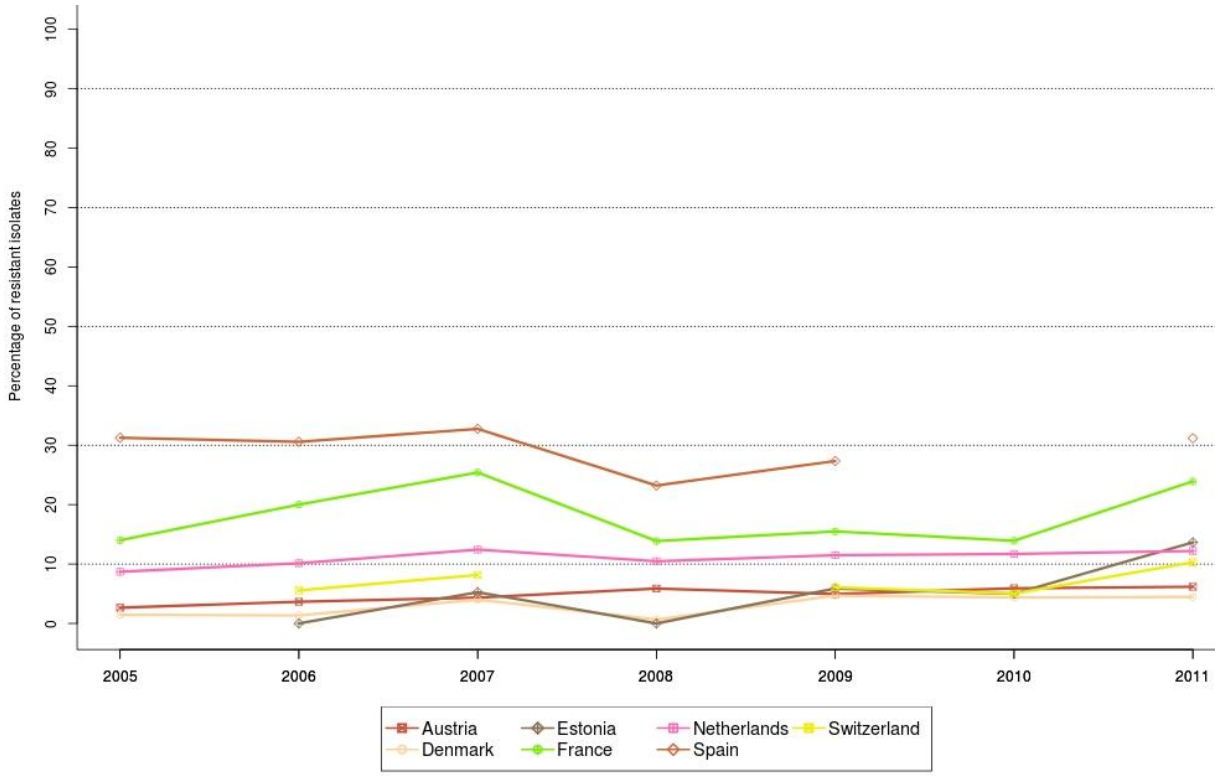
Note: Statistically significant increasing trends over seven years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Austria (↑) and Denmark (↑).

Figure EC11. Trends in cefotaxime resistance in indicator* Escherichia coli *from pigs in reporting MSs, 2005–2011, quantitative data



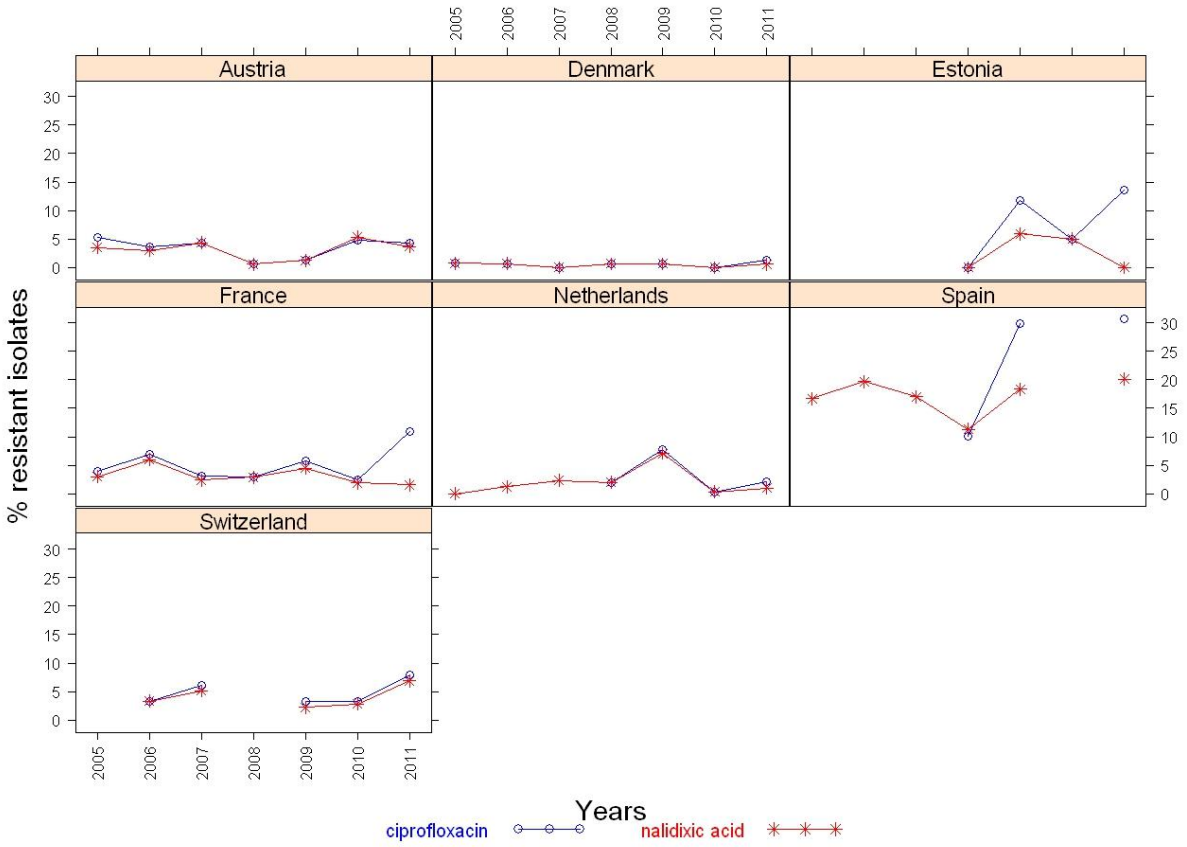
Note: No statistically significant trends over five or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in any of the reporting countries.

Figure EC12. Trends in chloramphenicol resistance in indicator* Escherichia coli *from pigs in reporting MSs and one non-MS, 2005–2011, quantitative data



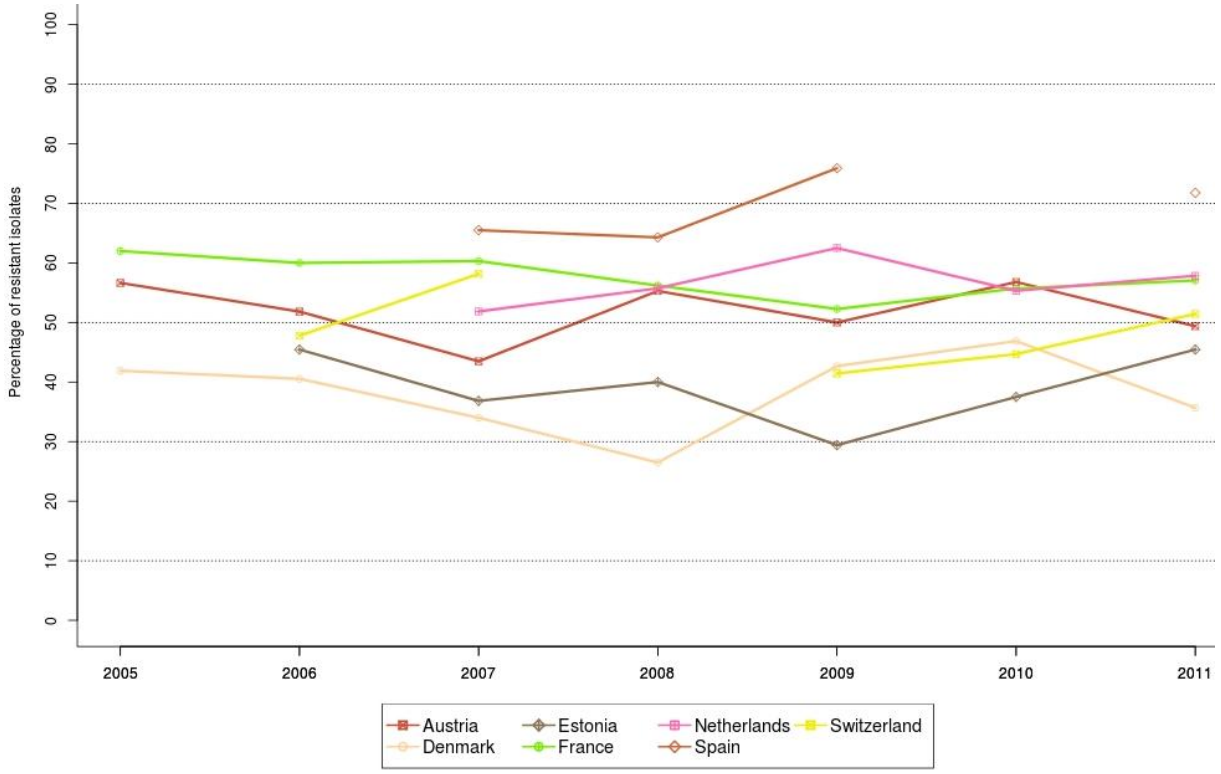
Note: Statistically significant increasing trends over seven years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Austria (↑) and Denmark (↑).

Figure EC13. Trends in ciprofloxacin and nalidixic acid resistance in indicator* Escherichia coli *from pigs in reporting MSs and one non-MS, 2005–2011, quantitative data



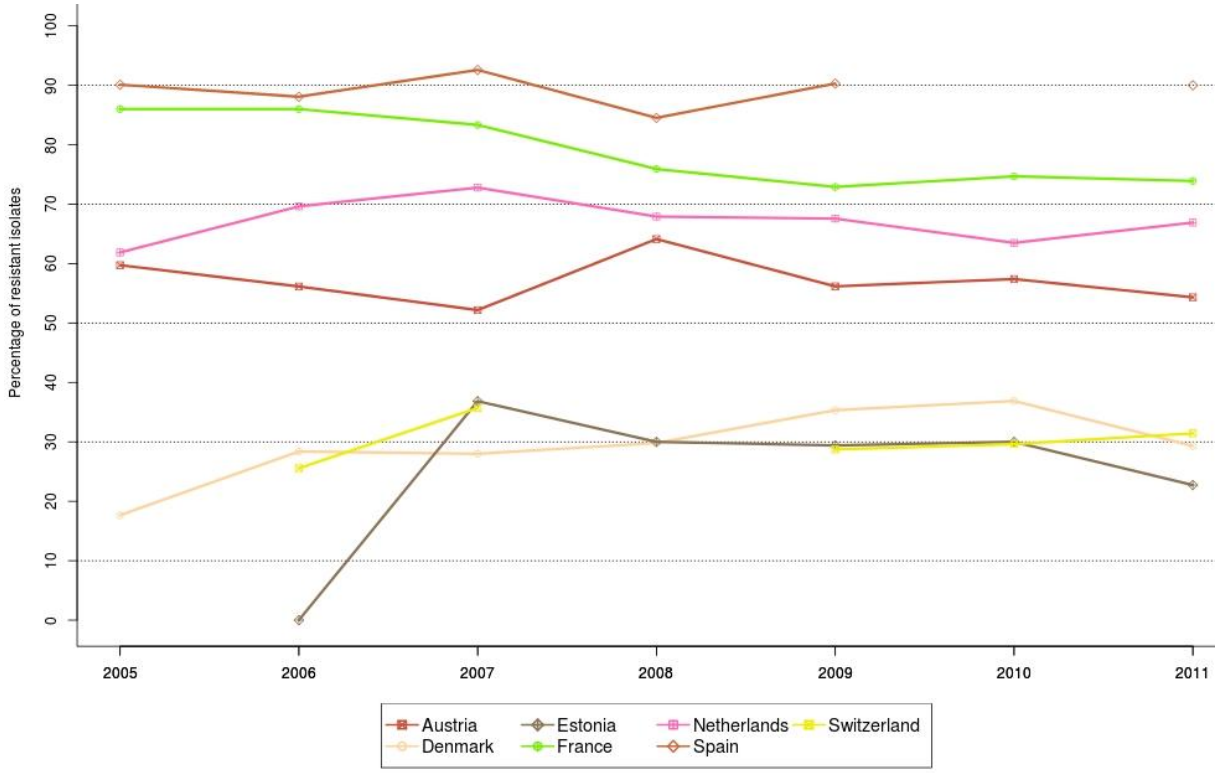
Note: No statistically significant trends over five or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed for either ciprofloxacin or nalidixic acid in any of the reporting countries.

Figure EC14. Trends in streptomycin resistance in indicator* Escherichia coli *from pigs in reporting MSs and one non-MS, 2005–2011, quantitative data



Note: No statistically significant trends over five or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed for any of the reporting countries.

Figure EC15. Trends in tetracycline resistance in indicator* Escherichia coli *from pigs in reporting MSs and one non-MS, 2005–2011, quantitative data

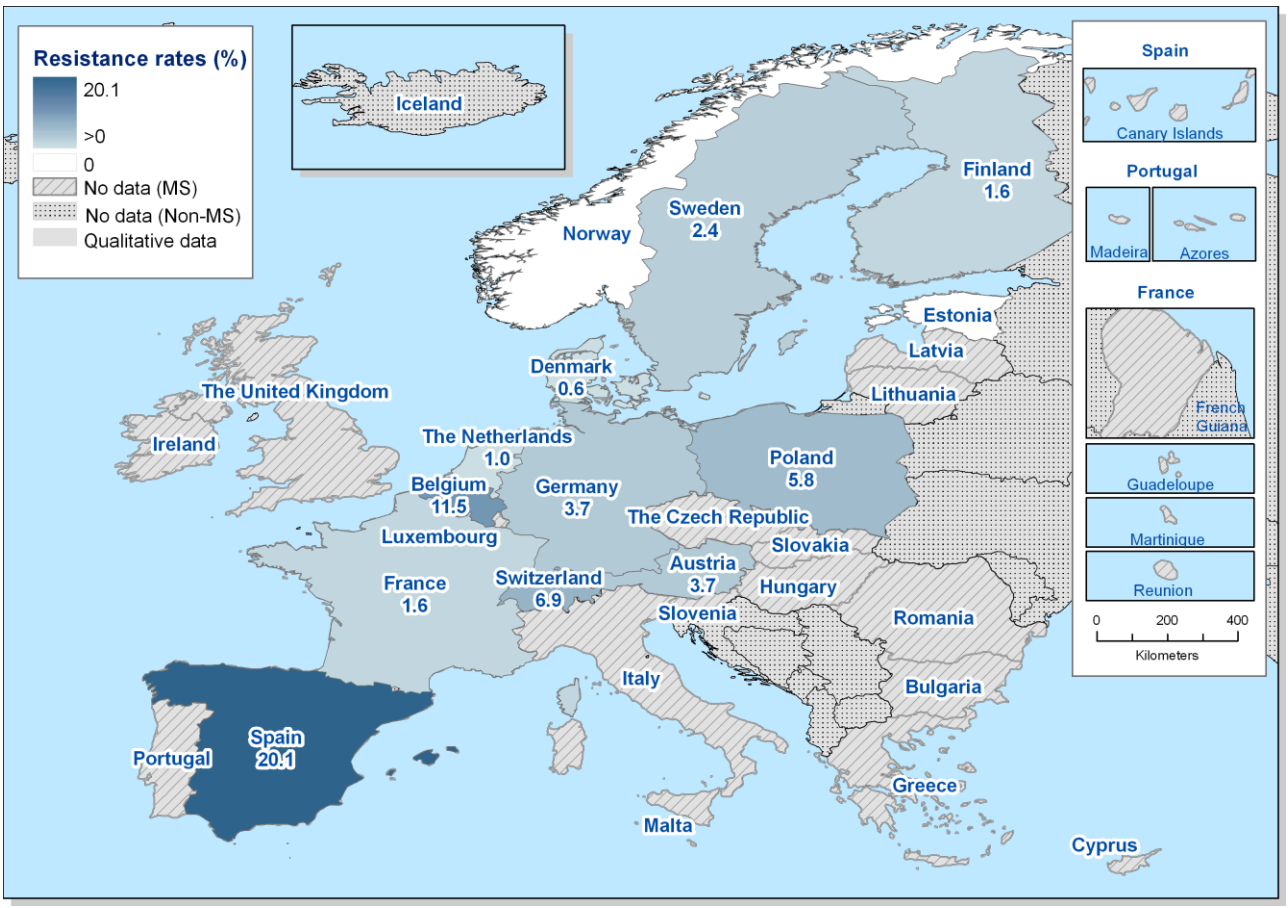


Note: Statistically significant increasing and decreasing trends over seven years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Denmark (↑) and France (↓).

Spatial distribution of resistance among indicator *Escherichia coli*

The spatial distribution of nalidixic acid and tetracycline resistance in indicator *E. coli* from pigs is shown in Figures EC16 and EC17, respectively. For nalidixic acid, most countries reported low levels of resistance so the spatial pattern was less clear, although both countries reporting 0 % resistance were in northern Europe while the highest resistance was in the southern European reporting MS. With regard to tetracyclines, the northern European countries tended to report the lowest occurrence of resistance whereas most western or southern European countries reported very or extremely high resistance.

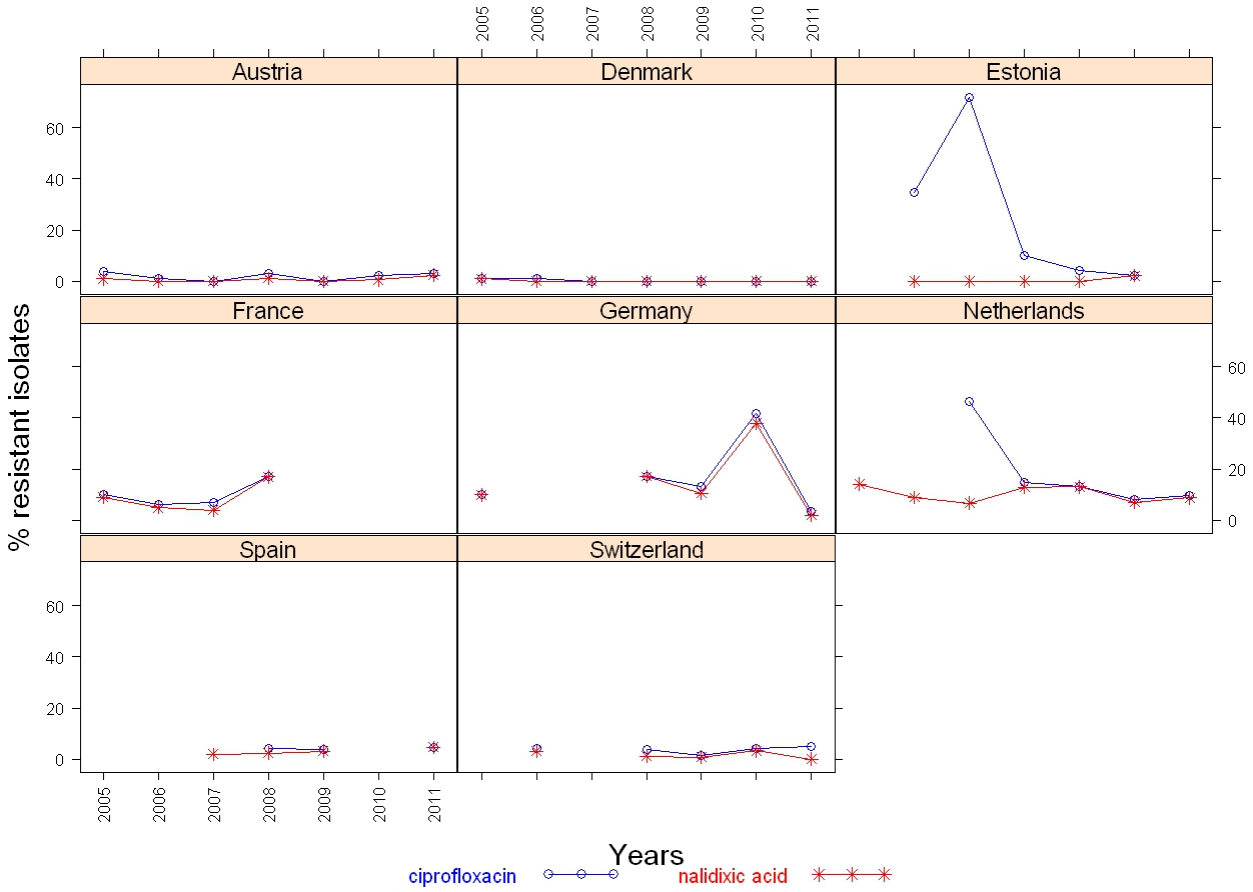
Figure EC16. Spatial distribution of nalidixic acid resistance among indicator* Escherichia coli *from pigs in countries reporting MIC data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data were used instead.

1. For Finland, 2010 data were used.

Figure EC17. Spatial distribution of tetracycline resistance among indicator* Escherichia coli *from pigs in countries reporting MIC data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data were used instead. The countries labelled as 'qualitative data' therefore include those reporting MIC data for fewer than 10 isolates or purely qualitative data (as proportion of resistant isolates).

1. For Finland, 2010 data were used.

Multi-resistance among indicator *E. coli* isolates from pigs

Five MSs and two non-MSs had tested for the complete harmonised set of antimicrobials for *E. coli* and reported isolate-based data. Between about one quarter and half of the indicator *E. coli* isolates from pigs were susceptible to the nine antimicrobials of the set in the reporting countries, the only exception being Spain, where only 3.6 % of the isolates were categorised as susceptible. Multi-resistance levels were high to very high in all reporting countries, except in Norway, where less than 10 % of the isolates showed multi-resistance (i.e. reduced susceptibility to three or more antimicrobial classes) (Table EC5). The frequency distributions (Figure EC18) showed that all reporting countries detected multi-resistance to as many as six or seven antimicrobial classes. Very few isolates exhibited co-resistance to cefotaxime and ciprofloxacin using either ECOFFs or clinical breakpoints as interpretative criteria (Table EC5).

Table EC5. Complete susceptibility, multi-resistance and index of diversity in* E. coli *from fattening pigs in MSs and non-MSs reporting isolate-based data, 2011

Country	Susceptible to all		Multi-resistant		Index of diversity	Co-resistant to CIP and CTX	
	n	%	n	%		n	%
Austria (N=162)	51	31.5	45	27.8	0.383	0 (0)	0 (0)
Denmark (N=157)	76	48.4	42	26.8	0.445	0 (0)	0 (0)
Estonia (N=22)	6	27.3	8	36.4	0.446	1 (0)	4.6 (0)
Germany (N=859)	204	23.8	460	53.6	0.574	3 (2)	0.4 (0.2)
Spain (N=169)	6	3.6	143	84.6	0.658	1 (0)	0.6 (0)
Norway (N=192)	103	53.7	19	9.9	0.280	0 (0)	0 (0)
Switzerland (N=175)	59	33.7	74	42.3	0.528	1 (1)	0.6 (0.6)

N = total number of isolates tested for susceptibility against the whole common antimicrobial set for *E. coli*.

n = Number of isolates per category of complete susceptibility or multiple resistance.

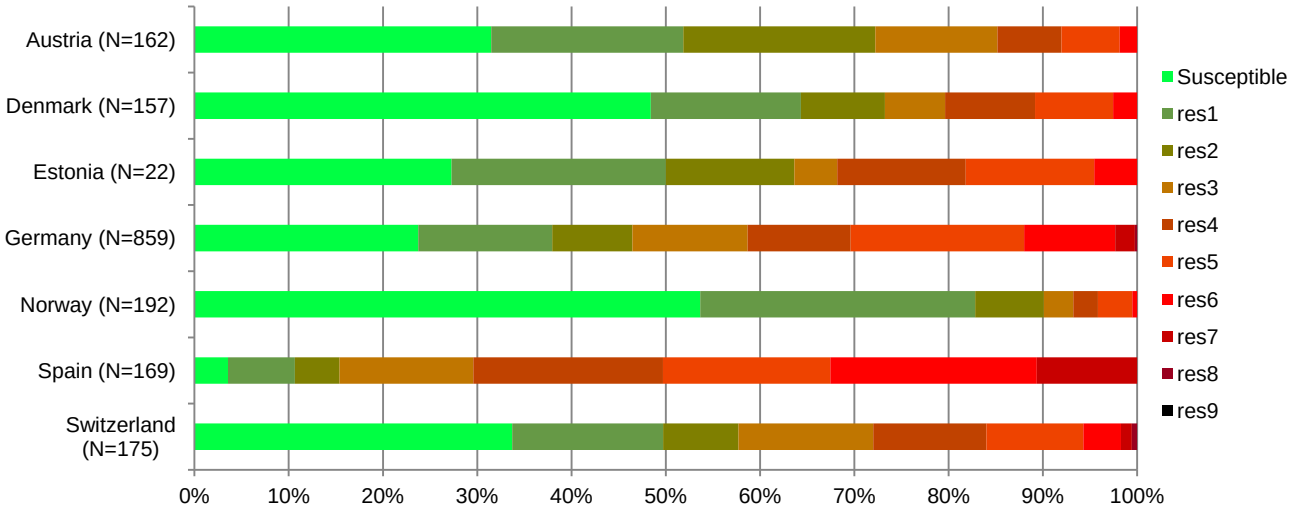
Susceptible to all = isolate susceptible to all antimicrobial substances of the EFSA common set for *E. coli*.

Multi-resistant = resistant to at least three different antimicrobial substances, belonging to any three antimicrobial families from the common antimicrobial set for *E. coli.*

Index of diversity = see definition in section 11.4.2.1 of Materials and Methods.

Co-resistant to cefotaxime (CTX) and ciprofloxacin (CIP) = the effectives and percentages of *E. coli* isolates non-susceptible to concentrations greater than ECOFFs (CTX >0.25 mg/L and CIP >0.03 mg/L). Figures in parentheses indicate the occurrence of co-resistance to CIP and CTX determined using clinical breakpoints (CTX >2 mg/L and CIP >1 mg/L).

Figure EC18. Frequency distribution of* E. coli *isolates completely susceptible and resistant to one to nine antimicrobials in pigs in MSs and non-MSs reporting isolate-based data, 2011



N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances for *E. coli*.

Susceptible = susceptible to all antimicrobial substances of the common set for *E. coli*.

res1/res9 = resistance to one antimicrobial substance/resistance to nine antimicrobial substances of the common set for *E. coli*.

6.2.2.3. Cattle (bovine animals)

In 2011, quantitative data for *E. coli* in cattle were provided by seven MSs and one non-MS (Switzerland) (Table EC6). These countries tested different production types and ages of cattle, including veal calves, young meat production animals, adult cattle and dairy cows; Denmark and Poland did not specify the type of cattle that were tested. The overall results for cattle presented in Table EC6 include all isolates of *E. coli* that were collected from this animal species by MSs which tested more than 10 isolates from cattle in total. Results are also presented for the specific production levels of cattle from which these *E. coli* isolates originated. Some MSs tested fewer than 10 isolates from individual production types. In such cases, the data for these production types are included in the overall results for cattle but are not presented in the production level-specific sections of this table.

In the reporting MSs, AMR monitoring in indicator *E. coli* isolates from cattle was chiefly based on active monitoring plans of healthy bovine animals either sampled from randomly selected herds (Belgium, Germany, the Netherlands) or randomly selected within the slaughterhouses (Austria, Denmark, Spain and Switzerland). In both cases samples are of faecal origin. The sampling plans performed at slaughter were stratified per slaughterhouse and the number of samples allocated in proportion to the annual slaughterhouse throughput. In any case, the sampling was evenly distributed throughout the year or a significant part of the year to account for a possible seasonal effect. Only one representative faecal sample was gathered per epidemiological unit, either individual bovine animal or herd, to account for clustering. In Germany, the monitoring programme in 2011 focused specifically on young meat production animals (1-2 years).

Resistance levels among *Escherichia coli*

The Netherlands reported much higher resistance levels among veal calves (aged less than one year) than among dairy cows. However, Austria and Switzerland both submitted data concerning young meat production animals (aged 1-2 years) and either adult cattle or dairy cows, and there was less difference in the resistance levels between these age groups in both countries. Belgium tended to report much higher resistance among isolates from veal calves than young meat production animals. Denmark and Poland generally reported low resistance levels but, as the cattle type was not specified, the results may merge more than one age group, and therefore these data are difficult to interpret. Germany was responsible for nearly half of all the samples from MSs in 2011, so its results will have had a major influence on the overall results.

Combining all types of cattle, the highest levels of resistance tended to be recorded against streptomycin, sulfonamides and tetracyclines; the overall resistance levels for these three antimicrobials were 17.4 %, 19.5 % and 20.2 %, respectively, at the reporting MS group level. Belgium, Spain and Switzerland reported high levels of resistance to these antimicrobials among young meat production animals, while Belgium and the Netherlands reported very high or extremely high resistance levels among veal calves. There was also a moderate level of resistance to ampicillin at the MS group reporting level when all types of cattle were combined (13.3 %). Most countries reported a slightly lower resistance level for this antimicrobial than for the previous three.

The occurrence of resistance to chloramphenicol, ciprofloxacin, gentamicin and nalidixic acid was less common, with an overall level at the reporting MS group of 7.3 %, 6.0 %, 2.5 % and 4.8 %, respectively. The highest resistance levels to all four antimicrobials were reported by Belgium for veal calves (50.0 % for chloramphenicol, 44.1 % for ciprofloxacin, 20.6 % for gentamicin and 41.2 % for nalidixic acid); most other countries reported low levels of resistance to these four antimicrobials. Many countries reported no resistance to cefotaxime, with the highest resistance level being 3.0 % and 4.5 %, recorded by the Netherlands and Belgium among veal calves and young meat production animals (under one year of age), respectively.

Table EC6. Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, streptomycin, sulfonamides and tetracyclines among isolates of* Escherichia coli *from cattle in countries reporting MIC data[1] in 2011, using harmonised epidemiological cut-off values

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Veal calves (under one year)										
Belgium	34	70.6	34	0	34	50.0	34	44.1	34	20.6
Netherlands	166	48.8	166	3.0	166	26.5	166	24.1	166	11.4
Total (2 MSs)	**200**	**52.5**	**200**	**2.5**	**200**	**30.5**	**200**	**27.5**	**200**	**13.0**
Young meat production animals (under one year)										
Belgium	154	25.3	154	4.5	154	14.3	154	13.0	154	2.6
Young meat production animals (1-2 years)										
Austria	41	0	41	0	41	2.4	41	0	41	2.4
Germany	909	10.7	909	0.4	909	5.4	909	3.6	909	2.0
Spain	109	14.7	109	0	109	11.0	109	4.6	109	2.8
Total (3 MSs)	**1,059**	**10.7**	**1,059**	**0.4**	**1,059**	**5.9**	**1,059**	**3.6**	**1,059**	**2.1**
Switzerland	164	17.7	164	0	164	11.6	164	4.9	164	3.7
Adult cattle (over 2 years)										
Austria	125	1.6	125	0	125	0.8	125	4.0	125	0
Dairy cows										
Netherlands	265	1.1	265	0	265	1.1	265	1.1	265	0
Switzerland	18	27.8	18	0	18	5.6	18	0	18	0
Unspecified cattle type										
Denmark	93	2.2	93	0	93	2.2	93	0	93	0
Poland	173	5.8	173	1.2	172	0	173	2.3	173	0
Total (2 MSs)	**266**	**4.5**	**266**	**0.8**	**265**	**0.8**	**266**	**1.5**	**266**	**0**
All types of cattle										
Austria	172	2.9	172	0	172	1.2	172	2.9	172	0.6
Belgium	188	33.5	188	3.7	188	20.7	188	18.6	188	5.9
Denmark	93	2.2	93	0	93	2.2	93	0	93	0
Germany	909	10.7	909	0.4	909	5.4	909	3.6	909	2.0
Netherlands	431	19.5	431	1.2	431	10.9	431	10.0	431	4.4
Poland	173	5.8	173	1.2	172	0	173	2.3	173	0
Spain	109	14.7	109	0	109	11.0	109	4.6	109	2.8
Total (7 MSs)	**2,075**	**13.3**	**2,075**	**0.9**	**2,074**	**7.3**	**2,075**	**6.0**	**2,075**	**2.5**
Switzerland	182	18.7	182	0	182	11.0	182	4.4	182	3.3

N = number of isolates tested.

% Res = percentage of resistant isolates.

1. Some MSs tested fewer than 10 isolates from individual production types. In such cases, the data for these production types are included in the overall results for cattle but are not presented in the production level-specific sections of this table.

Table EC6 (continued). Resistance (%) to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, streptomycin, sulfonamides and tetracyclines among isolates of* Escherichia coli *from cattle in countries reporting MIC data[1] in 2011, using harmonised epidemiological cut-off values

Country	Nalidixic acid		Streptomycin		Sulfonamides		Tetracyclines	
	N	% Res	N	% Res	N	% Res	N	% Res
Veal calves (under one year)								
Belgium	34	41.2	34	55.9	34	79.4	34	73.5
Netherlands	166	22.3	166	57.2	166	56.0	166	73.5
Total (2 MSs)	**200**	**25.5**	**200**	**57.0**	**200**	**60.0**	**200**	**73.5**
Young meat production animals (under one year)								
Belgium	154	11.7	154	27.3	154	30.5	154	19.5
Young meat production animals (1-2 years)								
Austria	41	0	41	2.4	41	2.4	41	7.3
Germany	909	2.0	909	15.1	909	16.9	909	17.2
Spain	109	4.6	109	33.9	108	38.0	109	45.0
Total (3 MSs)	**1,059**	**2.2**	**1,059**	**16.5**	**1,058**	**18.6**	**1,059**	**19.6**
Switzerland	164	3.7	164	31.7	164	35.4	164	36.6
Adult cattle (over 2 years)								
Austria	125	3.2	125	8.8	125	6.4	125	8.8
Dairy cows								
Netherlands	265	0.4	265	1.1	265	0.8	265	1.5
Switzerland	18	0	18	27.8	18	16.7	18	11.1
Unspecified cattle type								
Denmark	93	0	93	5.4	93	3.2	93	5.4
Poland	173	1.2	173	5.8	173	15.0	173	6.4
Total (2 MSs)	**266**	**0.8**	**266**	**5.6**	**266**	**10.9**	**266**	**6.0**
All types of cattle								
Austria	172	2.3	172	8.1	172	7.0	172	9.9
Belgium	188	17.0	188	32.4	188	39.4	188	29.3
Denmark	93	0	93	5.4	93	3.2	93	5.4
Germany	909	2.0	909	15.1	909	16.9	909	17.2
Netherlands	431	8.8	431	22.7	431	22.0	431	29.2
Poland	173	1.2	173	5.8	173	15.0	173	6.4
Spain	109	4.6	109	33.9	108	38.0	109	45.0
Total (7 MSs)	**2,075**	**4.8**	**2,075**	**17.4**	**2,074**	**19.5**	**2,075**	**20.2**
Switzerland	182	3.3	182	31.3	182	33.5	182	34.1

N = number of isolates tested.

% Res = percentage of resistant isolates.

1. Some MSs tested fewer than ten isolates from individual production types. In such cases, the data for these production types are included in the overall results for cattle but are not presented in the production level-specific sections of this table.

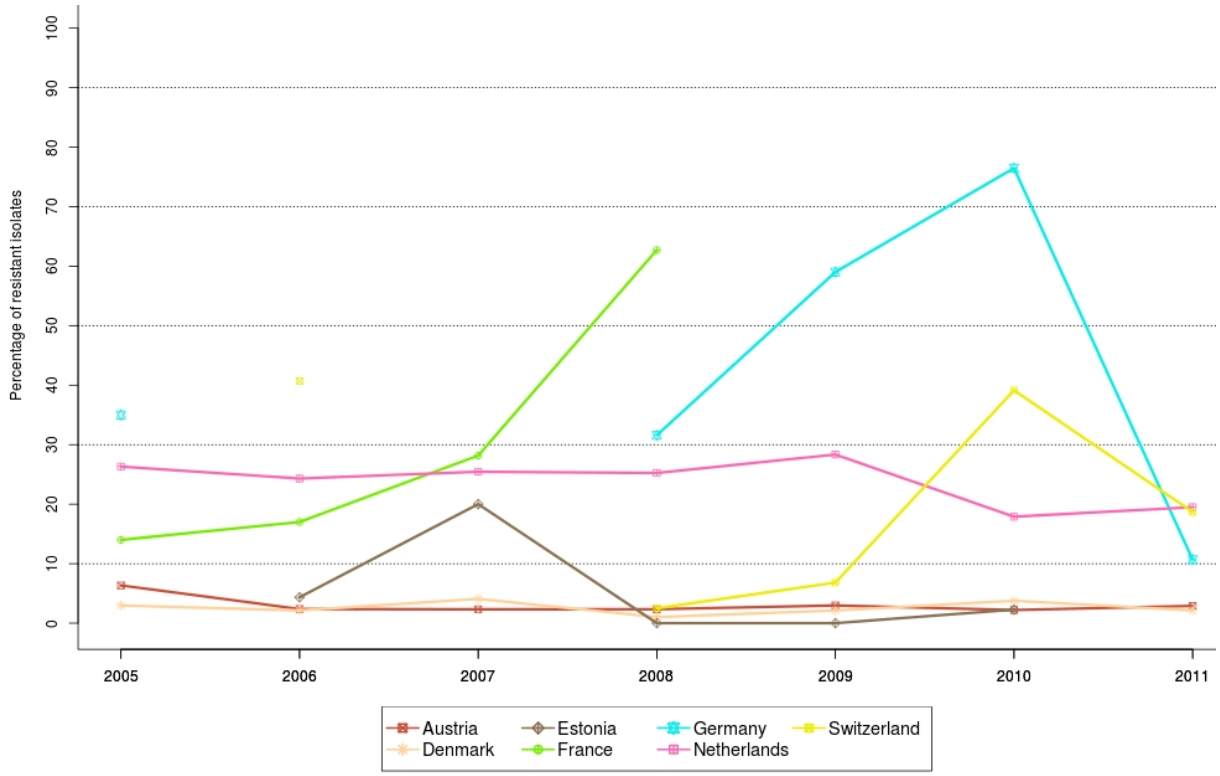
Temporal trends in resistance among indicator *Escherichia coli*

Figures EC19-EC24 display the trends in resistance to selected antimicrobials in *E. coli* from cattle. It should be noted that the figures presented for each country merge the results for all cattle production types and/or ages submitted each year. As in the other livestock species, the resistance levels varied substantially between MSs for several of the antimicrobials, including ampicillin, streptomycin and tetracyclines. Austria and Denmark reported the lowest levels of resistance for many of the antimicrobials. As in pigs, cefotaxime resistance has been below 5 % in all countries since 2005 (Figure EC20).

Considering the last years of reporting, the resistance levels reported by Austria, Denmark and the Netherlands in 2010 and 2011 were broadly comparable. Switzerland reported declines in resistance to most antimicrobials between 2010 and 2011, which is most probably because the study population in 2010 was veal calves less than six months old whereas in 2011 older cattle (>12 months) were sampled. In Germany, an extreme decline was reported despite only veal calves being sampled in 2010 and young meat production animals in 2011.

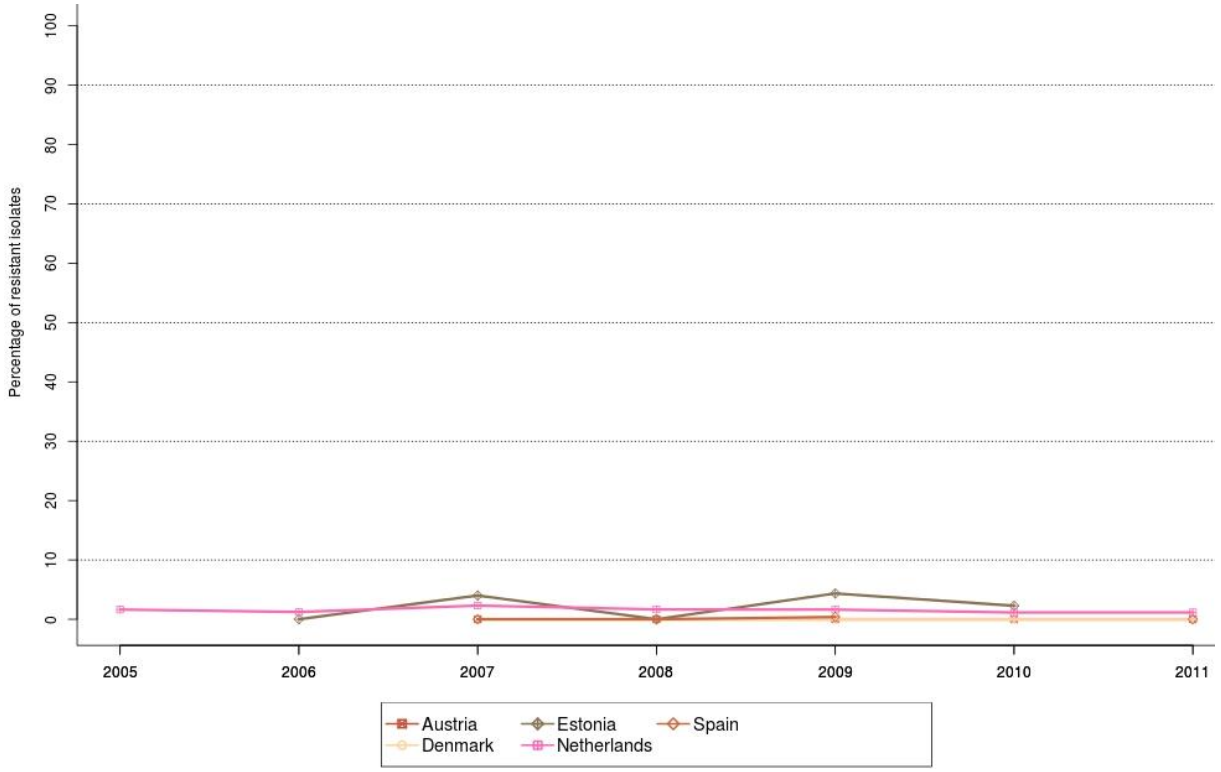
Some countries, such as Austria, Denmark and the Netherlands, have shown relatively stable resistance levels or only minor fluctuations or trends since 2006 whereas other countries, such as France, Germany and Switzerland, have shown more substantial fluctuations in resistance levels that are at least partially due to the sampling of different cattle production types in different years. There have been numerous statistically significant trends in resistance levels since 2005; for example, Germany showed significant declines in resistance to six of the antimicrobials. Significant decreasing trends were also observed in both the Netherlands and Switzerland. In Switzerland this is most probably because calves under six months of age were sampled in 2010, while cattle over 12 months of age were sampled in 2011. The only antimicrobial for which no countries showed any significant increasing or decreasing trends was cefotaxime.

Figure EC19. Trends in ampicillin resistance in indicator* Escherichia coli *from cattle in reporting MSs and one non-MS, 2005–2011, quantitative data



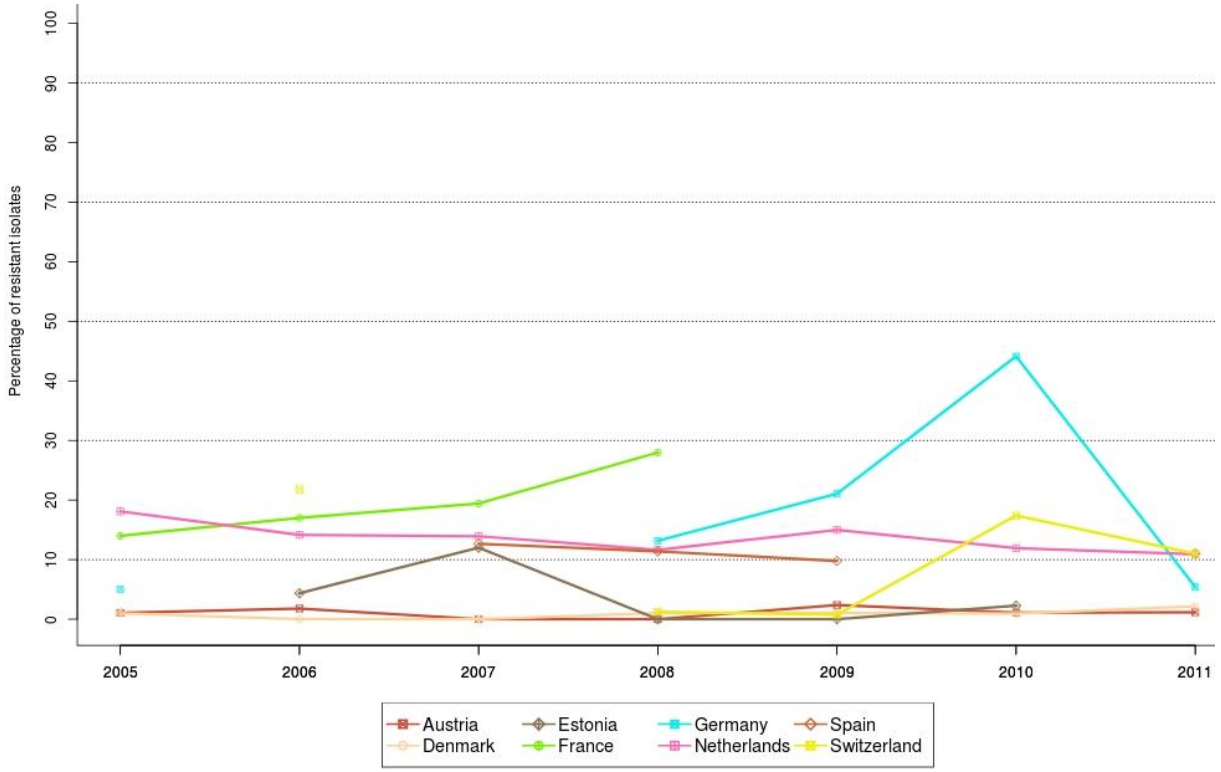
Note: Statistically significant decreasing trends over five or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Austria (↓), Germany (↓), the Netherlands (↓) and Switzerland (↓).

Figure EC20. Trends in cefotaxime resistance in indicator* Escherichia coli *from cattle in reporting MSs, 2005–2011, quantitative data



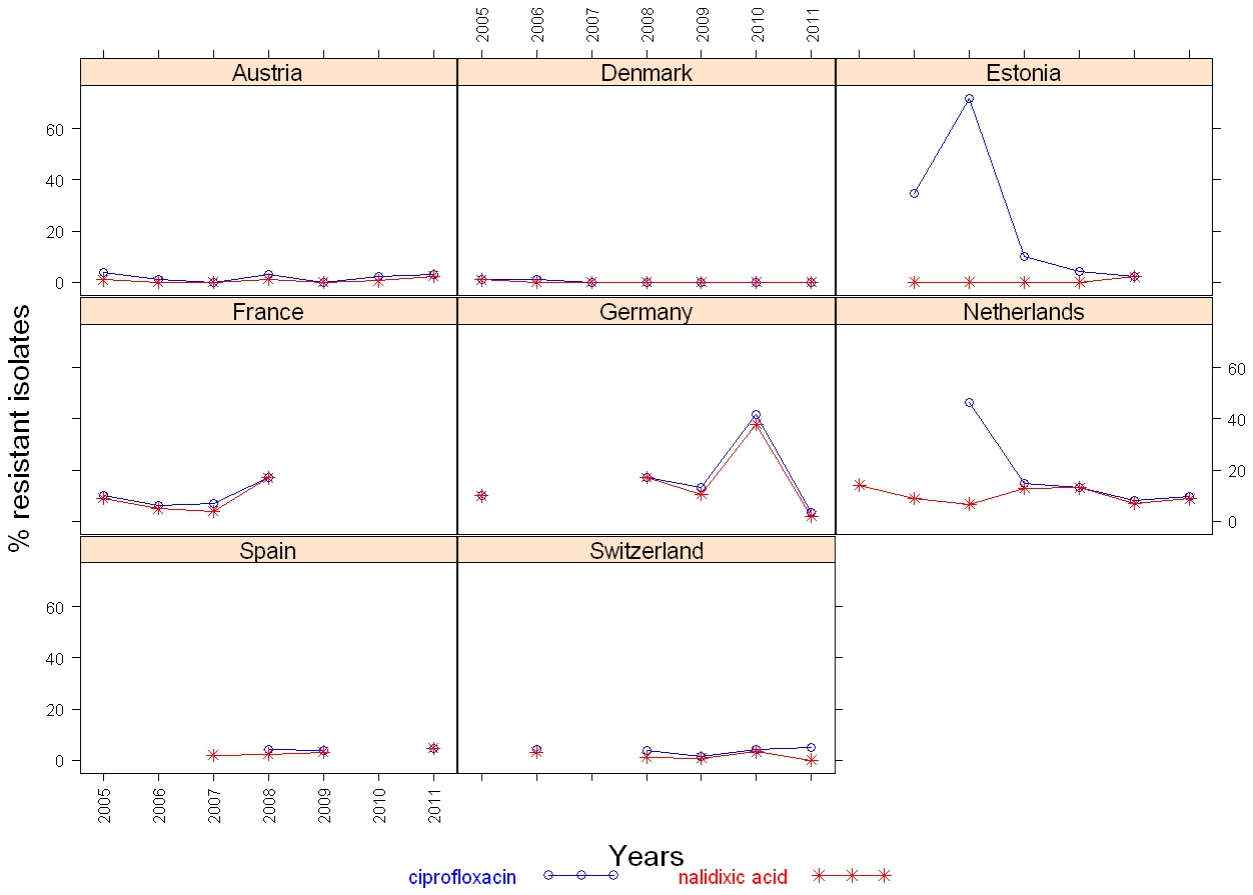
Note: No statistically significant trends over five or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in any of the reporting countries.

Figure EC21. Trends in chloramphenicol resistance in indicator* Escherichia coli *from cattle in reporting MSs and one non-MS, 2005–2011, quantitative data



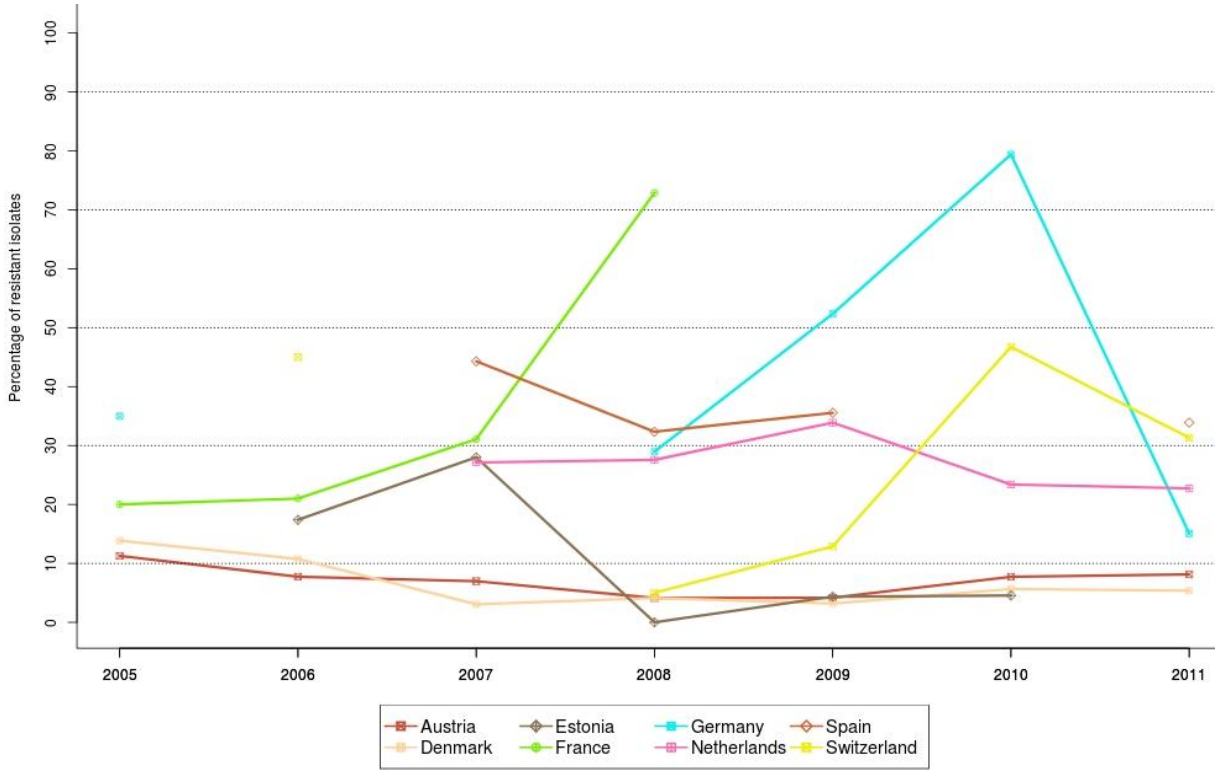
Note: Statistically significant decreasing trends over five or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Germany (↓), the Netherlands (↓) and Switzerland (↓).

Figure EC22. Trends in ciprofloxacin and nalidixic acid resistance in indicator* Escherichia coli *from cattle in reporting MSs and one non-MS, 2005–2011, quantitative data



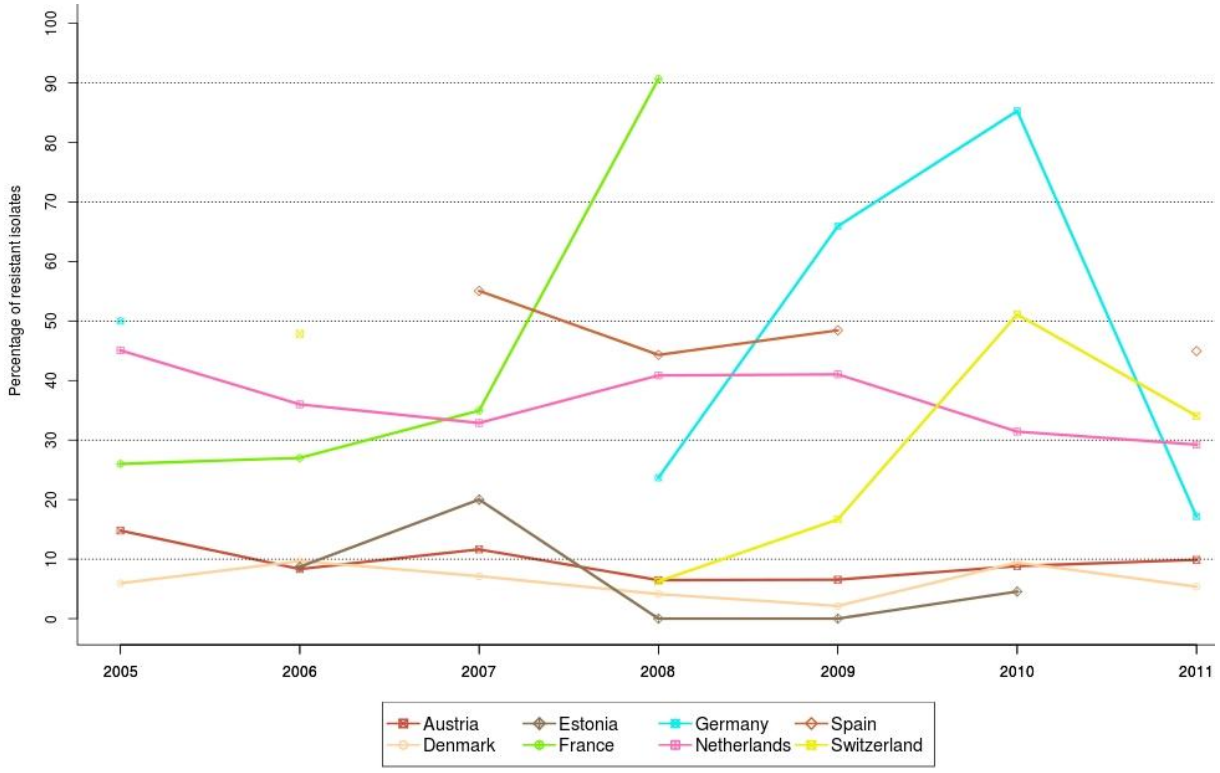
Note: Statistically significant decreasing trends over five or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Denmark (↓), Estonia (↓), Germany (↓) and the Netherlands (↓) for ciprofloxacin, and in Germany (↓) for nalidixic acid.

Figure EC23. Trends in streptomycin resistance in indicator* Escherichia coli *from cattle in reporting MSs and one non-MS, 2005–2011, quantitative data



Note: Statistically significant decreasing trends over five or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Denmark (↓), Estonia (↓), Germany (↓) and Switzerland (↓).

Figure EC24. Trends in tetracycline resistance in indicator* Escherichia coli *from cattle in reporting MSs and one non-MS, 2005–2011, quantitative data

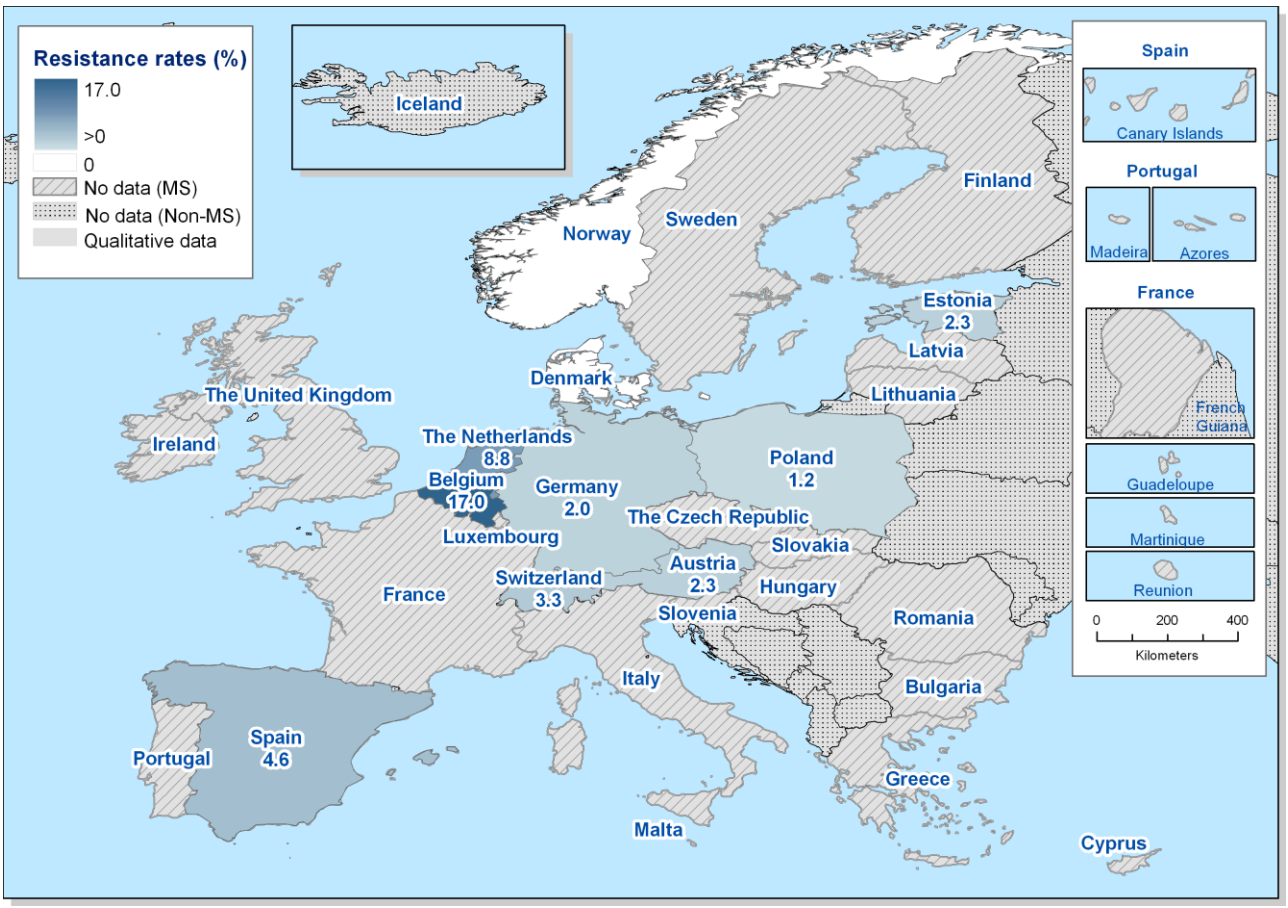


Note: Statistically significant decreasing trends over five or more years, as tested by a logistic regression model ($p \leq 0.05$), were observed in Austria (↓), Germany (↓), the Netherlands (↓) and Switzerland (↓).

Spatial distribution of resistance among indicator *Escherichia coli*

The spatial distributions of nalidixic acid and tetracycline resistance among *E. coli* from cattle are shown in Figures EC25 and EC26. Fewer countries have reported data for *E. coli* from cattle than for *E. coli* from *Gallus gallus* or pigs. Nevertheless, there was still some evidence that the lowest resistance to tetracyclines occurred in the northern countries and the highest occurred in the southern and western countries. With respect to nalidixic acid, the majority of countries reported low levels of resistance and no spatial pattern was evident.

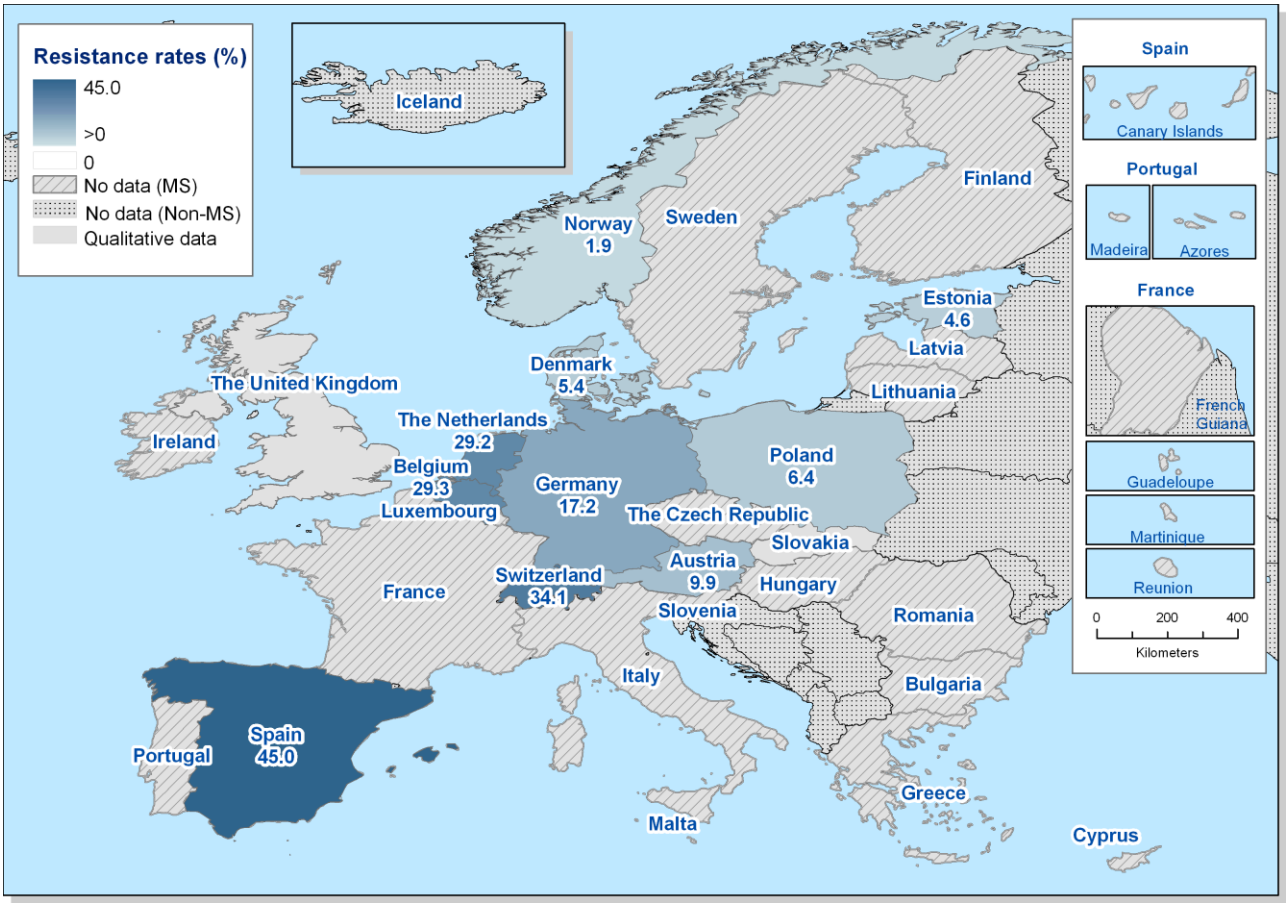
Figure EC25. Spatial distribution of nalidixic acid resistance among indicator* Escherichia coli *from cattle in countries reporting MIC data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data were used instead.

1. For Estonia and Norway, 2010 data were used.

Figure EC26. Spatial distribution of tetracycline resistance among indicator* Escherichia coli *from cattle in countries reporting MIC data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data were used instead. The countries labelled as 'qualitative data' therefore include those reporting MIC data for fewer than 10 isolates or purely qualitative data (as proportion of resistant isolates).

1. For Estonia and Norway, 2010 data were used.

Multi-resistance among indicator *E. coli* isolates from cattle

No tables and graphs on multi-resistance are presented in this report for *E. coli* in cattle because too few MSs reported multi-resistance isolate-based data on more than 10 isolates in the different production types of cattle animal species.

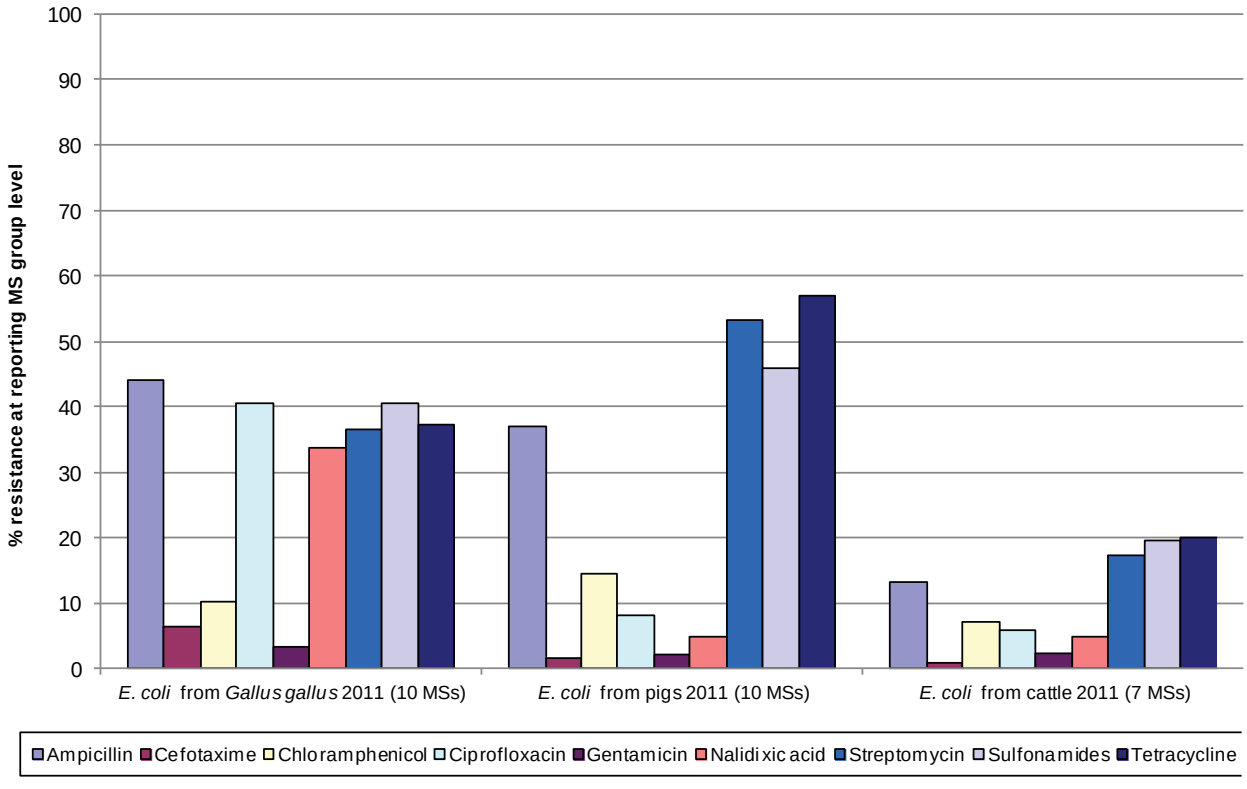
6.3. Overview of findings on indicator *E. coli* resistance at reporting MS group level, 2011

Figure EC27 displays the resistance levels among *E. coli* isolates in the reporting MS group, based on quantitative data submitted in 2011 for the various animal species. It should be borne in mind that the data for the different species are derived from different groups of MSs.

The resistance levels observed in *E. coli* isolates from cattle were lower than in *E. coli* from either *Gallus gallus* or pigs, most notably for ampicillin, streptomycin, sulfonamides and tetracyclines. This contrasts with the previous year, when the resistance levels were fairly similar among the different livestock types, but is similar to preceding years, when the levels in cattle were also lower. In 2011, compared with 2010, resistance levels increased at the reporting MS group level in *Gallus gallus* and pigs but decreased in cattle. This is in direct contrast to the situation in 2010, relative to 2009, when resistance levels decreased in both *Gallus gallus* and pigs but increased in cattle. This would partly explain the greater and lesser distinction between the resistance levels in different production types in 2011 and 2010, respectively. The variations at the reporting MS group level between years could be attributable to different MSs contributing data and different production types of livestock being sampled. The MSs that provided data for all three livestock species in both 2010 and 2011 usually reported the lowest resistance levels among cattle.

As in previous years, isolates from pigs had the highest levels of resistance to streptomycin, sulfonamides and tetracyclines, while isolates from *Gallus gallus* had the highest resistance to ampicillin, ciprofloxacin and nalidixic acid. Resistance to chloramphenicol and gentamicin was relatively low in all types of livestock, with the highest resistance level occurring in pigs and *Gallus gallus*, respectively. This differs to 2010, when the highest resistance levels for these two antimicrobials were observed in cattle. Chloramphenicol has not been used for food production animals in the EU for several years; thus, the resistance observed must either indicate persistence of resistance genes or co-selection resulting from use of related compounds (such as florfenicol). The lowest levels of resistance were usually observed to cefotaxime; the highest level of resistance to this antimicrobial occurred in isolates from *Gallus gallus*, which was also the case in previous years.

Figure EC27. Resistance in indicator* Escherichia coli *from fowl, pigs and cattle to ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, nalidixic acid, streptomycin, sulfonamides and tetracyclines at reporting MS group level, in 2011



6.4. Discussion

Antimicrobial resistance in indicator, commensal *E. coli* from animals and food can be used to examine the reservoir of resistance genes occurring in those bacteria that could be transferred to bacteria that are pathogenic for humans and/or animals. The major factor influencing the occurrence of resistance to antimicrobials in indicator *E. coli* is likely to be the selective pressures exerted by use of antimicrobials in the different food animal populations; variations in usage between animal species may also contribute to the observed differences in resistance levels between the animal species. Indicator *E. coli* are thus also of interest when investigating possible associations between the usage of antimicrobials in a given country and the occurrence of resistance in an animal species, because of their ubiquity in food-producing animals. Multi-resistance data, available for the first time in 2011, indicates that the co-resistance phenomenon is to be accounted for when analysing the relationship between antimicrobial use and resistance in animals.

A total of 12 MSs and 2 non-MSs provided quantitative MIC data in 2011 on at least one of the livestock species. For both *Gallus gallus* and pigs, 12 countries provided quantitative dilution data in 2011 compared with seven in 2010; for cattle, eight countries provided quantitative data concerning *E. coli* compared with seven in 2010. The EFSA recommendations (EFSA, 2008a) state that different animal species may be sampled once every three years, and this may account for the variation in the number of countries reporting data for each animal species between years. Reported AMR data in *E. coli* isolates from food-producing animals and food derived mainly from active and representative monitoring programmes, chiefly based on sampling performed at the slaughterhouse.

At the reporting MS group level, a high level of resistance was observed to several antimicrobials among food-producing animals, with some countries reporting a very or extremely high occurrence of resistance. Few MSs reported on antimicrobial resistance in meat, but those which did generally reported comparable resistance levels in meat as in the corresponding source animal species. Indeed, Denmark and Germany reported resistance in isolates from broiler meat broadly comparable to that recorded in isolates from broilers. Resistance recorded by Denmark, Germany and Sweden in isolates from pork is roughly similar to that reported from pigs. However, the most notable exceptions are for Germany, which reported somewhat higher resistance among isolates from pigs than in isolates from pig meat to ampicillin (44.7 % vs. 25.0 %), chloramphenicol (14.6 % vs. 0 %), streptomycin (59.4 % vs. 28.8 %), sulfonamides (47.7 % vs. 26.9 %) and tetracyclines (62.5 % vs. 30.8 %). Similarly, in cattle, resistance in isolates from meat from cattle recorded in Denmark and Germany was roughly comparable to that reported for bovine animals in the same MSs (Table EC6), for which Germany reported on isolates from young meat production animals and Denmark reported on isolates from unspecified cattle type.

In 2011, resistance levels were higher among *E. coli* isolates from *Gallus gallus* and pigs than isolates from cattle. This differs to the situation in 2010, when resistance levels were comparable in the different livestock species, but it is similar to the preceding years. In 2011, resistance at the reporting MS group level was higher than in 2010 for isolates from *Gallus gallus* and pigs but lower in isolates from cattle. In contrast, resistance levels in 2010 were lower than in 2009 in isolates from both *Gallus gallus* and pigs but higher among isolates from cattle. As resistance levels tend to vary substantially between countries, the variation in resistance in *Gallus gallus*, pigs and cattle observed between the years 2009, 2010 and 2011 at the overall MS group level may partly result from different MSs contributing to data as well as different production types of livestock being sampled.

This was the first year that resistance data were reported separately for different production types of *Gallus gallus* and cattle. However, only two countries provided data on laying hens, and only one of these MSs also provided data on broilers. Although there is limited information available in 2011 on which to draw firm conclusions, resistance levels appeared to be higher among broilers than in laying hens. Similarly, in 2011, few MSs reported on more than one production type or age group of cattle. Two countries also did not report which type of cattle were tested. Therefore, it is difficult to determine the extent to which differences observed between the age groups are real or simply an artefact of differing resistance levels between those countries. While the Netherlands reported much higher resistance levels among younger animals, the same was not found in Austria or Switzerland.

Generally, the highest resistance levels were identified for ampicillin, sulfonamides and tetracyclines, which are commonly used therapeutically in animals. Moreover, some countries have shown statistically significant increasing trends in resistance to these antimicrobials over five or more years since 2006. However, all of the trends in resistance to sulfonamides that were found to be statistically significant in all three of the food-

producing animal species were actually decreasing trends. At the MS group level, resistance to gentamicin was highest in *Gallus gallus* (3.5 %) and lowest in pigs (2.2 %).

Resistance was also identified to antimicrobials recognised to be critically important in human medicine, including fluoroquinolones (ciprofloxacin) and third-generation cephalosporins (cefotaxime). Resistance to ciprofloxacin in meat was generally at a low level, although Germany reported 52.3 % resistance in isolates from broiler meat. Only Denmark reported data on isolates from meat in both 2010 and 2011, and reported only a marginal increase in resistance levels; for example, 2.7 % of isolates from bovine meat tested resistant to ciprofloxacin in 2011 compared with none in 2010. At the reporting MS group level, resistance to ciprofloxacin in *E. coli* was much higher in isolates from *Gallus gallus* (40.5 %) than from pigs (8.3 %) or cattle (6.0 %). Although the level in *Gallus gallus* and pigs was higher than in 2010 (29 % and 2 %, respectively), the level in cattle was lower than in 2010 (15 %). While Austria and France have shown statistically significant increases in resistance to this antimicrobial in *Gallus gallus* since 2006, no statistically significant trends were observed in pigs and only statistically significant decreasing trends were identified in cattle.

The occurrence of resistance to nalidixic acid was often similar to that for ciprofloxacin, suggesting that mutation in the topoisomerase enzymes (gyrA or parC) may, in those cases, have been responsible for resistance. However, in some MSs, the occurrence of resistance to ciprofloxacin was slightly higher than that obtained for nalidixic acid. In these cases, mechanisms such as transferable fluoroquinolone resistance conferred by *qnr* genes may have been the responsible for resistance, as such plasmid-mediated mechanisms can result in that phenotypic pattern of resistance.

The occurrence of third-generation cephalosporin resistance was still generally low, although Belgium and Spain did report 19.1 % and 20.8 % resistance in *E. coli* from *Gallus gallus*, respectively. Third-generation cephalosporin resistance was higher in isolates from *Gallus gallus* than in pigs or cattle. Cefotaxime resistance was marginally higher than in 2010 at the reporting MS group level for isolates from *Gallus gallus* (6.4 % vs. 5 %) and pigs (1.7 % vs. 1 %) but slightly lower for isolates from cattle (0.9 % vs. 3 %). Resistance was also low in isolates from meat. Denmark was the only country to report on isolates from meat in both 2010 and 2011: cefotaxime resistance in broiler meat increased from 0.6 % to 2.5 %, and 2.5 % of broiler meat isolates were also resistant to ceftiofur, but none of the isolates from pig or bovine meat were resistant to cefotaxime or ceftiofur in 2011. Considering the data reported by MSs, there have been no statistically significant trends observed in resistance to cefotaxime since 2005 in any of the livestock species, with less than 5 % of isolates from pigs or cattle expressing resistance in all countries since 2005. The findings in relation to third-generation cephalosporin resistance are discussed further in Chapter 9. EFSA (EFSA, 2012b) has also published recommendations for surveillance of indicator *E. coli* resistant to cefotaxime, which would extend the scope of the current monitoring by including selective culture for such organisms. Current procedures rely on random selection of indicator *E. coli* isolates from primary culture plates; selective culture could additionally be used to detect the presence or absence of isolates resistant to cefotaxime in a sample (within the detection limit of the chosen method). Monitoring using selective media for cefotaxime resistance would thus detect cefotaxime-resistant *E. coli* present as a minor component of the total bacterial flora in the test sample and which might only occasionally be detected by random sampling from non-selective culture plates.

The resistance trends in each MS since 2006 were tested for statistical significance whenever five or more years of data were available. More statistically significant increasing trends were observed than decreasing trends in isolates from *Gallus gallus*. In contrast, all of the significant trends in cattle were decreasing. Since 2006, Germany has shown significant declines in resistance to four antimicrobials in isolates from *Gallus gallus* and six antimicrobials in isolates from cattle. Germany also reported substantially lower resistance in isolates from cattle in 2011 compared with 2010 for all antimicrobials despite only sampling veal calves in 2010 and young meat production animals in 2011.

Multi-resistance levels (proportions of isolates showing reduced susceptibility to at least three antimicrobial classes according to ECOFFs) were relatively high in indicator *E. coli* isolates from both broilers and pigs in most reporting countries. Co-resistance to cefotaxime and ciprofloxacin was detected at very low levels in both broilers and pigs, although more co-resistant strains were isolated from broilers than from pigs in the reporting countries.

7. ANTIMICROBIAL RESISTANCE IN ENTEROCOCCI

7.1. Introduction

A number of commensal bacteria are naturally present in the intestine of farm animals and some of these, such as *E. coli* and certain species of *Enterococcus*, tend to be consistently present, occurring in the intestine of all, or the majority, of animals. These bacterial organisms (*E. coli* representing the Gram-negative organisms and *Enterococcus* spp. representing the Gram-positive organisms) are therefore selected as indicator organisms which reflect the degree of resistance borne by the commensal flora of animals. They are considered a potential reservoir of resistance genes that can spread horizontally to zoonotic and other bacteria through the food chain (Neidhardt, 1996; Winokur et al., 2001; Wang et al., 2006). Of course, some antimicrobials have a largely Gram-negative or Gram-positive spectrum and the inclusion of both *E. coli* and *Enterococcus* spp. in the monitoring programme ensures that a broad range of important antimicrobials with a different spectrum of action can be covered. The generally ubiquitous occurrence of indicator organisms in many food-producing animal species means that randomised sampling strategies can be developed, allowing for statistical analysis of data and reducing the effect of sampling bias, as well as allowing inference to be made from the representative random sample investigated to the target population from which the sample was derived.

The *Enterococcus* species, *E. faecium* and *E. faecalis,* are suitable as indicator bacteria since both species are commonly isolated from animal faeces; furthermore, these species of *Enterococcus* are also important in human medicine. *Enterococcus* species can occur in the intestinal tract of animals at a different prevalence, dependent upon the animal species concerned, as well as varying, in some cases, with the age of the animal. The occurrence of *E. faecium* and *E. faecalis* in the intestinal tract of animals or on food, even if not directly significant for man, may constitute a reservoir of resistance genes which could be transferred either to pathogenic bacteria or to other commensal bacteria. In addition, they are considered good indicators of the selective pressure exerted by the use of antimicrobials on intestinal populations of Gram-positive bacteria in food animals.

According to current EU legislation, the monitoring of AMR in enterococci in animals and food is not mandatory. However, harmonised technical specifications for this monitoring, including sampling protocols, have been proposed to volunteering MSs in the EFSA guidelines (EFSA, 2008a). These encourage development of randomised sampling strategies allowing for robust statistical analysis of data and reducing the effect of sampling bias. Monitoring in accordance with the recommendations may be carried out at the farm or slaughterhouse level.

7.2. Antimicrobial resistance in indicator enterococci isolates from animals and food

A total of 10 MSs and two non-MSs (Norway and Switzerland) reported quantitative MIC data on antimicrobial resistance in enterococci isolated from animals and food in 2011. Only one country provided qualitative data, so no specific subsection for these data has been prepared. Tables EN1 and EN2 show the countries that reported *E. faecium* and *E. faecalis* MIC values in 2011. The total number of tests performed on enterococci isolates from animals and food in 2011 by MSs and non-MSs and for which quantitative MIC data are available was 69,166.

Table EN1. Overview of countries reporting antimicrobial resistance data using MIC and disc inhibition zones on* Enterococcus faecium *from animals and food in 2011

Method	Origin	Total number of MSs reporting	Countries
Dilution	*Gallus gallus* (fowl)	8	**MSs:** AT, BE, DK, ES, FI, FR, IE, NL
			Non-MSs: CH, NO
	Turkeys	1	**MS:** NL
	Pigs	8	**MSs:** AT, BE, DK, EE, ES, FR, NL, SE
			Non-MSs: CH
	Cattle (bovine animals)	4	**MSs:** AT, BE, ES, NL
			Non-MS: CH
	Meat from broilers (*Gallus gallus*)	2	**MSs:** DK, NL
	Meat from turkey	1	**MS:** NL
	Meat from pig	2	**MSs:** DK, NL
	Meat from bovine animals	1	**MS:** NL
	Meat from sheep	1	**MS:** NL
	Fruit	1	**MS:** NL
	Vegetables	1	**MS:** NL
	Spices and herbs	1	**MS:** NL

Table EN2. Overview of countries reporting antimicrobial resistance data using MIC and disc inhibition zones on* Enterococcus faecalis *from animals and food in 2011

Method	Origin	Total number of MSs reporting	Countries
Diffusion	Meat from broilers (*Gallus gallus*)	1	**MS:** HU
	Meat from turkey	1	**MS:** HU
	Meat from pig	1	**MS:** HU
	Meat from bovine animals	1	**MS:** HU
Dilution	*Gallus gallus* (fowl)	8	**MSs:** AT, BE, DK, ES, FI, FR, IE, NL
			Non-MSs: CH, NO
	Turkeys	1	**MS:** NL
	Pigs	7	**MSs:** AT, BE, DK, EE, ES, FR, NL
			Non-MS: CH
	Cattle (bovine animals)	4	**MSs:** AT, BE, ES, NL
			Non-MS: CH
	Meat from broilers (*Gallus gallus*)	2	**MSs:** DK, NL
	Meat from turkey	1	**MS:** NL
	Meat from pig	3	**MSs:** DK, NL, SE
	Meat from bovine animals	2	**MSs:** DK, NL
	Meat from sheep	1	**MS:** NL
	Fruit	1	**MS:** NL
	Vegetables	1	**MS:** NL
	Spices and herbs	1	**MS:** NL

The antimicrobials selected by the different MSs and non-MSs for susceptibility testing of *E. faecium* and *E. faecalis* are shown in Chapter 11, Materials and Methods, Table MM9.

The occurrence of resistance to ampicillin, chloramphenicol, erythromycin, gentamicin, linezolid, quinupristin/dalfopristin (*E. faecium* only), streptomycin, tetracyclines and vancomycin is presented in Tables EN3, EN4, EN6, EN7, EN9 and EN10 and described in detail in the text below. Chloramphenicol, gentamicin, linezolid and quinupristin/dalfopristin have not been included in previous years' reports. The tables presenting occurrence of resistance were generated if four or more MSs reported quantitative data for each *Enterococcus* species and sampling origin; tables showing resistance in isolates from cattle were also generated even though fewer than four countries reported data. In addition, only data where 10 or more isolates were available per country, per sampling origin and per year are included in the report.

Where the minimum criteria were met, temporal trend graphs have been generated, showing the percentage of isolates resistant to different antimicrobials for *Enterococcus* isolates from animals and food between 2006 and 2011. Only countries which had reported for four or more years in the 2006–2011 period were included. These trends are presented in Figures EN1–EN10, EN15–EN24 and EN29–EN38.

The spatial distributions of the tetracycline, erythromycin and vancomycin resistance levels are presented in Figures EN11–EN13 for *E. faecium* from *Gallus gallus* and Figures EN25–EN27 for *E. faecium* from pigs. Where data were unavailable for 2011 for a particular country, the data from 2010 were used instead. These antimicrobials are highlighted because of the public health importance of vancomycin and because of the differences in the levels of resistance frequently observed in different MSs to erythromycin and tetracyclines.

Further information on reported MIC distributions and numbers of isolates resistant to amoxicillin/clavulanic acid, ampicillin, bacitracin, chloramphenicol, ciprofloxacin, daptomycin, erythromycin, florfenicol, gentamicin, kanamycin, lincomycin, linezolid, narasin, neomycin, nitrofurantoin, penicillin, quinupristin/dalfopristin (*E. faecium* only), salinomycin, streptomycin, teicloplanin, tetracyclines, tigecycline, vancomycin and virginiamycin among *E. faecium* and *E. faecalis* can be found in the Level 3 tables published on the EFSA website.

7.2.1. Antimicrobial resistance in indicator enterococci isolates from food

7.2.1.1. Meat

In 2011, the Netherlands provided quantitative MIC data for *E. faecium* and *E. faecalis* isolates from meat from bovine animals, broilers (*Gallus gallus*) and pigs. Denmark also provided all of these data, except for *E. faecium* from meat from bovine animals. Sweden provided only data concerning *E. faecalis* isolates from meat from pigs. Data on antimicrobial resistance in indicator enterococci isolates reported by Denmark and Sweden were derived from active and representative monitoring programmes. In Denmark, enterococci isolates originated from meat sampled at wholesale and retail outlets, and were collected randomly throughout all regions of the country in the framework of three centrally coordinated sampling plans corresponding to each type of meat. In Sweden, the programme is based on a sampling plan of broiler fillets, stratified by slaughterhouses that participate and proportional to slaughterhouse broiler meat production capacity. The sampling strategies employed by the Netherlands were not detailed.

Resistance levels among tested enterococci isolated in broiler meat

Denmark and the Netherlands tested 83 and 24 isolates of *E. faecium*, respectively, as well as 34 and 110 isolates of *E. faecalis*, respectively, from meat from broilers (*Gallus gallus*). The Netherlands tended to report higher resistance levels than Denmark for both species of *Enterococcus.* The highest resistance among *E. faecium* isolates was to quinupristin/dalfopristin, for which Denmark reported high resistance (34.9 **%**) and the Netherlands reported extremely high resistance (75.0 %). Regarding erythromycin, Denmark and the Netherlands reported resistance levels of 19.3 % and 66.7 %, respectively, for *E. faecium* and 17.6 % and 62.2 %, respectively, for *E. faecalis*. For tetracyclines they reported resistance levels of 9.6 % and 45.8 %, respectively, for *E. faecium* and 26.5 % and 74.5 %, respectively, for *E. faecalis*. With respect to streptomycin, the Netherlands reported a high level of resistance among *E. faecium* (25.0 % resistance) and *E. faecalis* (50.0 % resistance) isolates, whereas Denmark reported no resistance among the former and only low resistance among *E. faecalis* (5.9 %). Both countries reported a low level of resistance to ampicillin in *E. faecium* (2.4 % for Denmark and 8.3 % for the Netherlands). Resistance among *E. faecalis* was lower, with all Danish isolates showing full sensitivity and only 0.9 % of isolates from the Netherlands expressing resistance. The Netherlands reported a low level of resistance to both chloramphenicol (4.5 %) and gentamicin (2.7 %) among *E. faecalis* isolates but found no resistance among *E. faecium*; Denmark reported no resistance to either of these two antimicrobials in either *Enterococcus* species. Neither country reported any resistance to linezolid or vancomycin among either enterococci species.

Resistance levels among tested enterococci isolated in pig meat

Denmark and the Netherlands tested 27 and 106 isolates of *E. faecium*, respectively, from meat from pigs, while Denmark, the Netherlands and Sweden tested 133, 233 and 29 isolates of *E. faecalis*, respectively. There was a moderate level of resistance to erythromycin among *E. faecium* (14.8 % in isolates from Denmark and 16.0 % in isolates from the Netherlands). Both countries reported only low levels of resistance among *E. faecalis* (8.3 % and 5.6 %, respectively), and Sweden reported no resistance. Resistance to tetracyclines among *E. faecium* was low for isolates from both Denmark (7.4 %) and the Netherlands (8.5 %). Both countries reported slightly higher levels of resistance among *E. faecalis* (17.3 % and 18.9 %, respectively) while Sweden reported 6.9 % resistance. Resistance to streptomycin was low for both *E. faecium* (3.7 % and 1.9 % resistance in Denmark and the Netherlands, respectively) and *E. faecalis* (5.3 %, 4.3 % and 3.4 % resistance in Denmark, the Netherlands and Sweden, respectively). The Netherlands reported 0.9 % resistance to ampicillin among *E. faecium* whereas all isolates from Denmark were fully sensitive. All three countries also reported full sensitivity to ampicillin among *E. faecalis*. With respect to chloramphenicol and gentamicin, Denmark and the Netherlands both reported full sensitivity among *E. faecium*. Sweden also reported no resistance to either of these antimicrobials among *E. faecalis*, whereas Denmark and the Netherlands reported a low or very low occurrence of resistance, of 3.8 % and 1.7 %, respectively, for chloramphenicol, and 1.5 % and 0.4 %, respectively, for gentamicin. No resistance was reported to linezolid or vancomycin in either of the enterococci species.

Resistance levels among tested enterococci isolated in bovine meat

The Netherlands tested 146 and 216 isolates of *E. faecium* and *E. faecalis*, respectively, from meat from bovine animals, while Denmark tested only 20 isolates of *E. faecalis*. The Netherlands reported very high resistance (61.6 %) to quinupristin/dalfopristin and a high level of resistance (22.6 %) to erythromycin among *E. faecium*. In contrast, both Denmark and the Netherlands reported only low levels of resistance to the latter antimicrobial among *E. faecalis* (5.0 % and 5.6 %, respectively). A moderate level of resistance to tetracyclines was reported for both *E. faecium* (13.0 %) and *E. faecalis* (20.0 % and 19.9 %, respectively). With regard to streptomycin, resistance was low for both *E. faecium* (6.8 %) and *E. faecalis* (10.0 % and 6.5 %, respectively). The Netherlands also reported a low level of resistance to ampicillin among *E. faecium* (1.4 %), whereas both countries reported full sensitivity among isolates of *E. faecalis*. Regarding chloramphenicol, the Netherlands reported very low resistance among *E. faecium* (0.7 %), while both Denmark and the Netherlands reported low resistance among *E. faecalis* (5.0 % and 2.3 %, respectively). The Netherlands also reported very low resistance to gentamicin among *E. faecium* (0.7 %) and *E. faecalis* (0.9 %) whereas Denmark reported no resistance among *E. faecalis.* A very low level of resistance to linezolid among *E. faecium* (0.7 %) was reported by the Netherlands, while no resistance was reported by Denmark, and neither country reported any resistance to vancomycin among either *E. faecium* or *E. faecalis*.

Multi-resistance among enterococci isolates from food

As fewer than four MSs reported resistance isolate-based data on more than 10 isolates of either *E. faecalis* or *E. faecium* in food, tables and graphs on multi-drug resistance are not presented in this report.

7.2.2. Antimicrobial resistance in indicator enterococci isolates from animals

7.2.2.1. Fowl (*Gallus gallus*)

In this report, data for fowl (*Gallus gallus*) include only data from **broilers**. Some countries collected samples at the farm, but in the majority of the reporting MSs enterococci isolates were collected from broiler carcases randomly sampled at the slaughterhouse as part of a national monitoring programme of resistance. The slaughterhouses included in the monitoring programme accounted for a major proportion, typically around 80 % or more, of the total production in the country. The sampling plan was stratified by slaughterhouse, the sample size per slaughterhouse being proportional to the annual throughput of animals slaughtered. For Denmark, Finland, Spain, Norway and Switzerland sampling was evenly spread throughout the year or a significant part of the year to account for any possible seasonal effect. Indicator enterococci isolates were isolated from caecal contents in France and the Netherlands, from cloacal swabs in Switzerland and from faecal samples in most other reporting MSs, by sampling healthy broilers at slaughter or environmental faeces with boot swabs at the farm. Only one representative sample of caecal content per flock/batch, derived either from a unique animal or from a number of slaughtered animals, was gathered to account for clustering. Information on the sampling strategy was not presented by Ireland.

Resistance levels in tested isolates

In 2011, eight MSs and two non-MSs reported quantitative antimicrobial resistance data on enterococci from *Gallus gallus*. Four of the MSs (Austria, Denmark, France and the Netherlands) and one of the non-MSs (Switzerland) that submitted data in 2011 also provided data in 2010. Belgium, Finland, Ireland, Spain and Norway submitted data in 2011 but did not in the previous year. In contrast, Sweden reported data in 2010 but did not submit any data in 2011. Tables EN3 and EN4 present, respectively, the occurrence of resistance to the selected nine antimicrobials among *E. faecium* and *E. faecalis* in these countries. As in previous years, resistance levels to many of the antimicrobials varied markedly between countries.

At the reporting MS group level, there was an extremely high level of resistance (73.5 %) to quinupristin/dalfopristin among *E. faecium*. Resistance levels in the individual reporting countries ranged between 43.9 % and 100 %, although three countries did not report any data for this antimicrobial. Resistance to tetracyclines was very high among both *E. faecium* (59.7 %) and *E. faecalis* (61.9 %) at the reporting MS group level. These resistance levels are similar to those reported in 2010 (56 % and 60 %, respectively). Resistance levels in the individual countries ranged between 5.6 % and 91.8 % for *E. faecium* and between 7.1 % and 94.6 % for *E. faecalis*. Belgium, France and Spain reported the highest resistance levels for both species of *Enterococcus*, while Denmark and Finland reported the lowest for both. Six countries reported either very high or extremely high resistance levels against *E. faecium* and seven countries against *E. faecalis*. Denmark, Norway and Switzerland reported higher resistance levels in *E. faecalis* than in *E. faecium*; in other countries resistance levels were more similar in both species.

There was also a very high level of resistance to erythromycin for both *E. faecium* (54.6 %) and *E. faecalis* (65.2 %) at the reporting MS group level. These levels were marginally higher than those reported in 2010, when 47 % and 56 % of isolates, respectively, expressed resistance. Spain and the Netherlands reported the highest resistance levels in both species of enterococci while Denmark and Norway reported the lowest in both. Norway reported a low level of resistance in *E. faecium* (5.7 %) and Denmark reported a moderate level (15.0 %) but all other countries reported high, very high or extremely high levels of resistance, ranging between 21.5 % and 88.9 %. Regarding *E. faecalis*, Denmark reported a moderate level of resistance (14.5 %) but all other countries reported an occurrence of resistance of between 25.8 % and 85.7 %. In Austria, Finland, Ireland, Norway and Switzerland, the level of resistance for *E. faecalis* was higher than that in *E. faecium*, the difference being more significant in Finland and Ireland.

Resistance to streptomycin was high at the reporting MS group level: 34.0 % of *E. faecium* isolates and 33.0 % of *E. faecalis* isolates expressed resistance. These levels are only marginally higher than those reported in 2010 (28 % and 25 %, respectively). Again, there was extensive variation in the resistance levels reported by individual countries, ranging from 0.6 % (Norway) to 60.6 % (Belgium) for *E. faecium* and from 0.0 % (Finland) to 59.3 % (Belgium) for *E. faecalis*. Norway reported much higher resistance in *E. faecalis* (16.1 %) than in *E. faecium* (0.6 %).

There was also a high level of resistance to ampicillin at the reporting MS group level in *E. faecium* (25.9 %), whereas the overall resistance level in *E. faecalis* was low (1.0 %). Regarding *E. faecium*, half of the countries reported low or very low resistance rates, with Finland and Norway reporting 0.5 % and 0.6 % resistance, respectively. However, Ireland reported extremely high resistance to this antimicrobial (74.8 %) and both the Netherlands and Spain reported a high resistance level of 36.1 %. Regarding *E. faecalis*, Belgium and Spain were the only countries to detect any resistance, reporting that 11.1 % and 1.6 % of isolates were resistant, respectively.

Resistance to gentamicin was at a low level among *E. faecium* (1.7 %) and *E. faecalis* (2.8 %) at the reporting MS group level. With respect to *E. faecium*, six countries reported no resistance while three others reported resistance levels ranging between 0.8 % and 11.1 %. For *E. faecalis,* most countries reported no or low resistance levels although Spain reported a high level of 27.0 % resistance.

At the reporting MS group level, there was very low resistance to chloramphenicol (0.6 %) among *E. faecium*, with only four MSs reporting low or very low levels of 0.5 % to 9.1 % resistance. There was also low resistance among *E. faecalis* (4.2 %) although eight countries reported resistance and at marginally higher levels of between 2.0 % and 15.9 %.

Concerning vancomycin, resistance was very low overall at the reporting MS group level in both *E. faecium* (0.7 %) and *E. faecalis* (0.6 %), which is comparable to the levels reported in 2010. Only Austria (1.4 %), Belgium (9.1 %), Finland (1.0 %) and the Netherlands (0.5 %) detected any resistance in the former, while only Belgium (3.7 %), Ireland (2.0 %) and Spain (1.6 %) reported resistance in the latter.

Belgium was the only country to report resistance to linezolid for both *E. faecium* (6.1 %) and *E. faecalis* (6.2 %).

Table EN3. Resistance (%) to ampicillin, chloramphenicol, erythromycin, gentamicin, linezolid, quinupristin/dalfopristin, streptomycin, tetracyclines and vancomycin among* Enterococcus faecium *from broilers* (Gallus gallus) *in countries reporting MIC data in 2011

Country	Ampicillin		Chloramphenicol		Erythromycin		Gentamicin		Linezolid	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	72	4.2	72	0	72	41.7	72	0	72	0
Belgium	33	24.2	33	9.1	33	72.7	33	0	33	6.1
Denmark	107	2.8	107	0	107	15.0	107	0	107	0
Finland	191	0.5	191	0.5	191	21.5	191	0	191	0
France	170	15.3	170	0.6	170	61.2	170	0	170	0
Ireland	123	74.8	123	0	123	41.5	123	0.8	-	-
Netherlands	427	36.1	427	0.5	427	78.5	427	3.5	427	0
Spain	36	36.1	36	0	36	88.9	36	11.1	36	0
Total (8 MSs)	**1,159**	**25.9**	**1,159**	**0.6**	**1,159**	**54.6**	**1,159**	**1.7**	**1,036**	**0.2**
Norway	176	0.6	176	0	176	5.7	176	0	176	0
Switzerland	13	7.7	13	0	13	23.1	-	-	13	0

Country	Quinupristin/dalfopristin		Streptomycin		Tetracyclines		Vancomycin	
	N	% Res	N	% Res	N	% Res	N	% Res
Austria	72	70.8	72	11.1	72	54.2	72	1.4
Belgium	33	100	33	60.6	33	87.9	33	9.1
Denmark	107	43.9	107	3.7	107	5.6	107	0
Finland	-	-	191	2.6	191	6.3	191	1.0
France	170	65.3	170	31.2	170	91.8	170	0
Ireland	-	-	123	39.8	123	82.9	122	0
Netherlands	427	80.8	427	56.0	427	73.8	427	0.5
Spain	36	94.4	36	44.4	36	91.7	36	0
Total (8 MSs)	**845**	**73.5**	**1159**	**34.0**	**1159**	**59.7**	**1158**	**0.7**
Norway	-	-	176	0.6	176	12.5	176	0
Switzerland	13	84.6	13	15.4	13	46.2	13	0

Belgium reported isolates from *Gallus gallus*, production level is unknown.

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

Table EN4. Resistance (%) to ampicillin, chloramphenicol, erythromycin, gentamicin, linezolid, streptomycin, tetracyclines and vancomycin among* Enterococcus faecalis *from broilers* (Gallus gallus) *in countries reporting MIC data in 2011

Country	Ampicillin		Chloramphenicol		Erythromycin		Gentamicin		Linezolid	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	101	0	101	7.9	101	58.4	101	1.0	101	0
Belgium	81	11.1	81	9.9	81	76.5	81	3.7	81	6.2
Denmark	110	0	110	0	110	14.5	110	0	110	0
Finland	169	0	169	0	169	58.0	169	0	169	0
France	112	0	112	5.4	112	66.1	112	0.9	112	0
Ireland	100	0	100	2.0	100	79.0	100	1.0	-	-
Netherlands	276	0	276	3.3	276	79.0	276	1.8	276	0
Spain	63	1.6	63	15.9	63	85.7	63	27.0	63	0
Total (8 MSs)	**1,012**	**1.0**	**1,012**	**4.2**	**1,012**	**65.2**	**1,012**	**2.8**	**912**	**0.5**
Norway	62	0	62	11.3	62	25.8	62	0	62	0
Switzerland	117	0	117	1.7	117	39.3	-	-	117	0

Country	Streptomycin		Tetracyclines		Vancomycin	
	N	% Res	N	% Res	N	% Res
Austria	101	16.8	101	58.4	101	0
Belgium	81	59.3	81	90.1	81	3.7
Denmark	110	3.6	110	17.3	110	0
Finland	169	0	169	7.1	169	0
France	112	31.3	112	94.6	112	0
Ireland	100	47.0	100	84.0	101	2.0
Netherlands	276	56.2	276	79.0	276	0
Spain	63	44.4	63	87.3	63	1.6
Total (8 MSs)	**1,012**	**33.0**	**1,012**	**61.9**	**1,013**	**0.6**
Norway	62	16.1	62	45.2	62	0
Switzerland	117	12.8	117	65.0	117	0

Belgium reported isolates from *Gallus gallus*, production level is unknown.

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

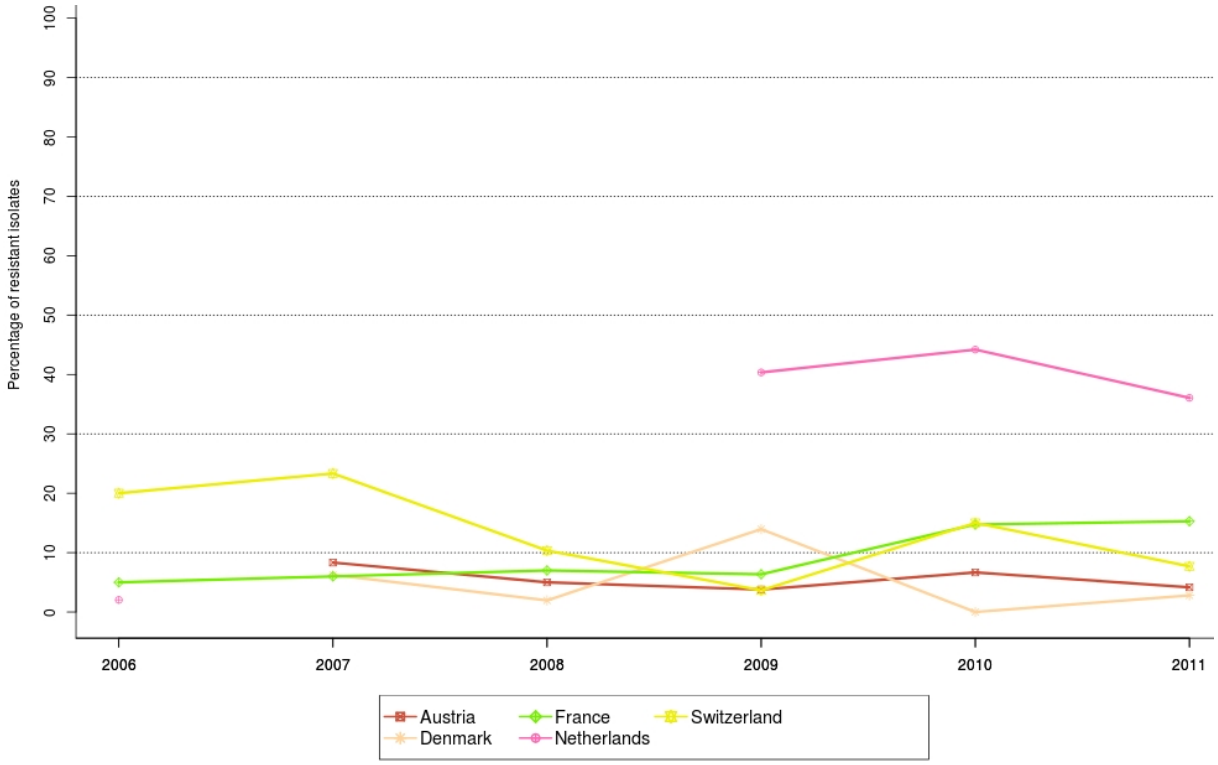
Temporal trends in resistance among indicator enterococci

Figures EN1–EN10 show the trends in resistance to ampicillin, erythromycin, streptomycin, tetracyclines and vancomycin in *E. faecium* and *E. faecalis* isolated from *Gallus gallus* between 2006 and 2011. Countries are included in the graphs only when they have reported resistance data for at least four years over the 2006–2011 period and trends could only be assessed when resistance data were reported for five years or more.

Resistance to vancomycin was low in all countries over this period in both *E. faecium* (Figure EN5) and *E. faecalis* (Figure EN10), as was resistance to ampicillin in *E. faecalis* (Figure EN6). However, the remaining seven graphs showed considerable variation in resistance levels between MSs. This was particularly noticeable for erythromycin and tetracycline resistance in both species of *Enterococcus*. The Netherlands and/or Spain tended to report relatively high resistance levels, while Denmark and/or Switzerland often reported the lowest. In addition, overall, there were no major changes from 2010 to 2011. However, compared with 2010, the more notable changes were a relatively large decline in resistance in *Gallus gallus* to both streptomycin (11.1 % vs. 40 %) and tetracyclines (54.2 % vs. 73 %) in *E. faecium* in Austria, and a concurrent increase in resistance to these two antimicrobials in this species in Switzerland (15.4 % vs. 0 % and 46.2 % vs. 30 %). These evolutions need to be confirmed by longer-term trends.

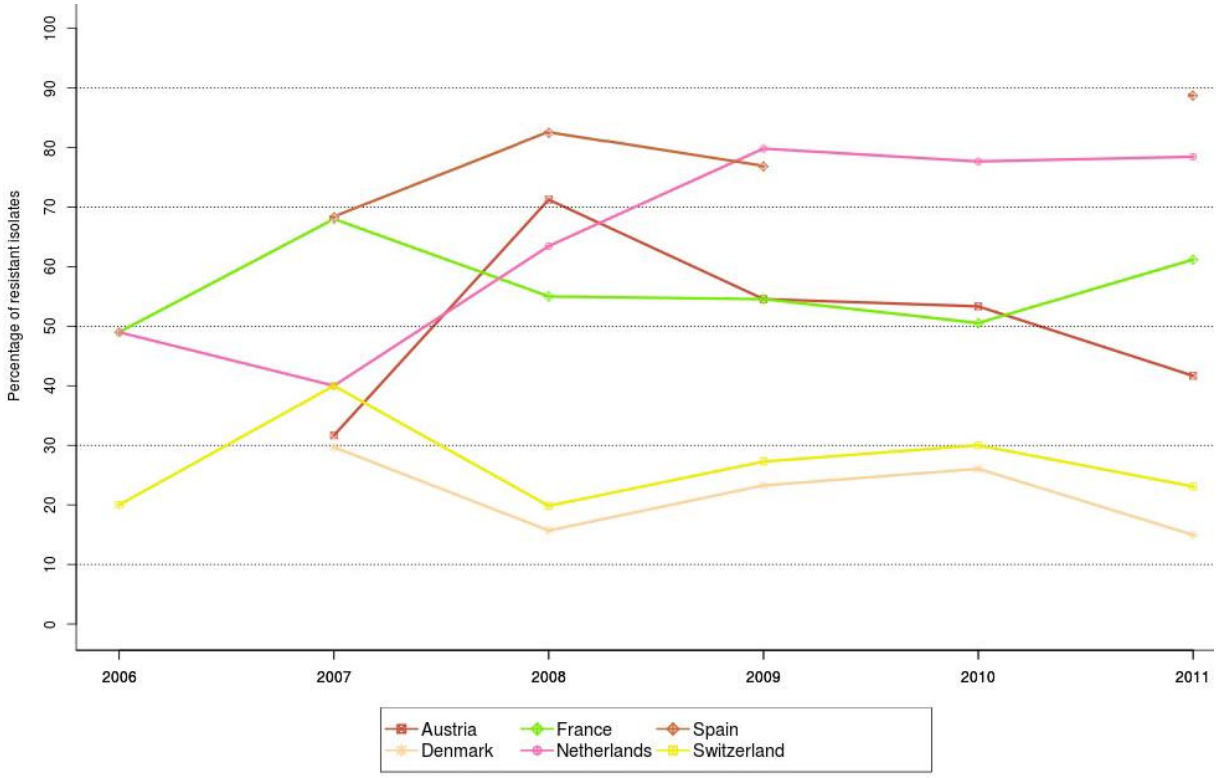
Since 2006, most countries have shown only minor random fluctuations or gradual increases or decreases in resistance. The Netherlands and Switzerland were responsible for many of the statistically significant trends since 2006. In the Netherlands, there has been a statistically significant increase in resistance to erythromycin in both species of *Enterococcus*, as well as to tetracyclines in *E. faecium* and streptomycin in *E. faecalis*. In contrast, Switzerland has recorded a statistically significant decrease in resistance to ampicillin and vancomycin in *E. faecium* as well as to streptomycin and tetracyclines in *E. faecalis*, although there has also been a significant increase in resistance to erythromycin in *E. faecalis* from this country. In addition, there has been a significant increase in resistance to ampicillin in *E. faecium* in France; otherwise resistance levels reported by this country did not change significantly over the reporting period. There have been significant declines in resistance to both vancomycin in *E. faecium* and tetracyclines in *E. faecalis* in Austria, as well as to streptomycin in *E. faecium* from Denmark. There were no statistically significant trends in resistance to either ampicillin or vancomycin in *E. faecalis*, as all countries expressed very low levels of, or no, resistance.

Figure EN1. Trends in ampicillin resistance in* Enterococcus faecium *from* Gallus gallus *in reporting MSs and one non-MS, 2006–2011, quantitative data



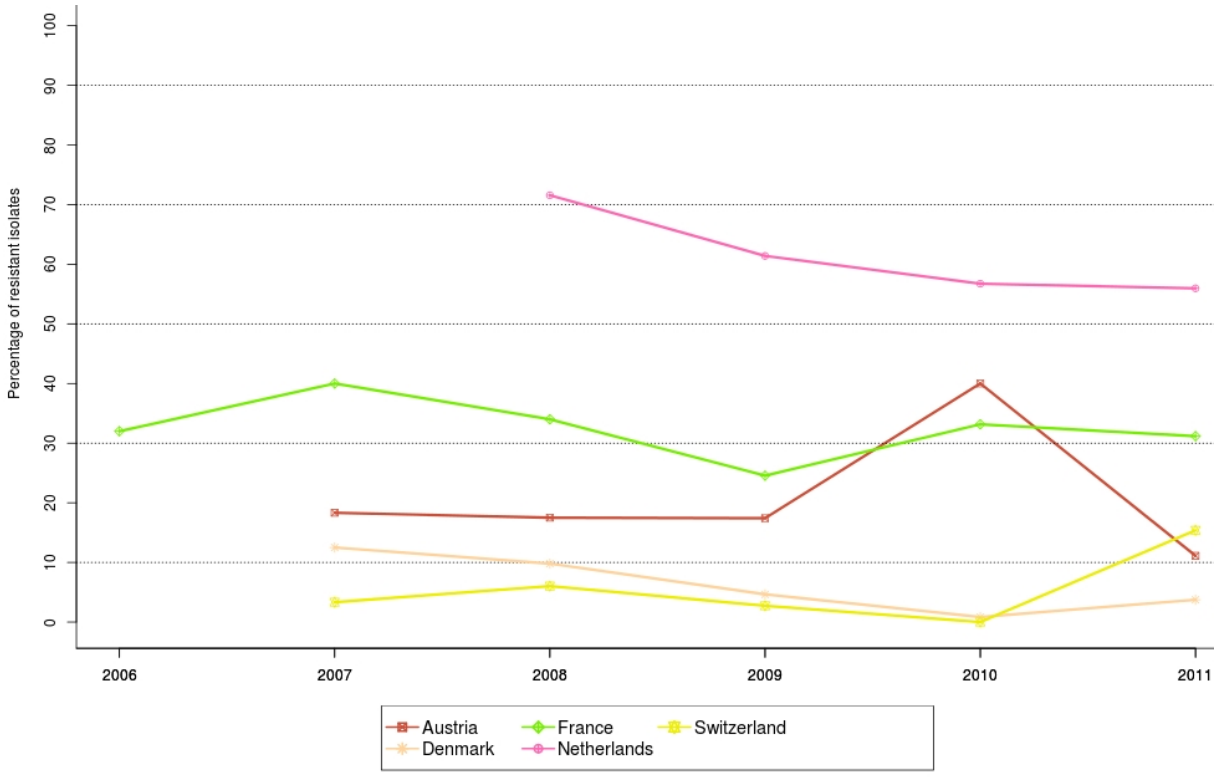
Note: A statistically significant increasing or decreasing trend over six years, as tested by a logistic regression model ($p \leq 0.05$), was observed in France (↑) and Switzerland (↓).

Figure EN2. Trends in erythromycin resistance in* Enterococcus faecium *from* Gallus gallus *in reporting MSs and one non-MS, 2006–2011, quantitative data



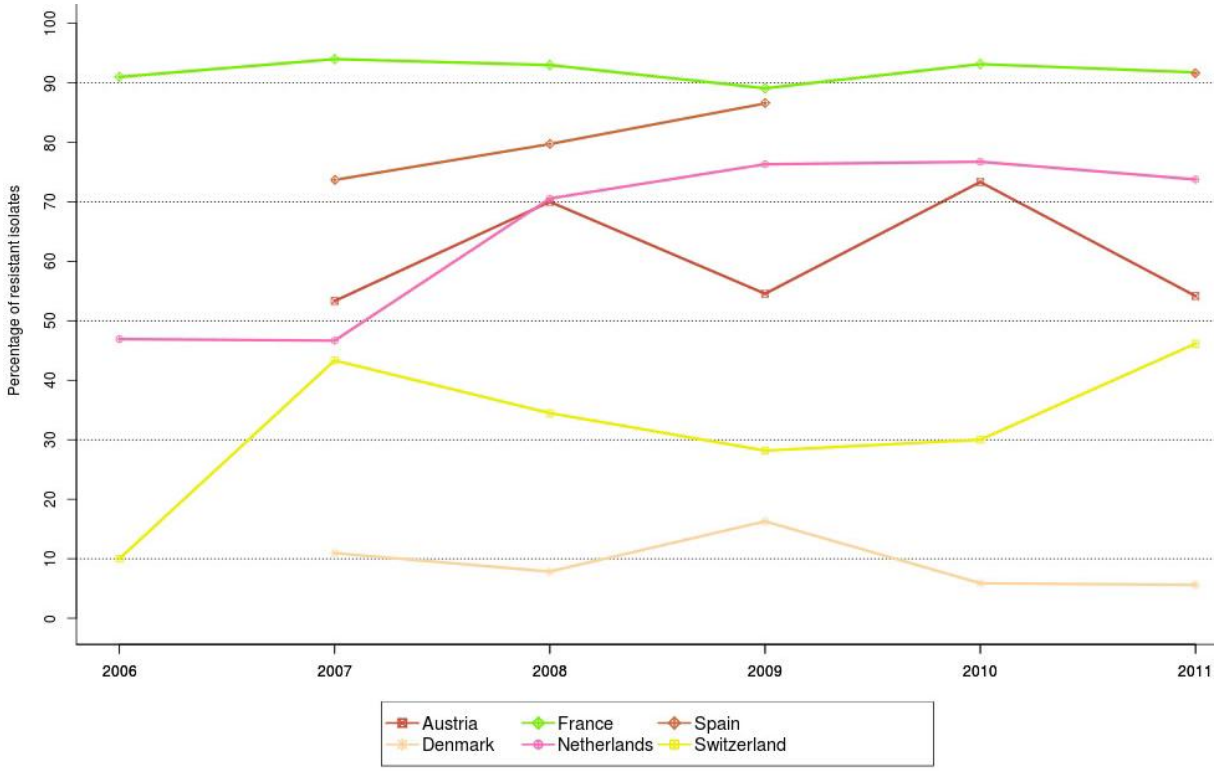
Note: A statistically significant increasing trend over six years, as tested by a logistic regression model ($p \leq 0.05$), was observed in the Netherlands (↑).

Figure EN3. Trends in streptomycin resistance in* Enterococcus faecium *from* Gallus gallus *in reporting MSs and one non-MS, 2006–2011, quantitative data



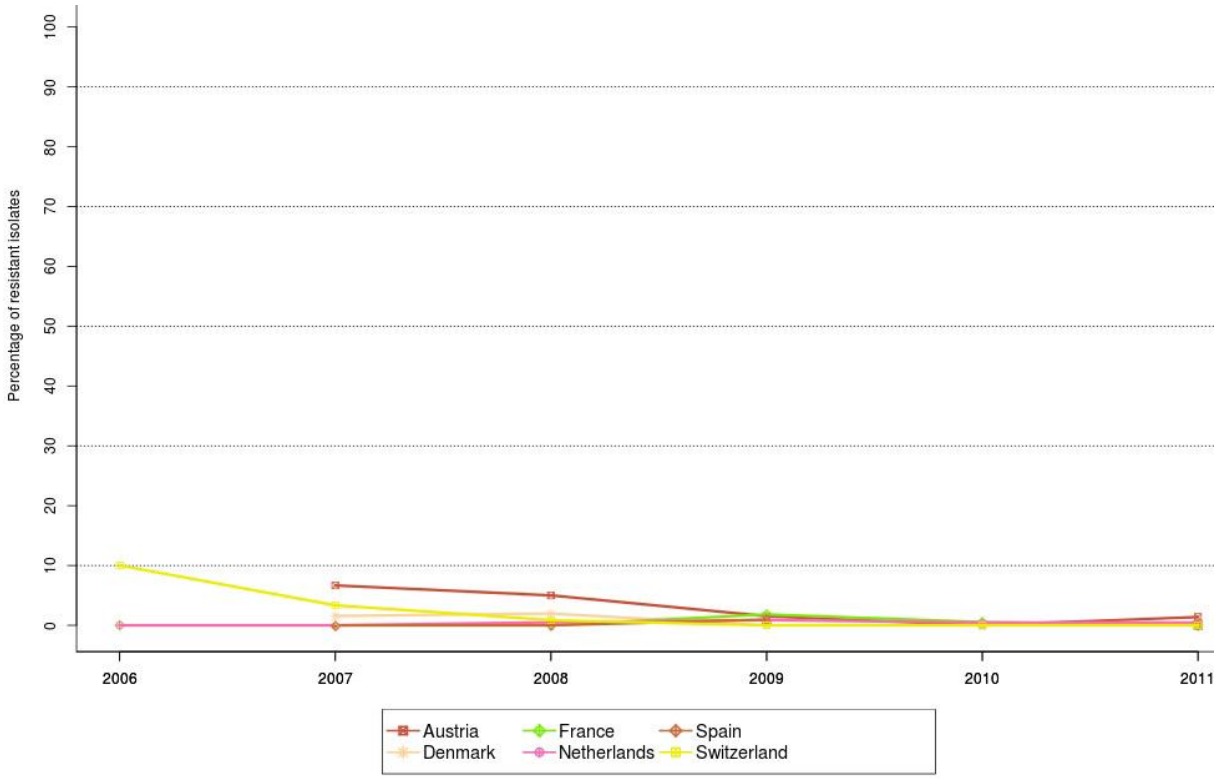
Note: A statistically significant decreasing trend over five years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Denmark (↓).

Figure EN4. Trends in tetracycline resistance in* Enterococcus faecium *from* Gallus gallus *in reporting MSs and one non-MS, 2006–2011, quantitative data



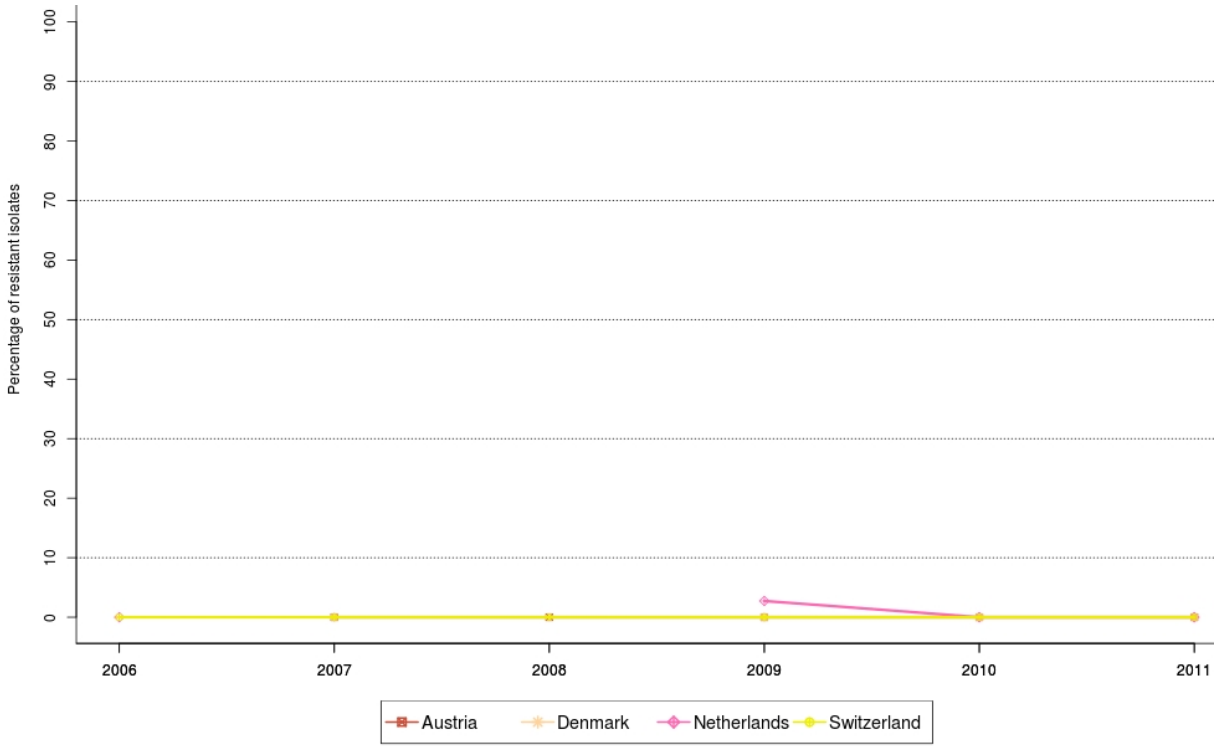
Note: A statistically significant increasing trend over six years, as tested by a logistic regression model ($p \leq 0.05$), was observed in the Netherlands (↑).

Figure EN5. Trends in vancomycin resistance in* Enterococcus faecium *from* Gallus gallus *in reporting MSs and one non-MS, 2006–2011, quantitative data



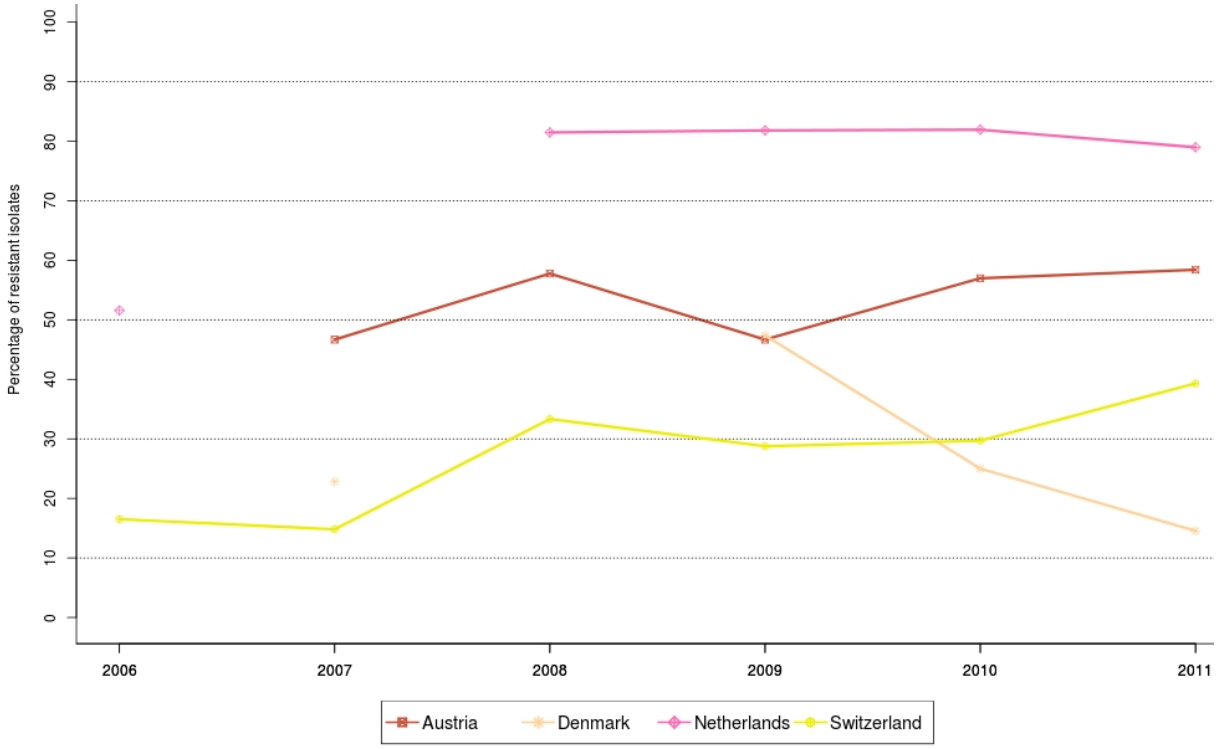
Note: A statistically significant decreasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Austria (↓) and Switzerland (↓).

Figure EN6. Trends in ampicillin resistance in* Enterococcus faecalis *from* Gallus gallus *in reporting MSs and one non-MS, 2006–2011, quantitative data



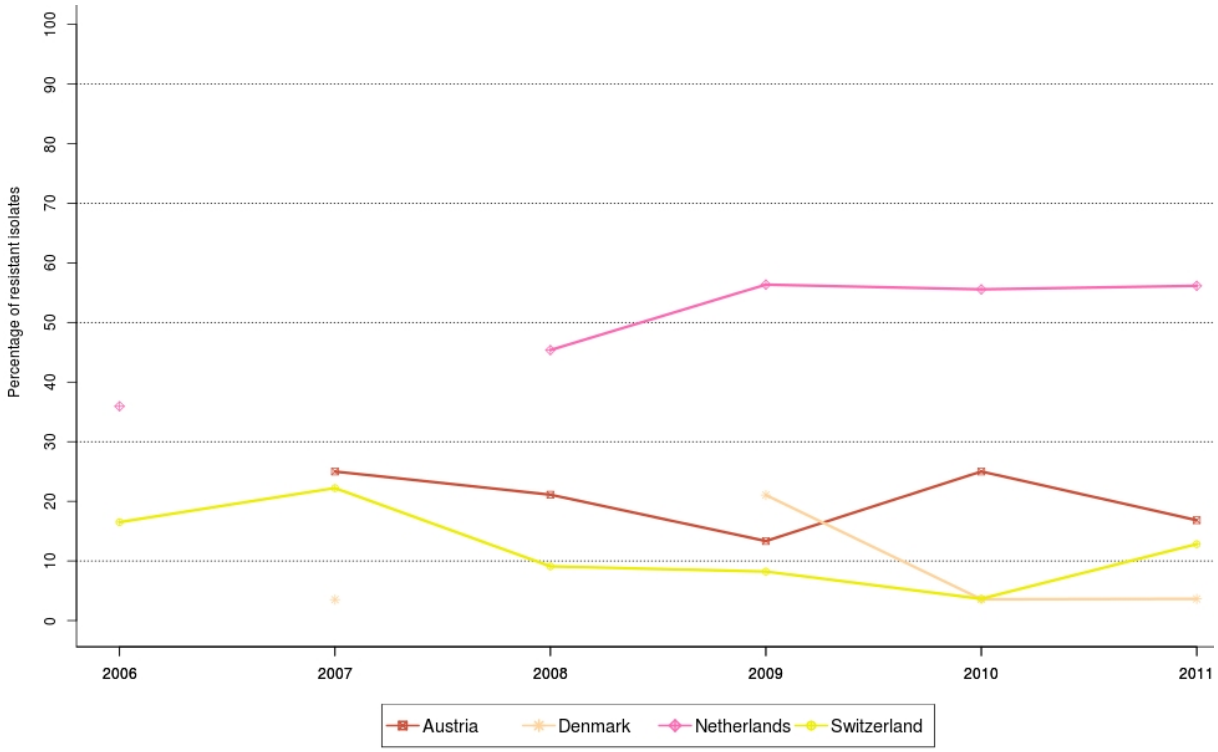
Note: No significant increasing or decreasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

Figure EN7. Trends in erythromycin resistance in* Enterococcus faecalis *from* Gallus gallus *in reporting MSs and one non-MS, 2006–2011, quantitative data



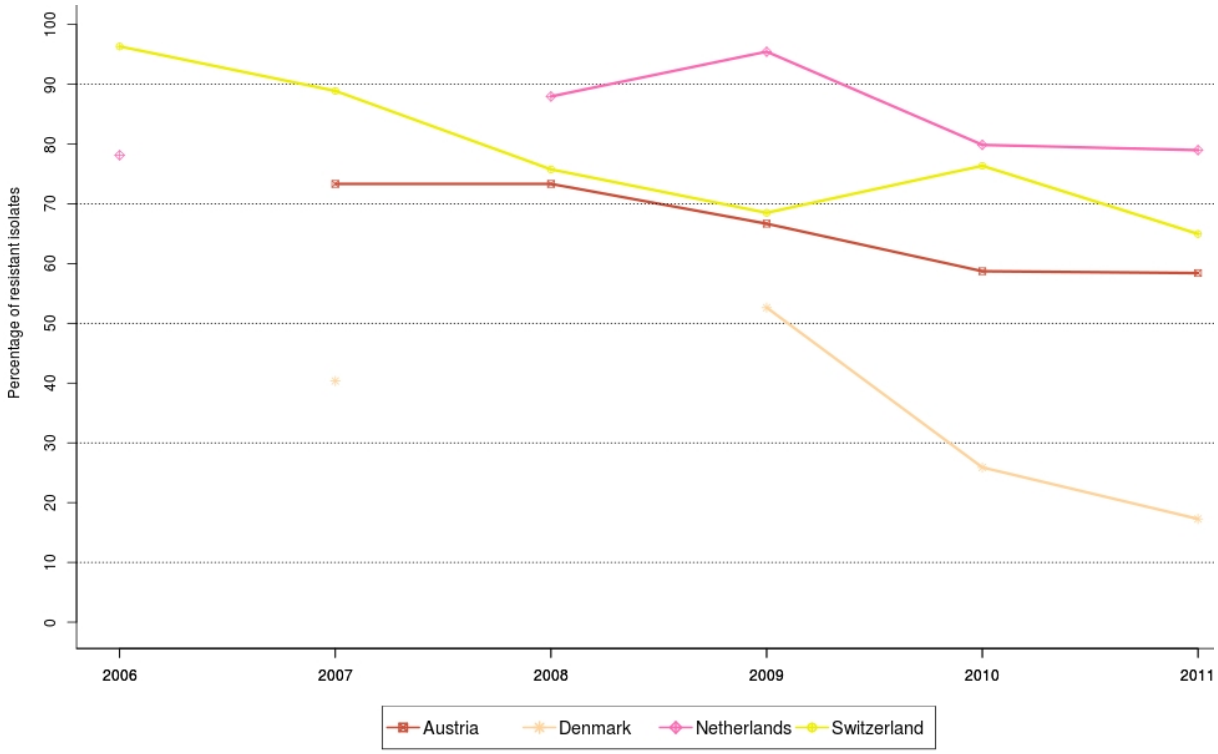
Note: A statistically significant increasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in the Netherlands (↑) and Switzerland (↑).

Figure EN8. Trends in streptomycin resistance in* Enterococcus faecalis *from* Gallus gallus *in reporting MSs and one non-MS, 2006–2011, quantitative data



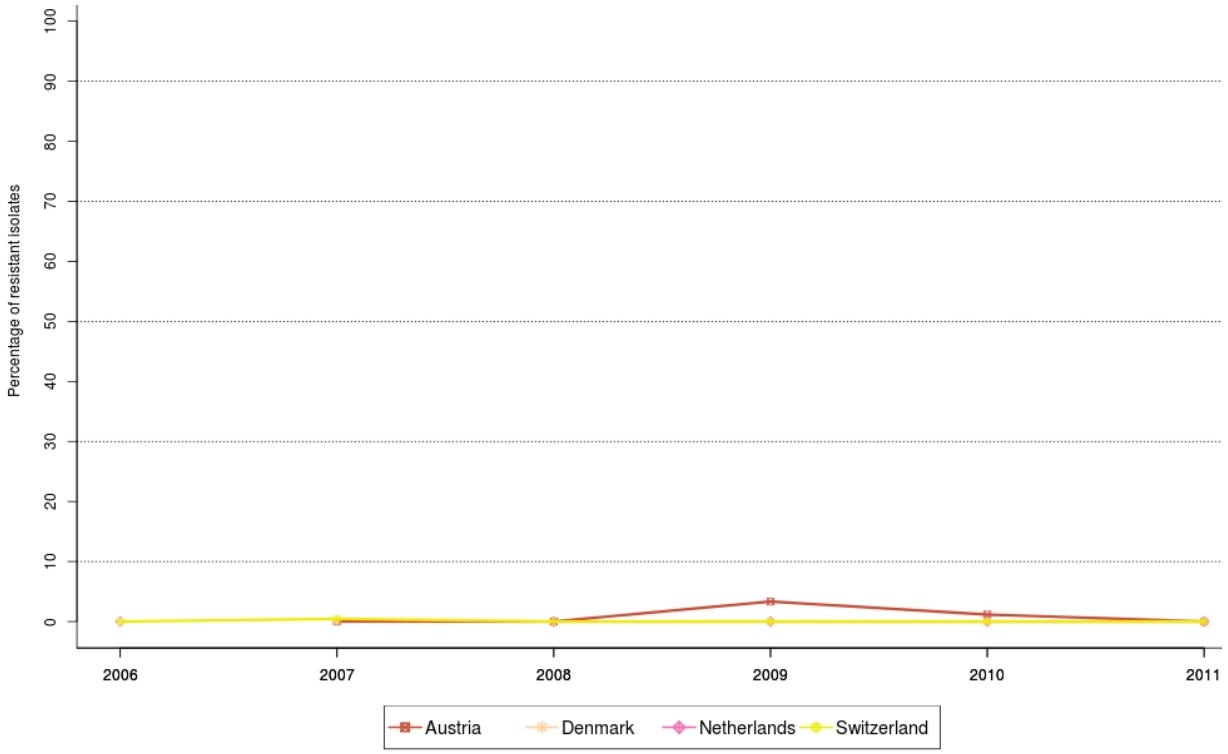
Note: A statistically significant increasing or decreasing trend, over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in the Netherlands (↑) and Switzerland (↓).

Figure EN9. Trends in tetracycline resistance in* Enterococcus faecalis *from* Gallus gallus *in reporting MSs and one non-MS, 2006–2011, quantitative data



Note: A statistically significant decreasing trend, over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Austria (↓) and Switzerland (↓).

Figure EN10. Trends in vancomycin resistance in* Enterococcus faecalis *from* Gallus gallus *in reporting MSs and one non-MS, 2006–2011, quantitative data

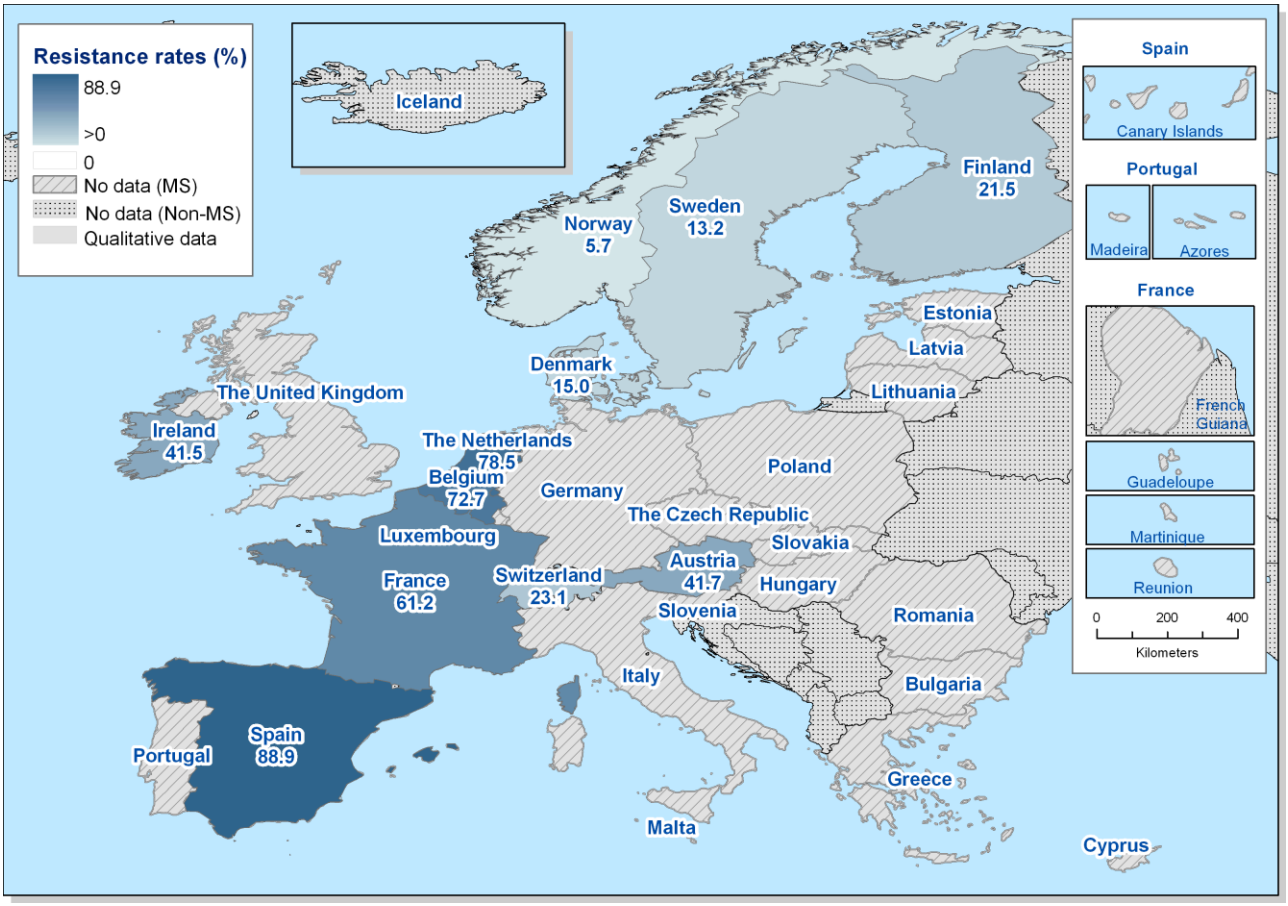


Note: No significant increasing or decreasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

Spatial distribution of resistance among *Enterococcus faecium*

The spatial distributions of erythromycin, tetracycline and vancomycin resistance in *E. faecium* are shown in Figures EN11–EN13. Resistance to both erythromycin and tetracyclines tended to be the lowest in the Nordic countries. Most of the other countries, which were either western or southern European, tended to report very high or extremely high resistance, with the highest levels often observed in the most westerly countries. Resistance levels were usually higher for tetracyclines than erythromycin. With respect to vancomycin, four countries reported low or very low resistance while the remainder reported full sensitivity and there was no clear spatial pattern.

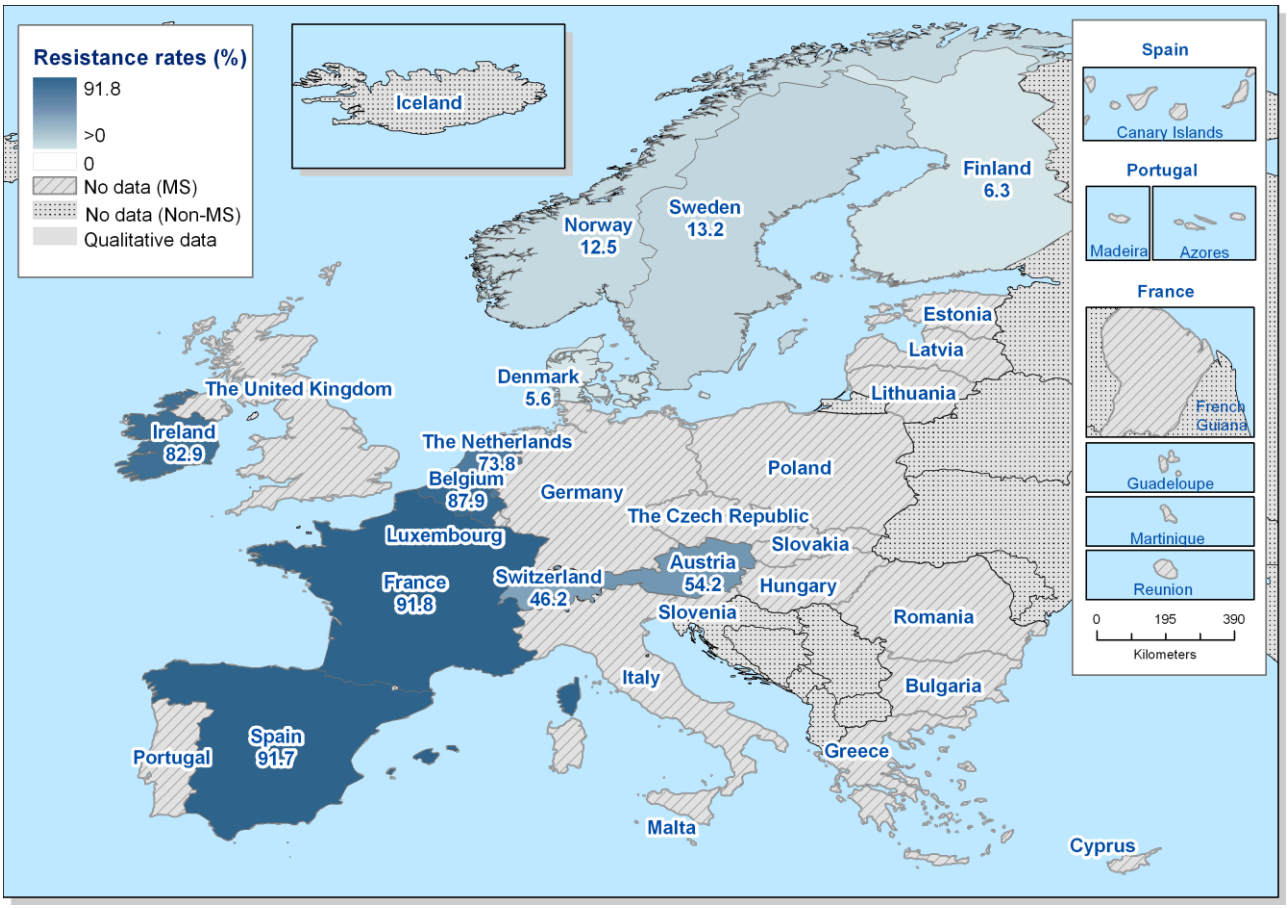
Figure EN11. Spatial distribution of erythromycin resistance among* Enterococcus faecium *from* Gallus gallus *in countries reporting quantitative data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data were used instead.

1. For Sweden, 2010 data were used.

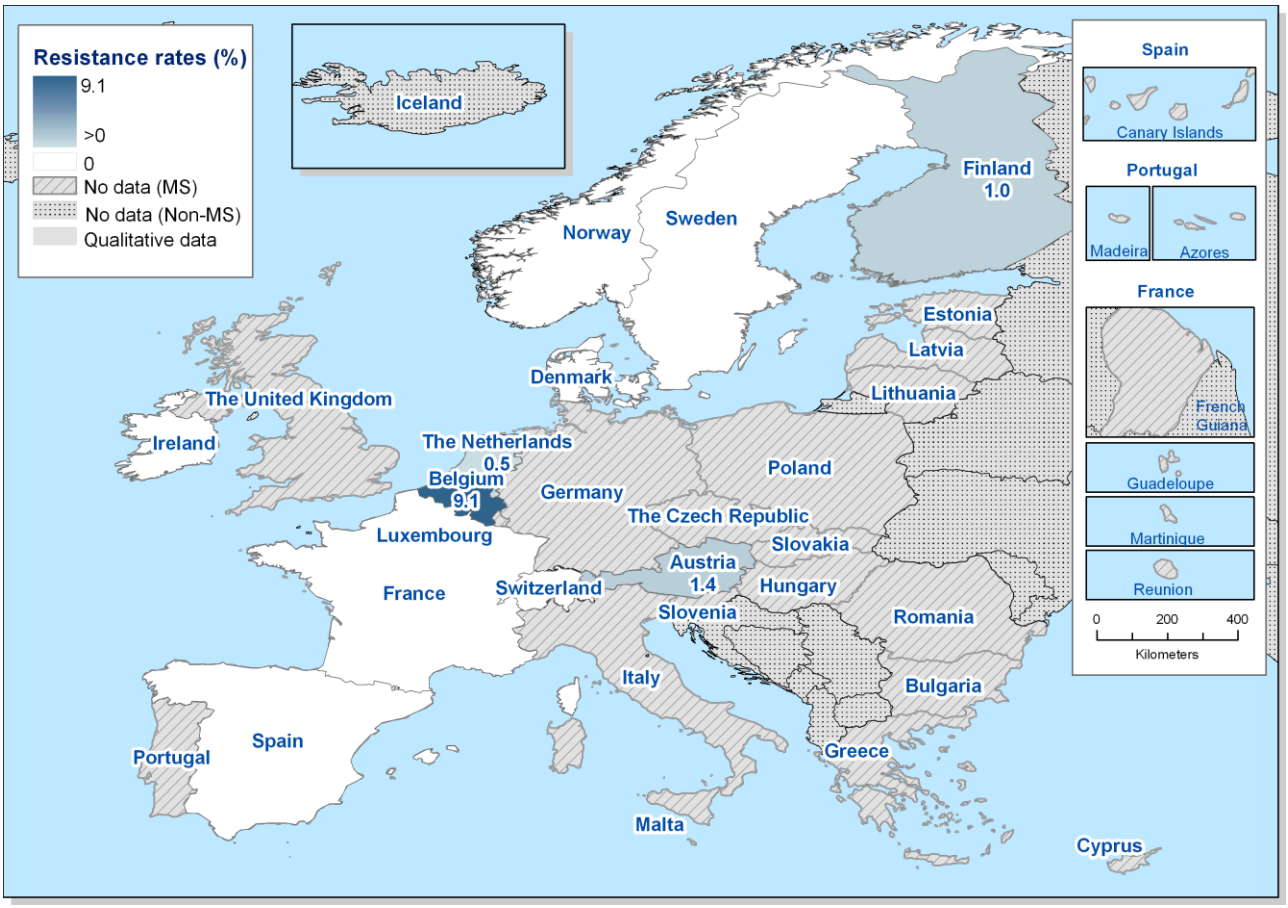
***Figure EN12. Spatial distribution of tetracycline resistance among* Enterococcus faecium *from* Gallus gallus *in countries reporting quantitative data in 2011*[1]**



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data were used instead.

1. For Sweden, 2010 data were used.

***Figure EN13. Spatial distribution of vancomycin resistance among* Enterococcus faecium *from* Gallus gallus *in countries reporting quantitative data in 2011*[1]**



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data were used instead.

1. For Sweden, 2010 data were used.

Multi-resistance among *E. faecium* isolates from broilers of *Gallus gallus*

In 2011, three MSs and one non-MS reported isolate-based data regarding resistance in indicator *E. faecium* from broilers. Among the reporting countries, important variations were observed in the percentages of completely susceptible isolates. Although all reporting countries recorded multi-resistant isolates (isolates exhibiting reduced susceptibility according to ECOFFs to at least three different antimicrobial classes), their proportions differed substantially between countries, from 2.8 % in Denmark up to 29.2 % in Austria and 83.3 % in Spain (Table EN5). The frequency distributions (Figure EN14) showed that isolates resistant to as many as five antimicrobials were reported from all reporting countries.

Table EN5. Complete susceptibility, multi-resistance and index of diversity in* E. faecium *from broilers of* Gallus gallus *in MSs and one non-MS reporting isolate-based data, 2011

Country	Susceptible to all		Multi-resistant		Index of diversity
	n	%	n	%	
Austria (N=72)	10	13.9	21	29.2	0.282
Denmark (N=107)	55	51.4	3	2.8	0.142
Spain (N=36)	0	0	30	83.3	0.448
Switzerland (N=13)	1	7.7	3	23.1	0.234

N = total number of isolates tested for susceptibility against the whole common antimicrobial set for *E. faecium*.

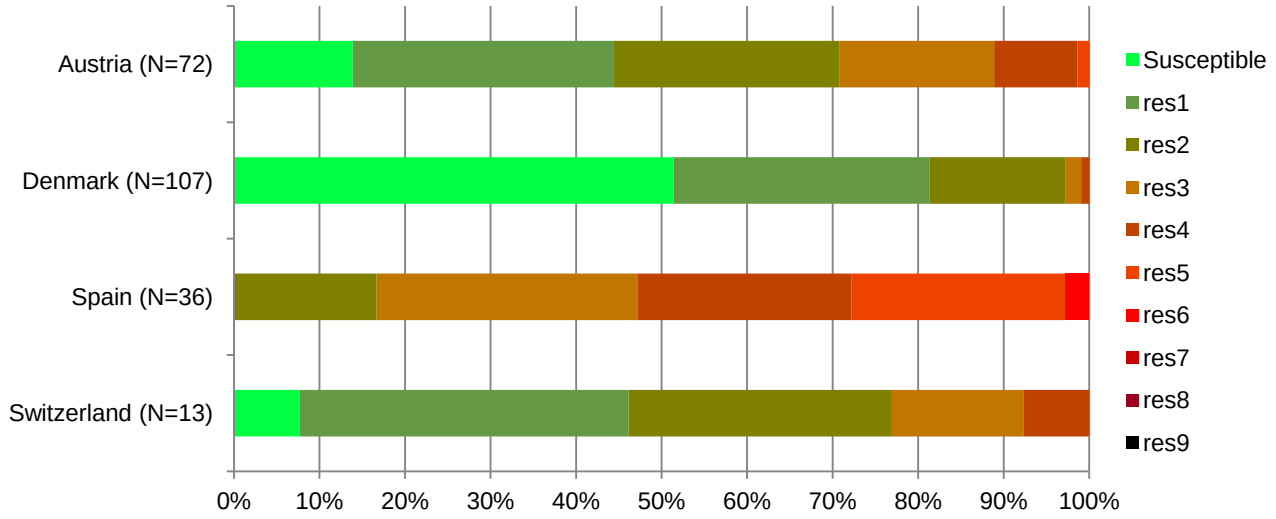
n = number of isolates per category of complete susceptibility or multiple resistance.

Susceptible to all = isolate susceptible to all antimicrobial substances of the EFSA common set for *E. faecium*.

Multi-resistant = resistant to at least three different antimicrobial substances, belonging to any three antimicrobial families from the common antimicrobial set for *E. faecium*.

Index of diversity = see definition in section 11.4.2.1 of Materials and Methods.

Figure EN14. Frequency distribution of* E. faecium *isolates completely susceptible and resistant to one to nine antimicrobials in broilers of* Gallus gallus *in MSs and one non-MS reporting isolate-based data, 2011



N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances for *E. faecium*.

Susceptible = susceptible to all antimicrobial substances of the common set for *E. faecium*.

res1/res9 = resistance to one antimicrobial substance/resistance to nine antimicrobial substances of the common set for *E. faecium*.

Multi-resistance among *E. faecalis* isolates from broilers of *Gallus gallus*

No tables and graphs on multidrug resistance are presented in this report since fewer than four MSs reported multi-resistance isolate-based data on more than 10 isolates of *E. faecalis* in broilers of *Gallus gallus*.

7.2.2.2. Pigs

The results for pigs were not split into production type as either all results related to **fattening pigs** or the production type was not specified. In the reporting MSs, antimicrobial resistance monitoring in indicator enterococci isolates from pigs was based on active monitoring plans based on random sampling of healthy slaughter pig carcasses at the slaughterhouse, with the exception of the Netherlands, for which the sampling strategy is unknown. The slaughterhouses included in the monitoring programme accounted for a major proportion, typically 80 % or more, of the total production in the country. The sampling plan was typically stratified by slaughterhouse (Denmark, Spain and Switzerland) by allocating the number of samples collected per slaughterhouse in proportion to the annual throughout of the slaughterhouse. An approximately equal distribution of the collected samples over the year enabled the different seasons to be covered. Only one representative faecal sample per epidemiological unit (batch), either derived from a unique carcass or pooled from a number of carcasses, was gathered to account for clustering.

Resistance levels in tested isolates

In 2011, seven MSs and one non-MS (Switzerland) provided quantitative data concerning enterococci from pigs. Sweden and Estonia provided data only for *E. faecium* and *E. faecalis,* respectively, while all other countries provided data for both species (Tables EN6 and EN7). Austria, Denmark, France, the Netherlands and Switzerland submitted data concerning *Enterococcus* isolates from pigs in both 2010 and 2011. Spain submitted data for *E. faecium* and *E. faecalis* in 2011, and Sweden also submitted data for *E. faecium* in 2011, whereas neither of these countries submitted data concerning enterococci in 2010. In contrast, Finland submitted data in 2010 for both species but not in 2011 and Estonia submitted data for *E. faecalis* in 2011, while this country reported data for *E. faecium* in 2010. As in previous years and other livestock species, in 2011 levels of resistance to most of the antimicrobials varied markedly between countries.

As in isolates from *Gallus gallus*, the highest resistance levels among *E. faecium* from pigs were recorded for quinupristin/dalfopristin. The overall reporting MS group level of resistance was 86.5 %, and all reporting countries had extremely high resistance levels, ranging between 72.4 % and 97.6 %.

At the reporting MS group level, there was a very high level of resistance to tetracyclines among *E. faecium* (63.6 %) and an extremely high level of resistance to this antimicrobial among *E. faecalis* (78.9 %). These resistance levels are slightly higher than those reported in 2010 (53 % for *E. faecium* and 71 % for *E. faecalis*). Regarding *E. faecium*, Sweden reported a moderate level of resistance (13.6 %) but all other countries reported high, very high or extremely high levels of resistance, ranging between 26.2 % and 85.4 %. All countries reported resistance levels between 50.0 % and 96.6 % for *E. faecalis*. Spain and the Netherlands reported the highest resistance levels for both species of *Enterococcus*. Most countries reported a relatively higher occurrence of resistance in *E. faecalis* than *E. faecium*, except France, which reported the opposite.

There was a high level of resistance to erythromycin at the reporting MS group level for both *E. faecium* and *E. faecalis* (34.8 % and 49.0 %, respectively). Resistance levels in the former ranged between 9.1 % (Sweden) and 75.6 % (Spain), with most countries reporting a high occurrence of resistance. Resistance levels in the latter ranged between 22.7 % (France) and 82.8 % (Spain), with three countries reporting a very or extremely high occurrence of resistance. The overall resistance level observed for *E. faecium* was comparable to that in 2010 (35 %) whereas that observed for *E. faecalis* was marginally higher than in 2010 (38 %). Just as for tetracyclines, most countries reported comparatively higher resistance among *E. faecalis* than in *E. faecium*, except for Austria and France.

Regarding streptomycin, the resistance levels in both *E. faecium* and *E. faecalis* were also high at the reporting MS group level (26.4 % and 32.6 %, respectively). Just under half of the countries reported low or moderate levels of resistance in *E. faecium*, ranging between 8.0 % and 13.6 %, while Spain reported the highest resistance level of 75.6 %. Concerning *E. faecalis*, Spain, again, reported an extremely high level of resistance (79.3 %), but all other countries reported comparatively lower resistance levels of between 18.2 % and 40.6 %. As for erythromycin, the overall resistance level for *E. faecium* was similar to that in 2010 (23 %) whereas the level of resistance in *E. faecalis* was higher than that in 2010 (21 %).

Overall, there was a moderate level of resistance to ampicillin among *E. faecium* (11.5 %), which is roughly comparable to, though slightly higher than, in 2010 (7 % resistance). Three countries reported no resistance

to this antimicrobial, with the remainder reporting levels between 2.3 % (France) and 23.4 % (the Netherlands). As in 2010, no isolates of *E. faecalis* expressed resistance to ampicillin.

In contrast, there was a very low level of resistance to chloramphenicol (1.0 %) at the reporting MS group level among *E. faecium* but a moderate level of resistance (17.0 %) among *E. faecalis.* Four countries reported no resistance in *E. faecium* while the other three countries reported low levels of 1.1 % to 4.9 %. All reporting countries reported resistance in *E. faecalis*, at levels between 4.5 % and 31.0 %.

Overall, there was very low resistance to gentamicin in *E. faecium* (0.6 %). Three MSs reported no resistance and three others reported resistance levels of 0.9 % to 2.4 %. All countries reported resistance in *E. faecalis*, resulting in a slightly higher overall resistance level of 12.3 %. The majority of MSs reported low resistance, although two reported high resistance levels of 21.4 % (Denmark) and 31.0 % (Spain).

Only two countries (Denmark and the Netherlands) reported resistance to vancomycin among *E. faecium*, resulting in a very low level of resistance at the reporting MS group level (0.4 %). All countries reported full sensitivity to vancomycin in *E. faecalis*. In comparison, 0.9 % of *E. faecium* isolates and 0 % of *E. faecalis* isolates were resistant to vancomycin in 2010.

No countries reported linezolid resistance in *E. faecalis*, and only France reported resistance among *E. faecium* (1.1 %), resulting in a very low overall resistance level of 0.2 %.

The higher resistance levels observed in *E. faecalis* for erythromycin, streptomycin and tetracyclines are likely to be, at least partly, attributable to the fact that Sweden reported relatively low levels of resistance to these antimicrobials in *E. faecium* but did not report any data for *E. faecalis*.

Table EN6. Resistance (%) to ampicillin, chloramphenicol, erythromycin, gentamicin, linezolid, quinupristin/dalfopristin, streptomycin, tetracyclines and vancomycin among* Enterococcus faecium *from pigs in countries reporting MIC data in 2011

Country	Ampicillin		Chloramphenicol		Erythromycin		Gentamicin		Linezolid	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	61	0	61	4.9	61	49.2	61	0	61	0
Denmark	116	10.3	116	0	116	32.8	116	0.9	116	0
France	87	2.3	87	1.1	87	28.7	87	1.1	87	1.1
Netherlands	184	23.4	184	0	184	28.3	184	0	184	0
Spain	41	4.9	41	2.4	41	75.6	41	2.4	41	0
Sweden	22	0	22	0	22	9.1	22	0	22	0
Total (6 MSs)	**511**	**11.5**	**511**	**1.0**	**511**	**34.8**	**511**	**0.6**	**511**	**0.2**
Switzerland	25	0	25	0	25	20.0	-	-	25	0

Country	Quinupristin/dalfopristin		Streptomycin		Tetracyclines		Vancomycin	
	N	% Res	N	% Res	N	% Res	N	% Res
Austria	61	95.1	61	11.5	61	26.2	61	0
Denmark	116	80.2	116	40.5	116	62.1	116	0.9
France	87	72.4	87	25.3	87	65.5	87	0
Netherlands	184	91.8	184	13.6	184	77.2	184	0.5
Spain	41	97.6	41	75.6	41	85.4	41	0
Sweden	-	-	22	13.6	22	13.6	22	0
Total (6 MSs)	**489**	**86.5**	**511**	**26.4**	**511**	**63.6**	**511**	**0.4**
Switzerland	25	80.0	25	8.0	25	40.0	25	0

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

Table EN7. Resistance (%) to ampicillin, chloramphenicol, erythromycin, gentamicin, linezolid, streptomycin, tetracyclines and vancomycin among* Enterococcus faecalis *from pigs in countries reporting MIC data in 2011

Country	Ampicillin		Chloramphenicol		Erythromycin		Gentamicin		Linezolid	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	112	0	112	13.4	112	39.3	112	2.7	112	0
Denmark	117	0	117	23.1	117	53.8	117	21.4	117	0
Estonia	11	0	11	9.1	11	27.3	11	9.1	11	0
France	22	0	22	4.5	22	22.7	22	9.1	22	0
Netherlands	74	0	74	12.2	74	54.1	74	6.8	74	0
Spain	29	0	29	31.0	29	82.8	29	31.0	29	0
Total (6 MSs)	**365**	**0**	**365**	**17.0**	**365**	**49.0**	**365**	**12.3**	**365**	**0**
Switzerland	64	0	64	6.3	64	32.8	-	-	64	0

Country	Streptomycin		Tetracyclines		Vancomycin	
	N	% Res	N	% Res	N	% Res
Austria	112	25.9	112	68.8	112	0
Denmark	117	36.8	117	86.3	117	0
Estonia	11	18.2	11	63.6	11	0
France	22	22.7	22	50.0	22	0
Netherlands	74	23.0	74	86.5	74	0
Spain	29	79.3	29	96.6	29	0
Total (6 MSs)	**365**	**32.6**	**365**	**78.9**	**365**	**0**
Switzerland	64	40.6	64	56.3	64	0

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

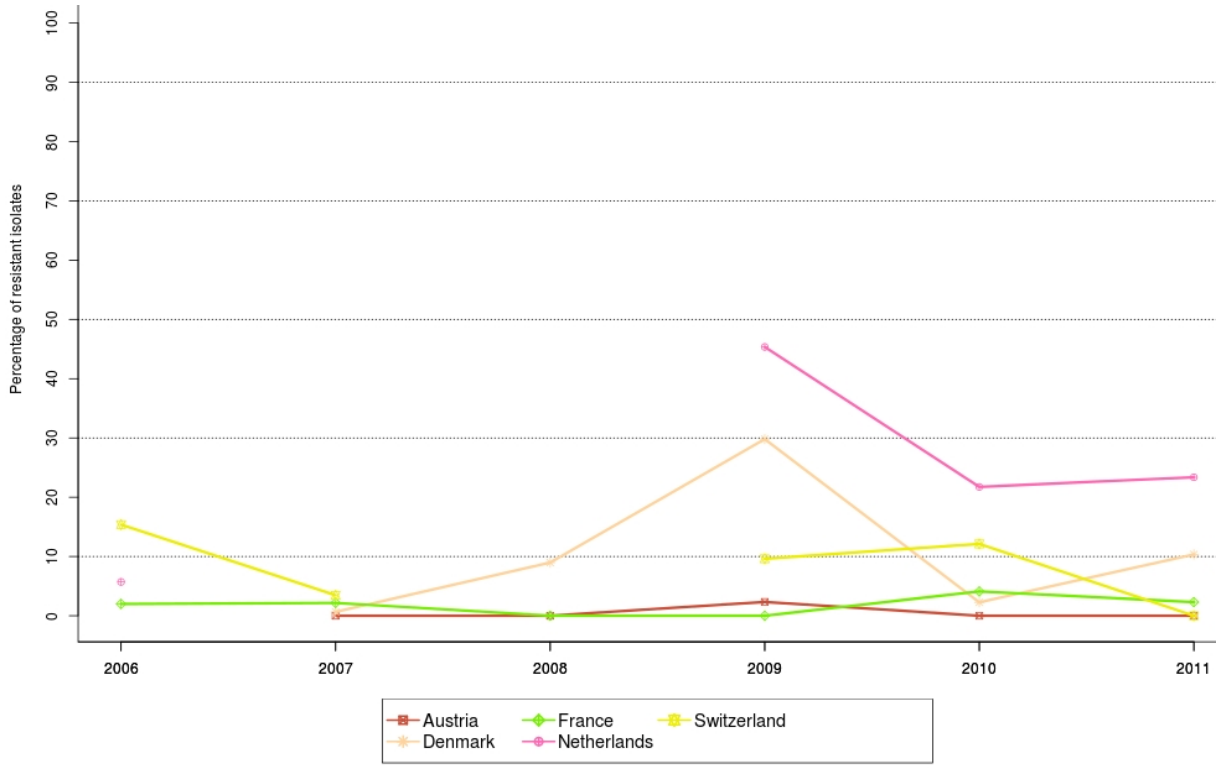
Temporal trends in resistance among indicator enterococci

Figures EN15–EN24 show the trends in resistance to ampicillin, erythromycin, streptomycin, tetracyclines and vancomyin in *E. faecium* and *E. faecalis* from pigs between 2006 and 2011. Similarly to the isolates from *Gallus gallus*, there was substantial variation between countries in the reported levels of resistance to several of the antimicrobials, particularly to tetracyclines in *E. faecium* (Figure EN18). France, the Netherlands and/or Spain often reported relatively high resistance levels whereas Austria and/or Switzerland tended to report comparatively low resistance levels for many antimicrobials. Whereas Denmark often reported the lowest resistance levels among isolates from *Gallus gallus*, this country reported relatively high resistance levels among isolates from pigs (e.g. Figure EN23). No resistance to ampicillin in *E. faecalis* has been recorded since 2006 (Figure EN20). Resistance to vancomycin among both *E. faecium* (Figure EN19) and *E. faecalis* (Figure EN24) has also been low in all countries since 2006.

One of the most obvious trends visible from the graphs is the sharp decline in resistance to streptomycin among *E. faecium* in the Netherlands (Figure EN17). As only four data points are available, this finding was not tested for statistical significance, but several other significant trends were identified in this country as well as others. Both France and the Netherlands have shown statistically significant declines in resistance to three antimicrobials. Both countries have shown significant declines in resistance to erythromycin and tetracyclines in *E. faecium*. The third decline for both countries involved streptomycin, but in France the decline was among *E. faecium*, whilst in the Netherlands the decline was recorded in *E. faecalis*. The only other statistically significant trends that were detected related to an increase in resistance to tetracyclines among *E. faecium* in Switzerland, and a decline in resistance to erythromycin in *E. faecium* from Denmark. No statistically significant trends in resistance to ampicillin or vancomycin were recorded in either species of *Enterococcus*, or to erythromycin or tetracyclines in *E. faecalis*.

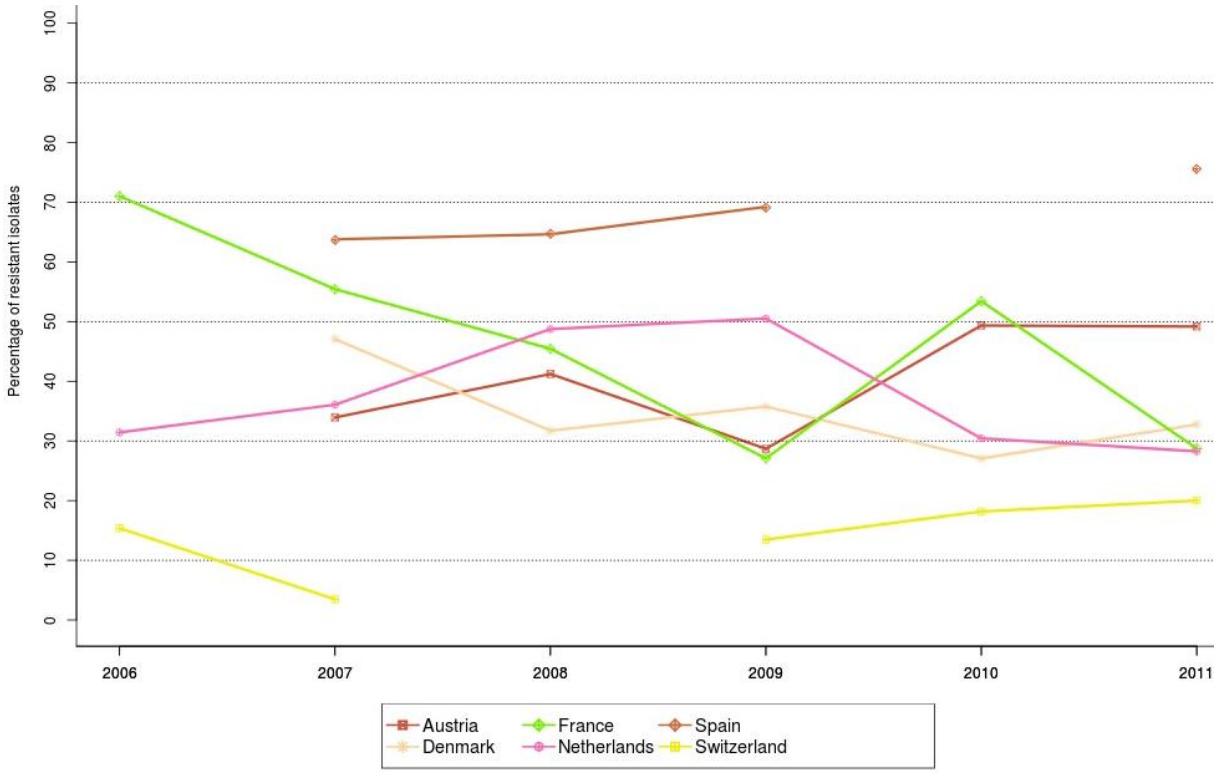
Compared with 2010, the resistance levels of individual countries were usually broadly comparable or higher. One exception was France, which reported lower resistance levels in 2011 than in 2010 in *E. faecium* to erythromycin (28.7 % vs. 53 %), streptomycin (25.3 % vs. 37 %) and tetracyclines (65.5 % vs. 77 %), while this was not observed among *E. faecalis* isolates, in which resistance levels were higher than in the previous year (erythromycin: 22.7 % vs. 6 %; streptomycin: 22.7 % vs. 6 %; tetracyclines: 50.0 % vs. 31 %). These data were not plotted in the trend graphs as France reported resistance data in *E. faecalis* for fewer than four years. These inter-annual evolutions need to be confirmed by longer-term trends.

Figure EN15. Trends in ampicillin resistance in* Enterococcus faecium *from pigs in reporting MSs and one non-MS, 2006–2011, quantitative data



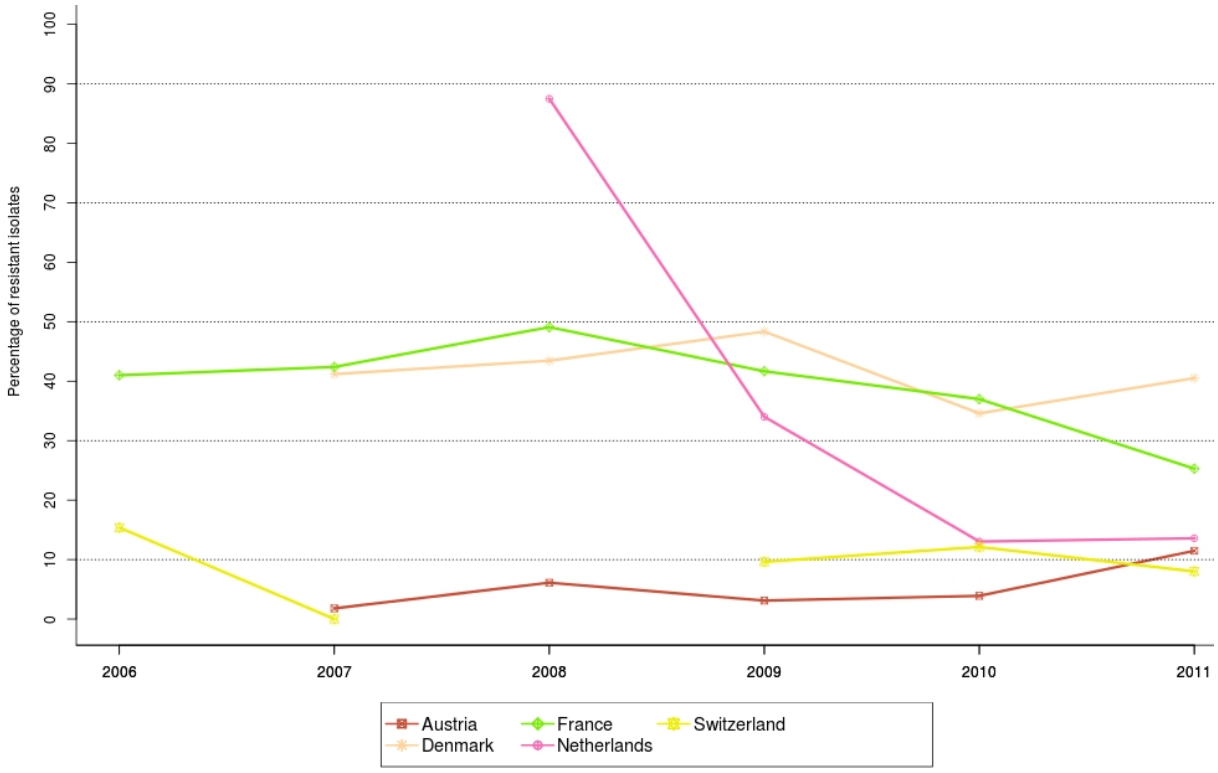
Note: No significant increasing or decreasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

Figure EN16. Trends in erythromycin resistance in* Enterococcus faecium *from pigs in reporting MSs and one non-MS, 2006–2011, quantitative data



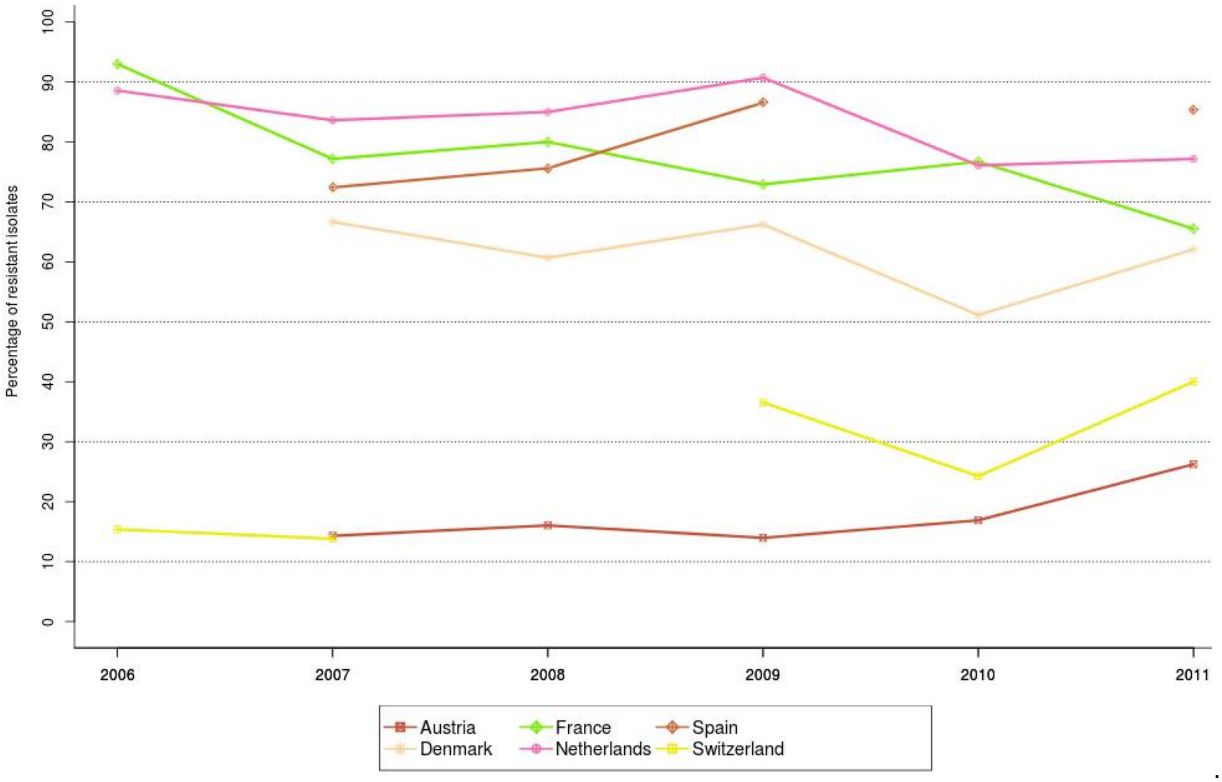
Note: A statistically significant decreasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Denmark (↓), France (↓) and the Netherlands (↓).

Figure EN17. Trends in streptomycin resistance in* Enterococcus faecium *from pigs in reporting MSs and one non-MS, 2006–2011, quantitative data



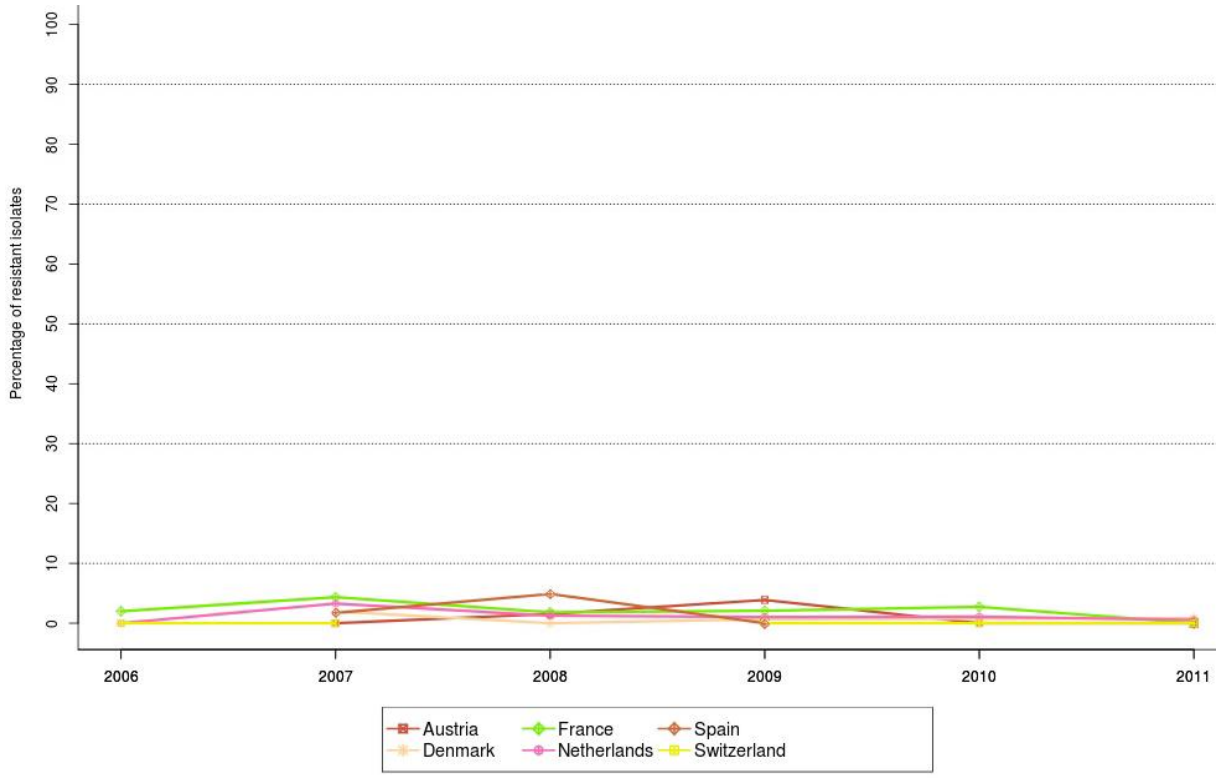
Note: A statistically significant decreasing trend over six years, as tested by a logistic regression model ($p \leq 0.05$), was observed in France (↓).

Figure EN18. Trends in tetracycline resistance in* Enterococcus faecium *from pigs in reporting MSs and one non-MS, 2006–2011, quantitative data



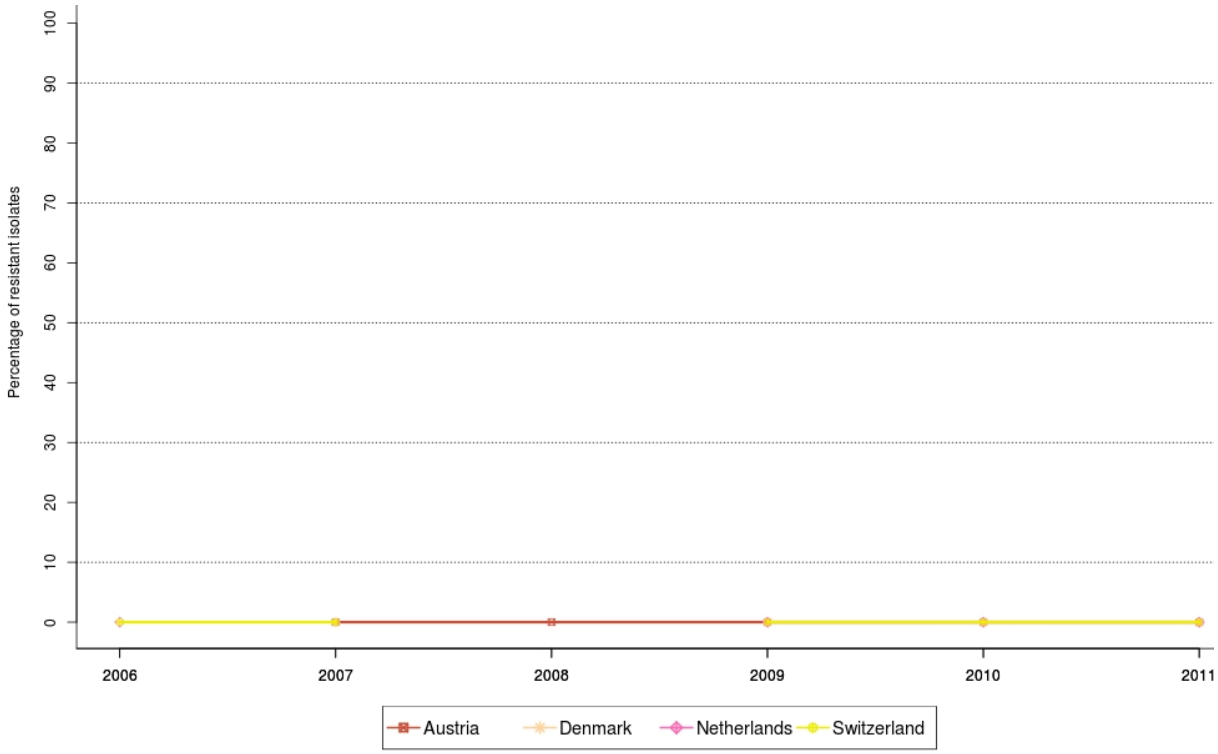
Note: A statistically significant increasing or decreasing trend, over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in France (↓), the Netherlands (↓) and Switzerland (↑).

Figure EN19. Trends in vancomycin resistance in* Enterococcus faecium *from pigs in reporting MSs and one non-MS, 2006–2011, quantitative data



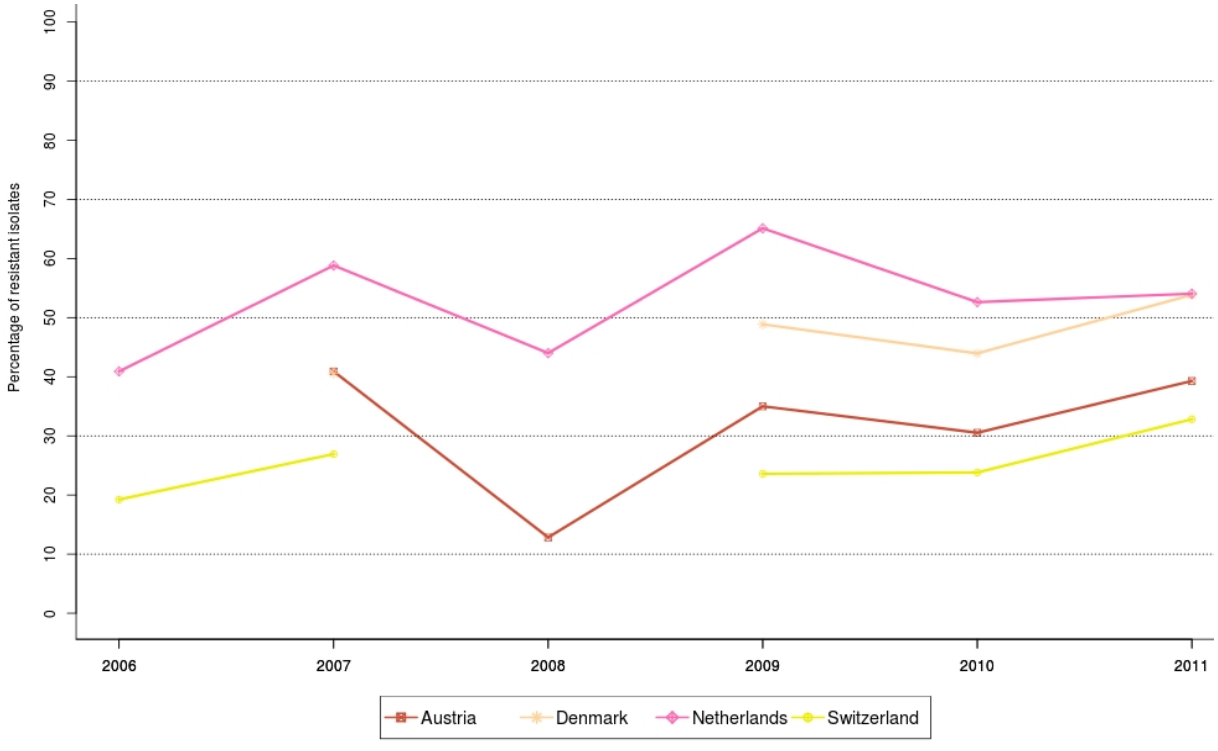
Note: No significant increasing or decreasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

Figure EN20. Trends in ampicillin resistance in* Enterococcus faecalis *from pigs in reporting MSs and one non-MS, 2006–2011, quantitative data



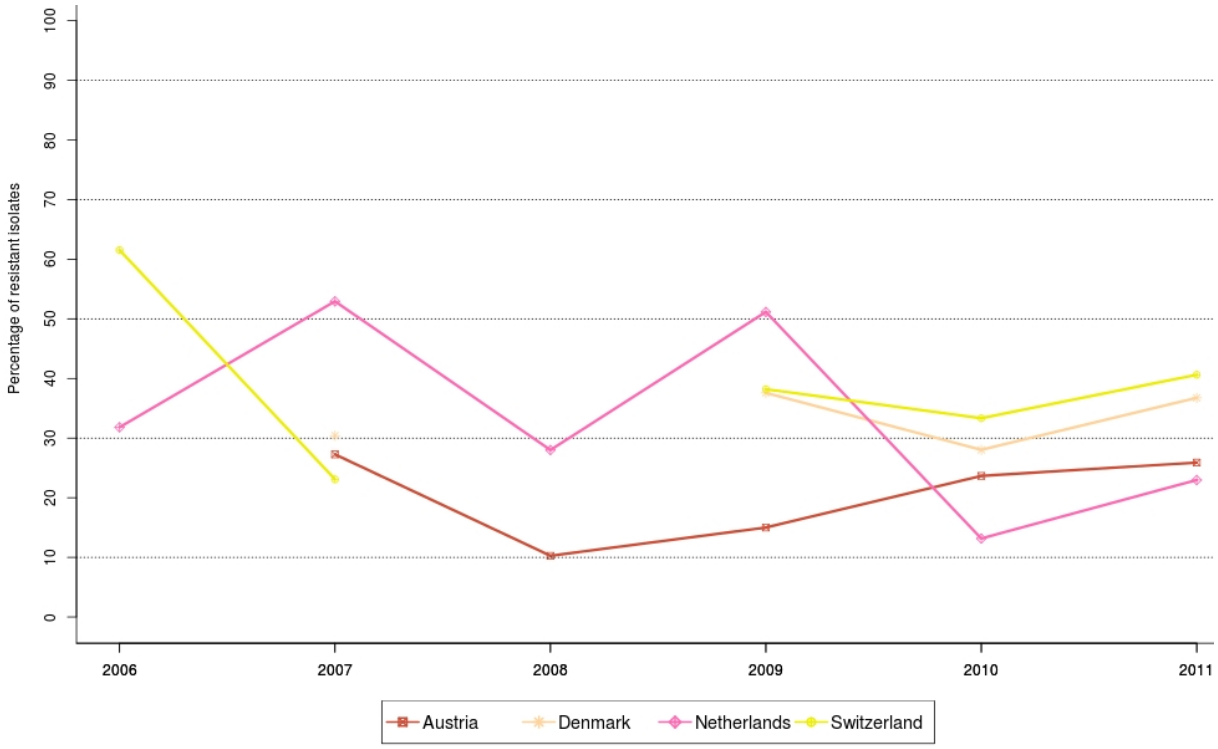
Note: No significant increasing or decreasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

Figure EN21. Trends in erythromycin resistance in* Enterococcus faecalis *from pigs in reporting MSs and one non-MS, 2006–2011, quantitative data



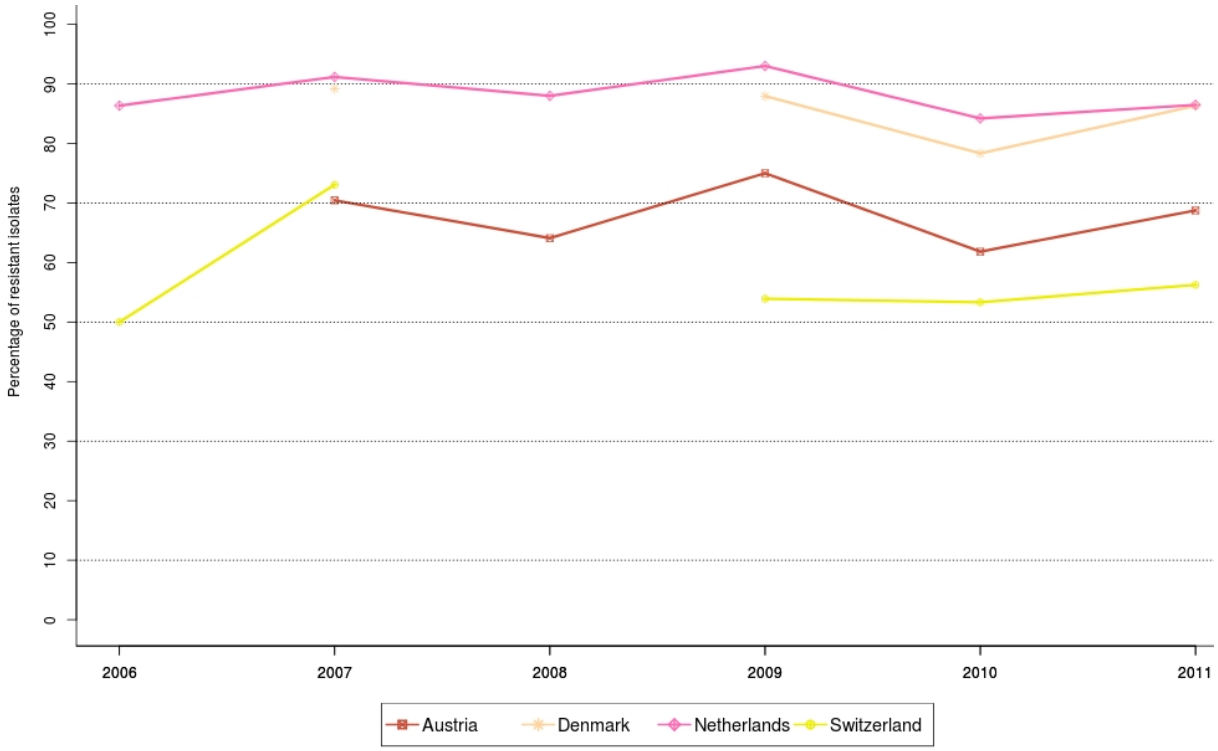
Note: No significant increasing or decreasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

Figure EN22. Trends in streptomycin resistance in* Enterococcus faecalis *from pigs in reporting MSs and one non-MS, 2006–2011, quantitative data



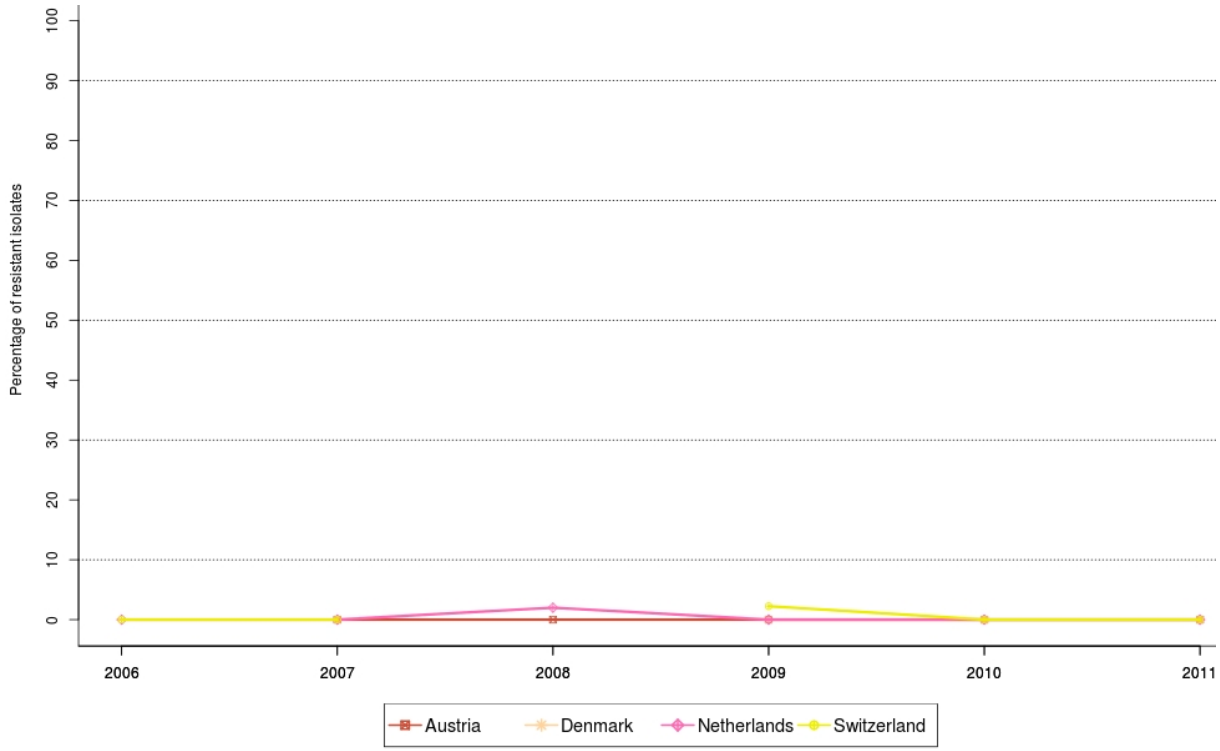
Note: A statistically significant decreasing trend over six years, as tested by a logistic regression model ($p \leq 0.05$), was observed in the Netherlands (↓).

Figure EN23. Trends in tetracycline resistance in* Enterococcus faecalis *from pigs in reporting MSs and one non-MS, 2006–2011, quantitative data



Note: No significant increasing or decreasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

Figure EN24. Trends in vancomycin resistance in* Enterococcus faecalis *from pigs in reporting MSs and one non-MS, 2006–2011, quantitative data

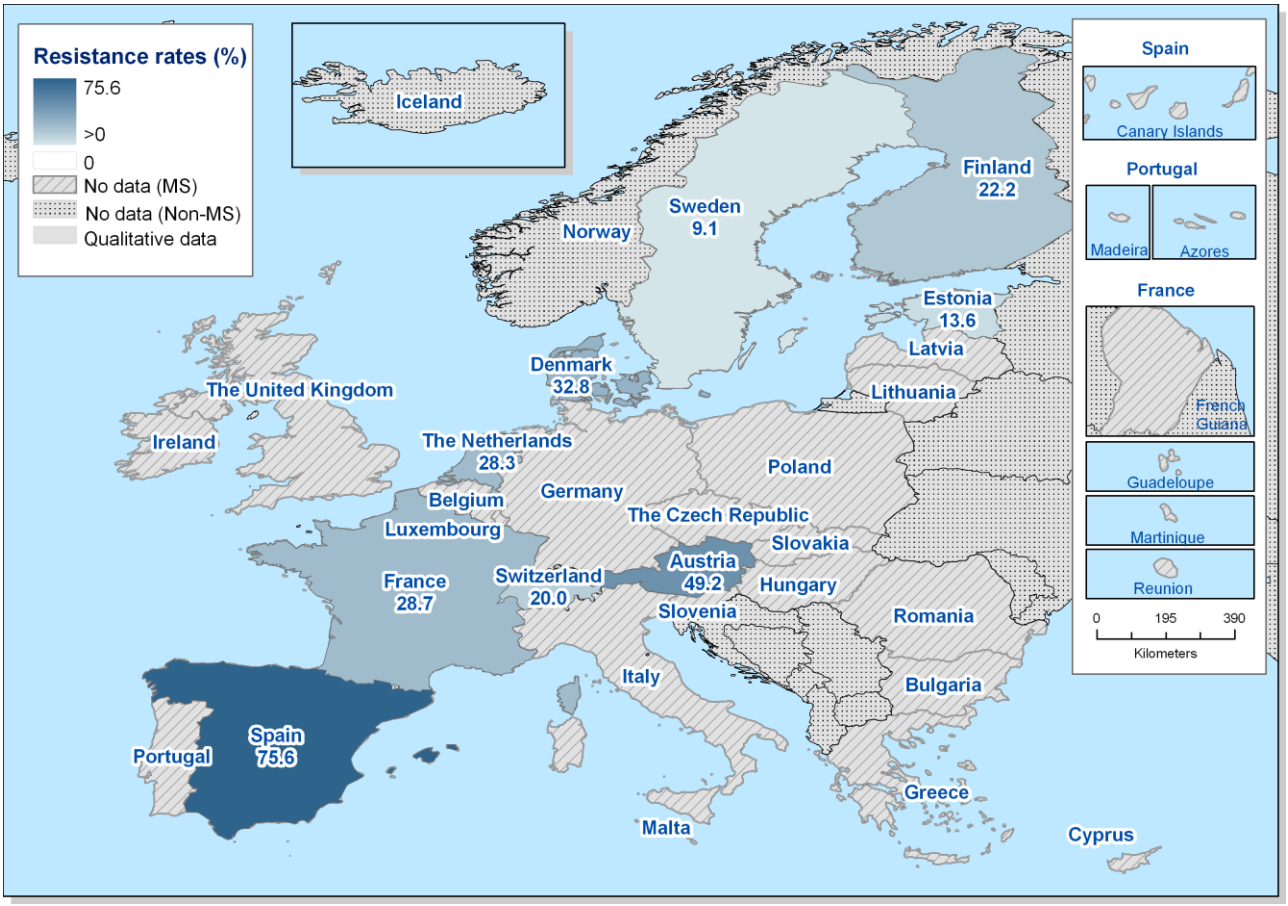


Note: No significant increasing or decreasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

Spatial distribution of resistance among *Enterococcus faecium*

The spatial distributions of erythromycin, tetracycline and vancomycin resistance among *E. faecium* from pigs are presented in Figures EN25–EN27. The spatial patterns were less clear than for isolates from *Gallus gallus*. The most western countries still tended to report the highest resistance levels for tetracyclines. Sweden reported the lowest resistance to tetracyclines and erythromycin while Spain reported the highest resistance level for both. Denmark and the Netherlands reported very low resistance to vancomycin while all other countries reported full sensitivity.

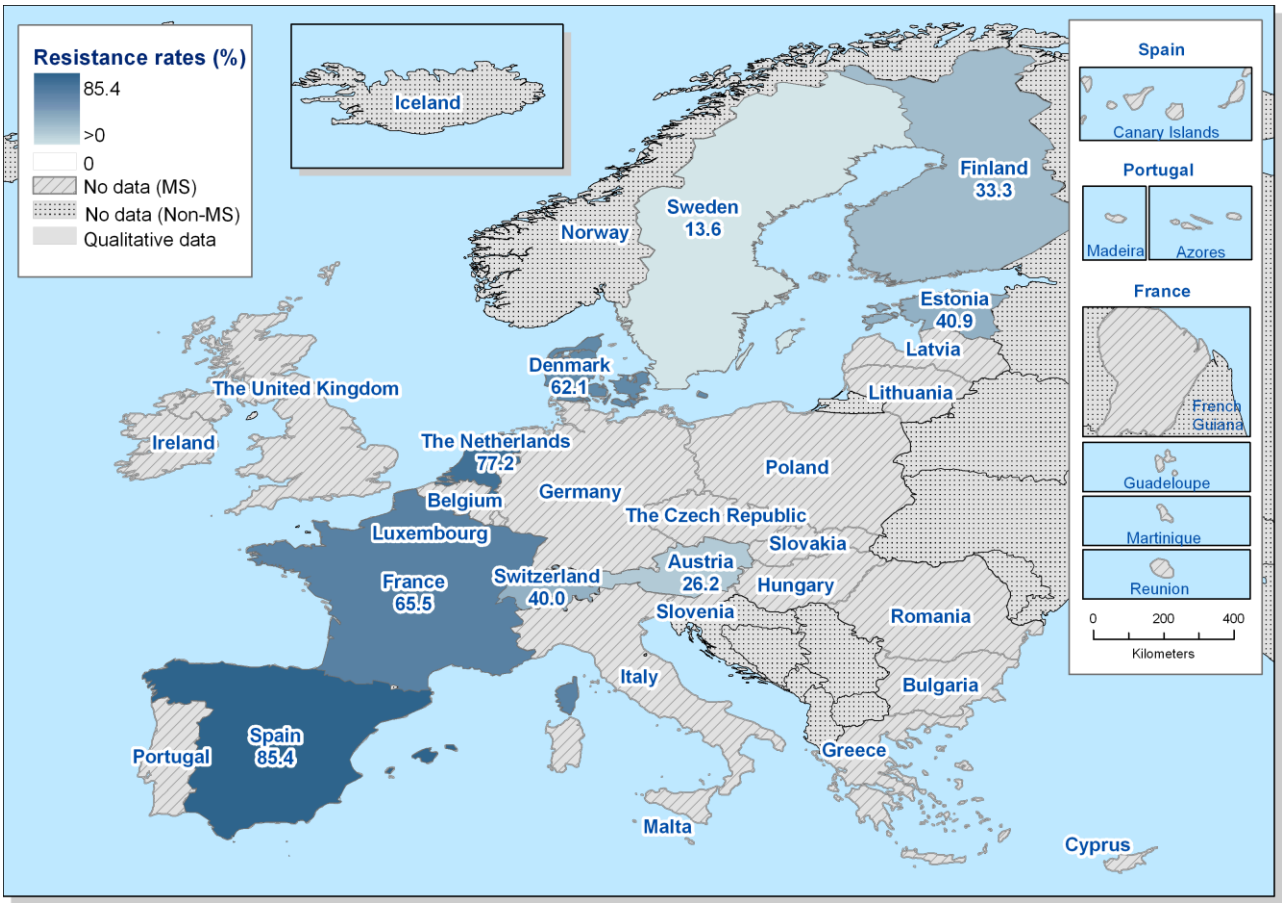
Figure EN25. Spatial distribution of erythromycin resistance among* Enterococcus faecium *from pigs in countries reporting quantitative data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data were used instead.

1. For Estonia and Finland, 2010 data were used.

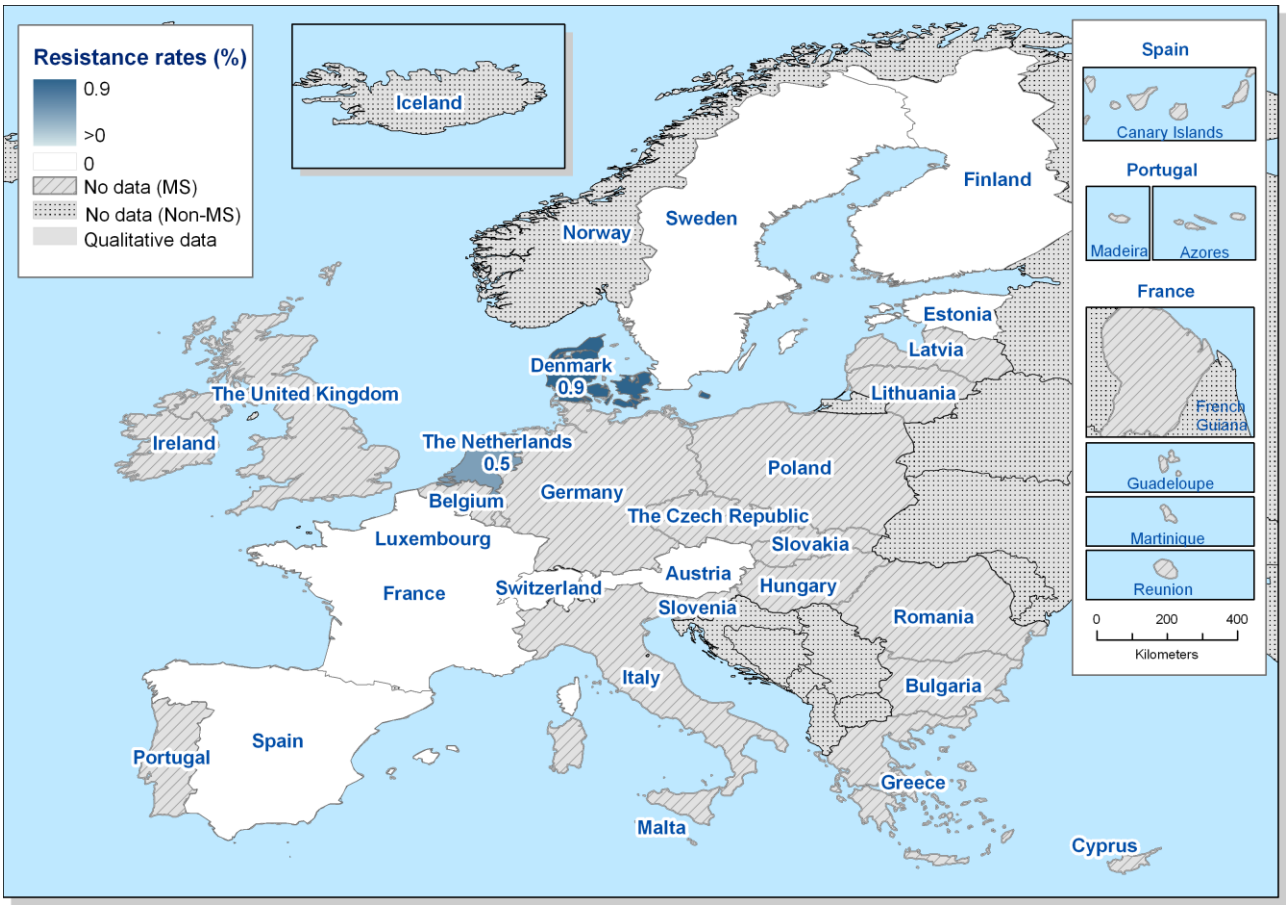
Figure EN26. Spatial distribution of tetracycline resistance among* Enterococcus faecium *from pigs in countries reporting quantitative data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data were used instead.

1. For Estonia and Finland, 2010 data were used.

Figure EN27. Spatial distribution of vancomycin resistance among* Enterococcus faecium *from pigs in countries reporting quantitative data in 2011[1]



Note: Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, 2010 data were used instead.

1. For Estonia and Finland, 2010 data were used.

Multi-resistance among *E. faecium* isolates from pigs

In 2011, three MSs and one non-MS reported isolate-based data regarding resistance in indicator *E. faecium* from pigs. Among the reporting countries, important variations were observed in the percentages of completely susceptible isolates. Although all reporting countries recorded multi-resistant isolates (isolates exhibiting reduced susceptibility according to ECOFFs to at least three different antimicrobial classes), their proportions differed substantially between countries, from 14.8 % in Austria up to 44.8 % in Denmark and 82.9 % in Spain (Table EN8). The frequency distributions (Figure EN28) showed that isolates resistant to as many as five antimicrobials were reported from all reporting MSs.

Table EN8. Complete susceptibility, multi-resistance and index of diversity in* E. faecium *from pigs in MSs and one non-MS reporting isolate-based data, 2011

Country	Susceptible to all		Multi-resistant		Index of diversity
	n	%	n	%	
Austria (N=61)	1	1.6	9	14.8	0.241
Denmark (N=116)	19	16.4	52	44.8	0.347
Spain (N=41)	1	2.4	34	82.9	0.286
Switzerland (N=25)	5	20.0	6	24.0	0.227

N = total number of isolates tested for susceptibility against the whole common antimicrobial set for *E. faecium*.

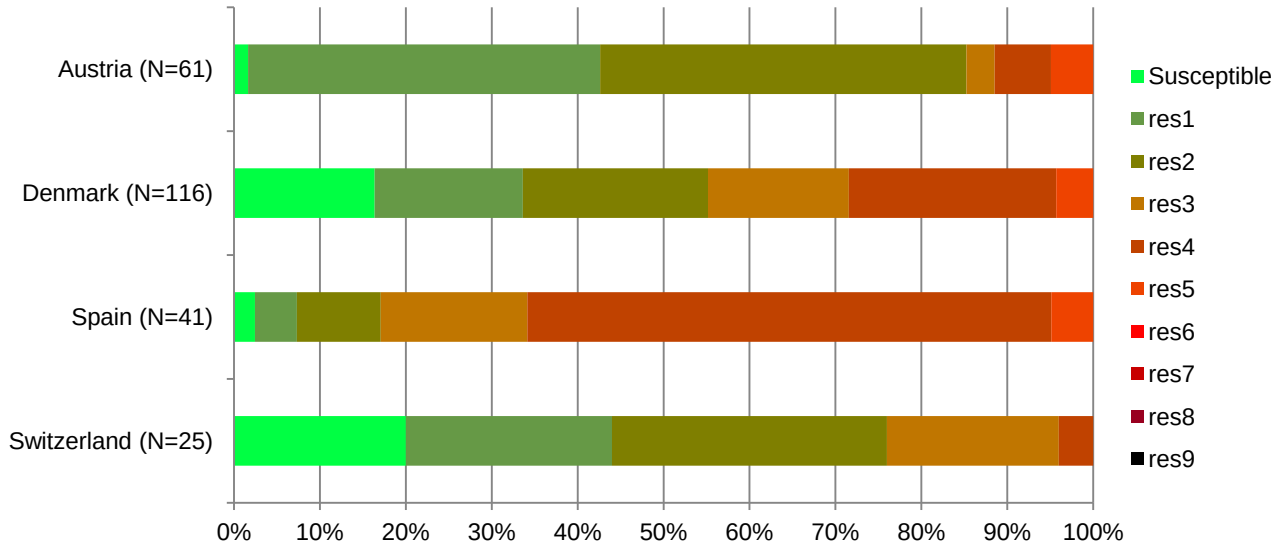
n = number of isolates per category of complete susceptibility or multiple resistance.

Susceptible to all = isolate susceptible to all antimicrobial substances of the EFSA common set for *E. faecium*.

Multi-resistant = resistant to at least three different antimicrobial substances, belonging to any three antimicrobial families from the common antimicrobial set for *E. faecium*.

Index of diversity = see definition in section 11.4.2.1 of Materials and Methods.

Figure EN28. Frequency distribution of* E. faecium *isolates completely susceptible and resistant to one to nine antimicrobials in pigs in MSs and one non-MS reporting isolate-based data, 2011



N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances for *E. faecium*.

Susceptible = susceptible to all antimicrobial substances of the common set for *E. faecium*.

res1/res9 = resistance to one antimicrobial substance/resistance to nine antimicrobial substances of the common set for *E. faecium*.

Multi-resistance among *E. faecalis* isolates from pigs

No tables and graphs on multidrug resistance are presented in this report since fewer than four MSs reported multi-resistance isolate-based data on more than 10 isolates of *E. faecalis* in pigs.

7.2.2.3. Cattle (bovine animals)

In 2011, four MSs provided quantitative data concerning *E. faecium* from cattle, and three MSs and one non-MS provided quantitative data concerning *E. faecalis* from cattle. These countries tested different production types and ages of cattle, including veal calves (aged under one year), young meat production animals, and adult or dairy cattle. The antimicrobial resistance data for cattle have been presented by production type. The overall results for cattle presented in Tables EN9 and EN10 include all isolates of enterococci that were collected from this animal species by MSs which tested more than 10 isolates from cattle in total. Results are also presented for the specific production levels of cattle from which these enterococci isolates originated. Some MSs tested fewer than 10 isolates from individual production types. In such cases, the data for these production types are included in the overall results for cattle but are not presented in the production level-specific sections of these tables.

Enterococci sampling was carried out in Spain and Switzerland according to their national monitoring programmes. Sample collection was conducted at slaughterhouses, stratified by slaughterhouse capacity and spread evenly throughout the year. In Austria, sampling was carried out according to a federal monitoring programme. Details of the Belgian and Dutch sampling strategy are unknown.

Austria and the Netherlands submitted data for *E. faecium* in both 2010 and 2011. Belgium and Spain only submitted data in 2011, whereas Estonia and Switzerland submitted data for this species in 2010 but not in 2011. With respect to *E. faecalis*, Belgium also only submitted data in 2011 but otherwise the same countries submitted data in both 2010 and 2011.

Resistance levels in tested isolates

For *E. faecium*, both Austria and the Netherlands reported data for two different age groups of cattle. In the Netherlands, there was much higher resistance among younger cattle, whereas there was no such difference apparent in Austria, with all young meat production animals from that country testing fully sensitive (except for quinupristin/dalfopristin). For *E. faecalis,* three of the four reporting countries provided data on two different age categories. As for *E. faecium*, the Netherlands reported much higher resistance among younger cattle whereas in Austria and Switzerland there was less contrast between age groups.

As in both *Gallus gallus* and pigs, the highest resistance levels among *E. faecium* were recorded for quinupristin/dalfopristin. Combining all types of cattle, there was a very high occurrence of resistance (64.1 %) at the reporting MS group level. Resistance was at a high, very high or extremely high level in all reporting countries.

The overall proportion of isolates from cattle that tested resistant to tetracyclines was 34.2 % for *E. faecium* and 35.6 % for *E. faecalis*. For *E. faecium*, resistance levels ranged between 0 % and 72.0 %, while for *E. faecalis* resistance ranged between 17.9 % and 78.9 %. Austria and Belgium reported relatively higher levels of resistance among *E. faecalis* than in *E. faecium*, which was also the case for isolates from adult cattle in the Netherlands, but not for young cattle.

There was also a moderate to high level of resistance to erythromycin and streptomycin: overall at the reporting MS group level, 30.5 % of *E. faecium* and 22.9 % of *E. faecalis* isolates from cattle were resistant to the former, and 21.3 % of *E. faecium* and 18.6 % of *E. faecalis* isolates were resistant to the latter. As for tetracyclines, resistance levels varied markedly between countries and production types. Resistance to erythromycin tended to be slightly higher than resistance to streptomycin, except in Switzerland, where the opposite was true. Countries tended to report broadly similar resistance levels for both *E. faecium* and *E. faecalis* from the same production type of cattle. The Netherlands reported much higher resistance to both antimicrobials among *Enterococcus* obtained from younger cattle than from adult cattle, whereas in Austria and Switzerland, the resistance levels in young and adult animals were roughly comparable.

Regarding *E. faecium*, the Netherlands and Belgium reported a moderate level of resistance to ampicillin among isolates from veal calves and young meat production animals, respectively, and Spain reported a low level of resistance (4.0 %) to this antimicrobial among isolates from young meat production animals; in contrast, Austria reported full sensitivity among both young meat production animals and adult cattle, and the Netherlands also reported no resistance among dairy cattle. Belgium reported 8.3 % resistance to this

antimicrobial in *E. faecalis* from young meat production animals but no other *E. faecalis* isolates were resistant to ampicillin, regardless of production type.

At the reporting MS group level, there was a low level of resistance to chloramphenicol in both *E. faecium* (4.2 %) and *E. faecalis* (9.9 %). Regarding *E. faecium,* Belgium reported moderate resistance in young meat production animals, and the Netherlands and Spain reported low resistance levels in veal calves and young meat production animals, respectively, whereas Austria reported no resistance in any age groups. Resistance levels were slightly higher in *E. faecalis*, particularly from the younger age groups of cattle, although there was still no resistance detected in adult cattle among MSs.

Regarding gentamicin, there was a low overall level of resistance in isolates of both *E. faecium* (2.2 %) and *E. faecalis* (2.4 %) from cattle. Concerning *E. faecium*, resistance was reported only by the Netherlands for veal calves under one year of age (4.8 %) and by Spain for young meat production animals aged 1-2 years (4.0 %). For *E. faecalis*, Austria, Belgium and the Netherlands reported low levels of resistance in adult cattle (3.2 %), young meat production animals (4.2 %) and veal calves (3.3 %), respectively.

There was a low level of linezolid resistance in *E. faecium* from cattle (1.4 %). The Netherlands and Spain reported low resistance among veal calves (2.1 %) and young meat production animals (8.0 %), but Austria and Belgium found no resistance in any age group. Regarding *E. faecalis,* there was a very low overall level of resistance in cattle (0.4 %). The Netherlands was the only country to detect any resistance, at a low level of 1.7 % in veal calves.

The Netherlands also reported a low level of resistance to vancomycin (1.7 %) among *E. faecalis* isolates from veal calves, but all other countries reported full sensitivity to this antimicrobial in both *E. faecium* and *E. faecalis.*

Table EN9. Resistance (%) to ampicillin, chloramphenicol, erythromycin, gentamicin, linezolid, quinupristin/dalfopristin, streptomycin, tetracyclines and vancomycin among* Enterococcus faecium *from cattle in countries reporting MIC data in 2011

Country	Ampicillin		Chloramphenicol		Erythromycin		Gentamicin		Linezolid	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Veal calves (under one year)										
Netherlands	145	12.4	145	6.2	145	46.9	145	4.8	145	2.1
Young meat production animals (under one year)										
Belgium	29	13.8	29	17.2	29	58.6	29	0	29	0
Young meat production animals (1-2 years)										
Austria	11	0	11	0	11	0	11	0	11	0
Spain	25	4.0	25	4.0	25	40.0	25	4.0	25	8.0
Total (2 MSs)	**36**	**2.8**	**36**	**2.8**	**36**	**27.8**	**36**	**2.8**	**36**	**5.6**
Adult cattle (over 2 years)										
Austria	36	0	36	0	36	5.6	36	0	36	0
Dairy cows										
Netherlands	108	0	108	0	108	9.3	108	0	108	0
All types of cattle										
Austria	47	0	47	0	47	4.3	47	0	47	0
Belgium	32	12.5	32	15.6	32	59.4	32	0	32	0
Netherlands	253	7.1	253	3.6	253	30.8	253	2.8	253	1.2
Spain	25	4.0	25	4.0	25	40.0	25	4.0	25	8.0
Total (4 MSs)	**357**	**6.4**	**357**	**4.2**	**357**	**30.5**	**357**	**2.2**	**357**	**1.4**

Table continued overleaf.

N = number of isolates tested.

% Res = percentage of resistant isolates.

Table EN9 (continued). Resistance (%) to ampicillin, chloramphenicol, erythromycin, gentamicin, linezolid, quinupristin/dalfopristin, streptomycin, tetracyclines and vancomycin among* Enterococcus faecium *from cattle in countries reporting MIC data in 2011

Country	Quinupristin/dalfopristin		Streptomycin		Tetracyclines		Vancomycin	
	N	% Res	N	% Res	N	% Res	N	% Res
Veal calves (under one year)								
Netherlands	145	65.5	145	35.2	145	55.2	145	0
Young meat production animals (under one year)								
Belgium	29	96.6	29	44.8	29	65.5	29	0
Young meat production animals (1-2 years)								
Austria	11	36.4	11	0	11	0	11	0
Spain	25	92.0	25	28.0	25	72.0	25	0
Total (2 MSs)	**36**	**75.0**	**36**	**19.4**	**36**	**50.0**	**36**	**0**
Adult cattle (over 2 years)								
Austria	36	36.1	36	2.8	36	2.8	36	0
Dairy cows								
Netherlands	108	58.3	108	1.9	108	1.9	108	0
All types of cattle								
Austria	47	36.2	47	2.1	47	2.1	47	0
Belgium	32	96.9	32	46.9	32	65.6	32	0
Netherlands	253	62.5	253	20.9	253	32.4	253	0
Spain	25	92.0	25	28.0	25	72.0	25	0
Total (4 MSs)	**357**	**64.1**	**357**	**21.3**	**357**	**34.2**	**357**	**0**

N = number of isolates tested.

% Res = percentage of resistant isolates.

Table EN10. Resistance (%) to ampicillin, chloramphenicol, erythromycin, gentamicin, linezolid, streptomycin, tetracyclines and vancomycin among* Enterococcus faecalis *from cattle in countries reporting MIC data in 2011

Country	Ampicillin		Chloramphenicol		Erythromycin		Gentamicin	
	N	% Res	N	% Res	N	% Res	N	% Res
Veal calves (under one year)								
Netherlands	60	0	60	31.7	60	43.3	60	3.3
Young meat production animals (under one year)								
Belgium	24	8.3	24	8.3	24	62.5	24	4.2
Young meat production animals (1-2 years)								
Austria	28	0	28	3.6	28	7.1	28	0
Switzerland	37	0	37	27.0	37	35.1	-	-
Adult cattle (over 2 years)								
Austria	95	0	95	0	95	7.4	95	3.2
Dairy cows								
Netherlands	36	0	36	0	36	8.3	36	0
Switzerland	19	0	19	5.3	19	26.3	-	-
All types of cattle								
Austria	129	0	129	1.6	129	7.8	129	2.3
Belgium	28	7.1	28	14.3	28	67.9	28	3.6
Netherlands	96	0	96	19.8	96	30.2	96	2.1
Total (3 MSs)	**253**	**0.8**	**253**	**9.9**	**253**	**22.9**	**253**	**2.4**
Switzerland	56	0	56	19.6	56	32.1	-	-

Country	Linezolid		Streptomycin		Tetracyclines		Vancomycin	
	N	% Res	N	% Res	N	% Res	N	% Res
Veal calves (under one year)								
Netherlands	60	1.7	60	35.0	60	56.7	60	1.7
Young meat production animals (under one year)								
Belgium	24	0	24	62.5	24	75.0	24	0
Young meat production animals (1-2 years)								
Austria	28	0	28	0	28	32.1	28	0
Switzerland	37	0	37	45.9	37	70.3	37	0
Adult cattle (over 2 years)								
Austria	95	0	95	6.3	95	17.9	95	0
Dairy cows								
Netherlands	36	0	36	0	36	19.4	36	0
Switzerland	19	0	19	42.1	19	78.9	19	0
All types of cattle								
Austria	129	0	129	5.4	129	21.7	129	0
Belgium	28	0	28	67.9	28	75.0	28	0
Netherlands	96	1.0	96	21.9	96	42.7	96	1.0
Total (3 MSs)	**253**	**0.4**	**253**	**18.6**	**253**	**35.6**	**253**	**0.4**
Switzerland	56	0	56	44.6	56	73.2	56	0

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

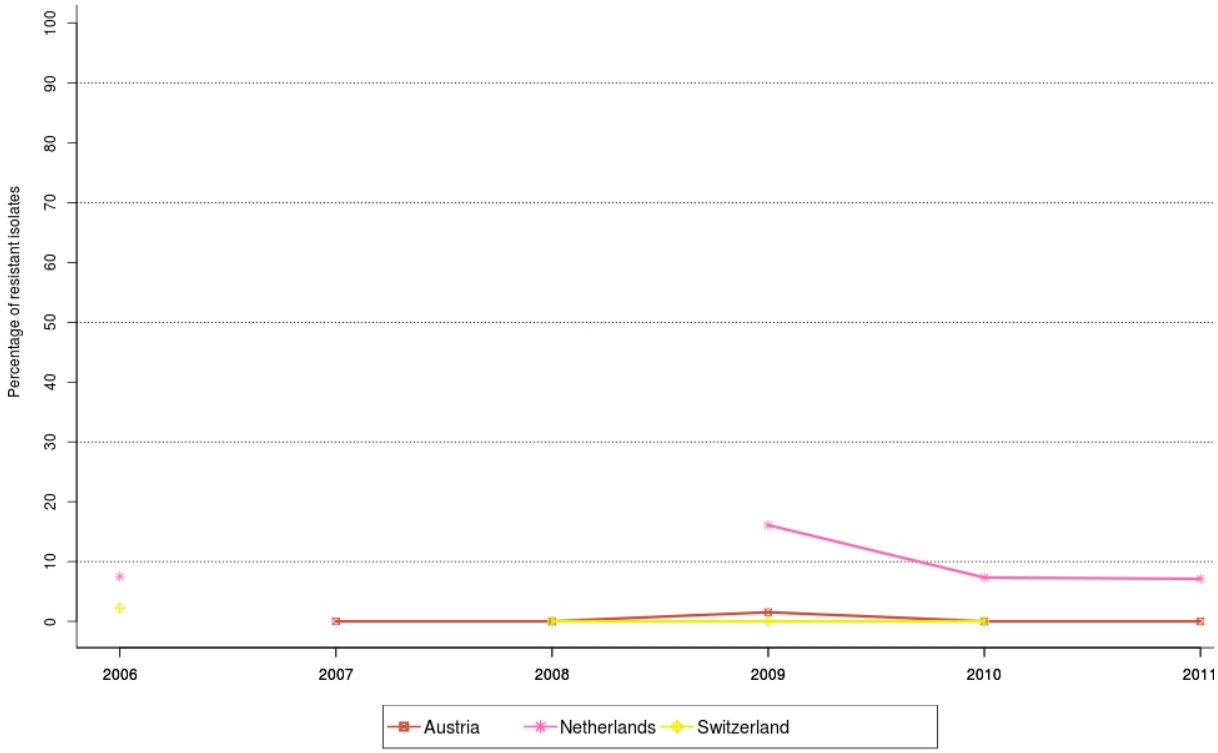
Note: Includes data when fewer than four countries have reported.

Temporal trends in resistance among indicator enterococci

Figures EN29–EN38 show the trends in resistance to ampicillin, erythromycin, streptomycin, tetracyclines and vancomycin observed in *E. faecium* and *E. faecalis* from cattle from 2006 to 2011. The results for all types of cattle are merged together. Often only three MSs submitted sufficient data to warrant their inclusion in the trend graphs, but there was still wide variation between the different countries' resistance levels for some of the antimicrobials, such as tetracyclines. For most of the antimicrobials, there were only minor differences between the resistance levels that were reported in 2010 and 2011. Similarly to the *Enterococcus* isolates from pigs, no ampicillin resistance has been detected among *E. faecalis* since 2006, and vancomycin resistance has been at a low level in both species of *Enterococcus*.

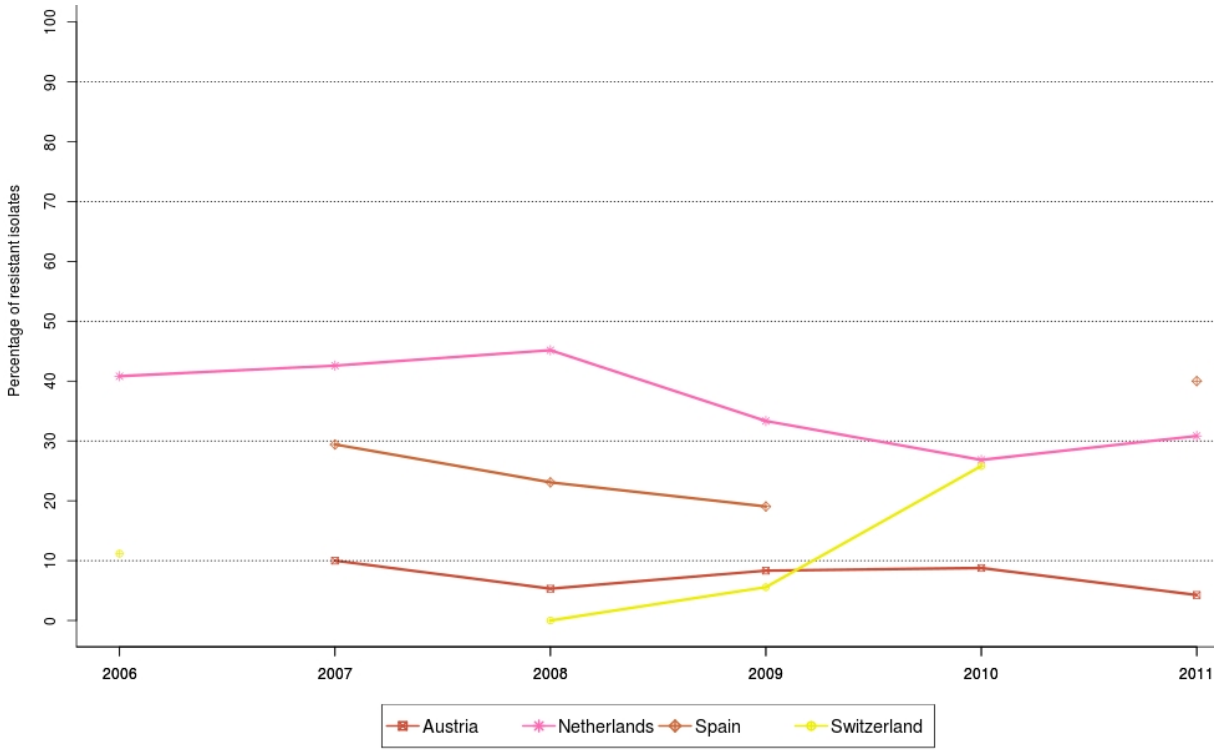
For many antimicrobials, the Netherlands (or Spain for *E. faecium* only) reported the highest resistance levels among enterococci from cattle. However, there have been declines in the resistance levels reported by the former since 2006; as in pigs, there was a large decline in resistance to streptomycin among *E. faecium* from the Netherlands but there were insufficient data points to test for statistical significance. Nevertheless, statistically significant declines have been identified in this country for resistance to erythromycin and tetracyclines in *E. faecium*, as well as to streptomycin in *E. faecalis*. The only other statistically significant trends since 2006 were recorded in Austria: a decrease in vancomycin resistance in *E. faecium* and an increase in tetracycline resistance in *E. faecalis*. No statistically significant trends were detected for five of the trend graphs, including resistance to ampicillin in both species of *Enterococcus*, with most countries simply showing random fluctuations or fairly stable resistance levels.

Figure EN29. Trends in ampicillin resistance in* Enterococcus faecium *from cattle in reporting MSs and one non-MS, 2006–2011, quantitative data



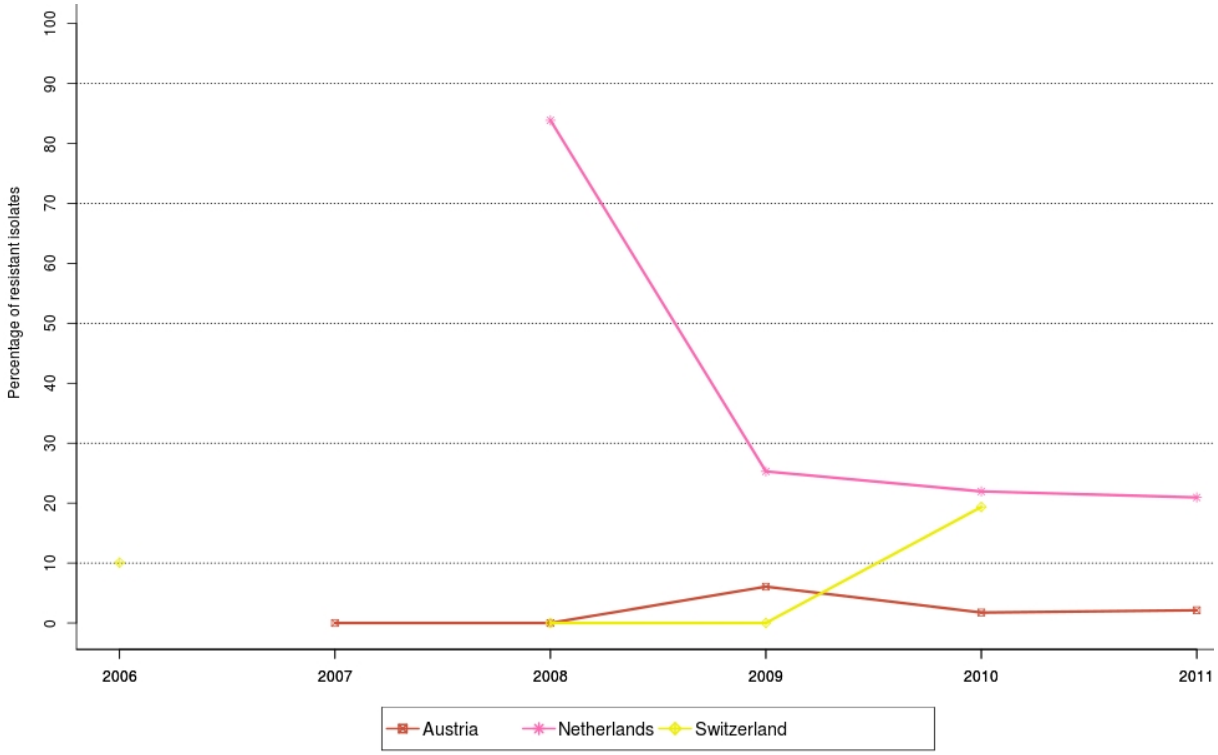
Note: No significant increasing or decreasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

Figure EN30. Trends in erythromycin resistance in* Enterococcus faecium *from cattle in reporting MSs and one non-MS, 2006–2011, quantitative data



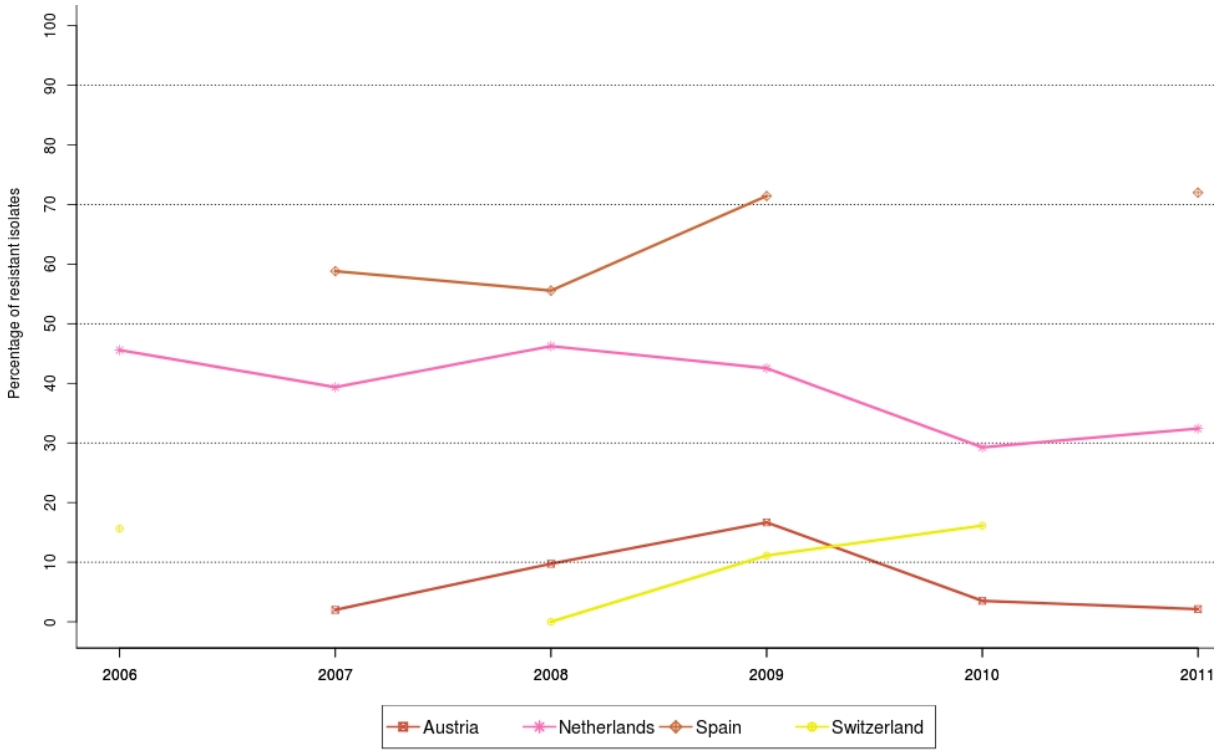
Note: A statistically significant decreasing trend over six years, as tested by a logistic regression model ($p \leq 0.05$), was observed in the Netherlands (↓).

Figure EN31. Trends in streptomycin resistance in* Enterococcus faecium *from cattle in reporting MSs and one non-MS, 2006–2011, quantitative data



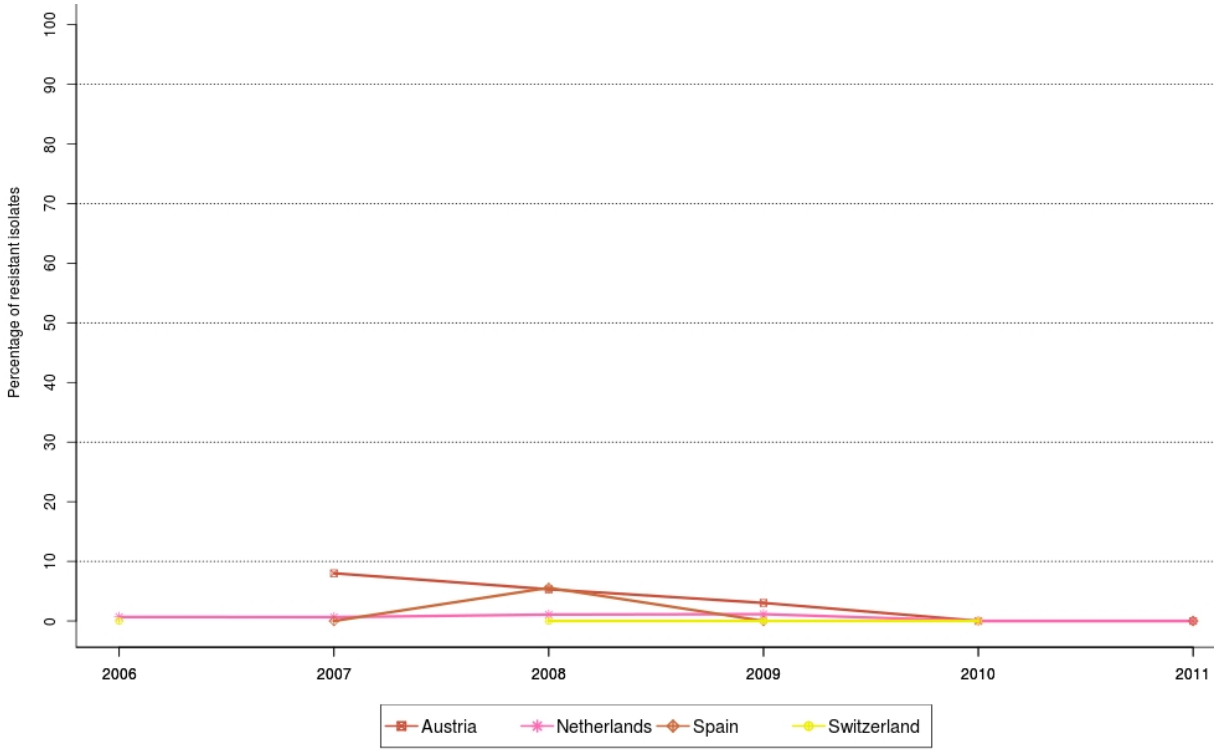
Note: No significant increasing or decreasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

Figure EN32. Trends in tetracycline resistance in Enterococcus faecium *from cattle in reporting MSs and one non-MS, 2006–2011, quantitative data*



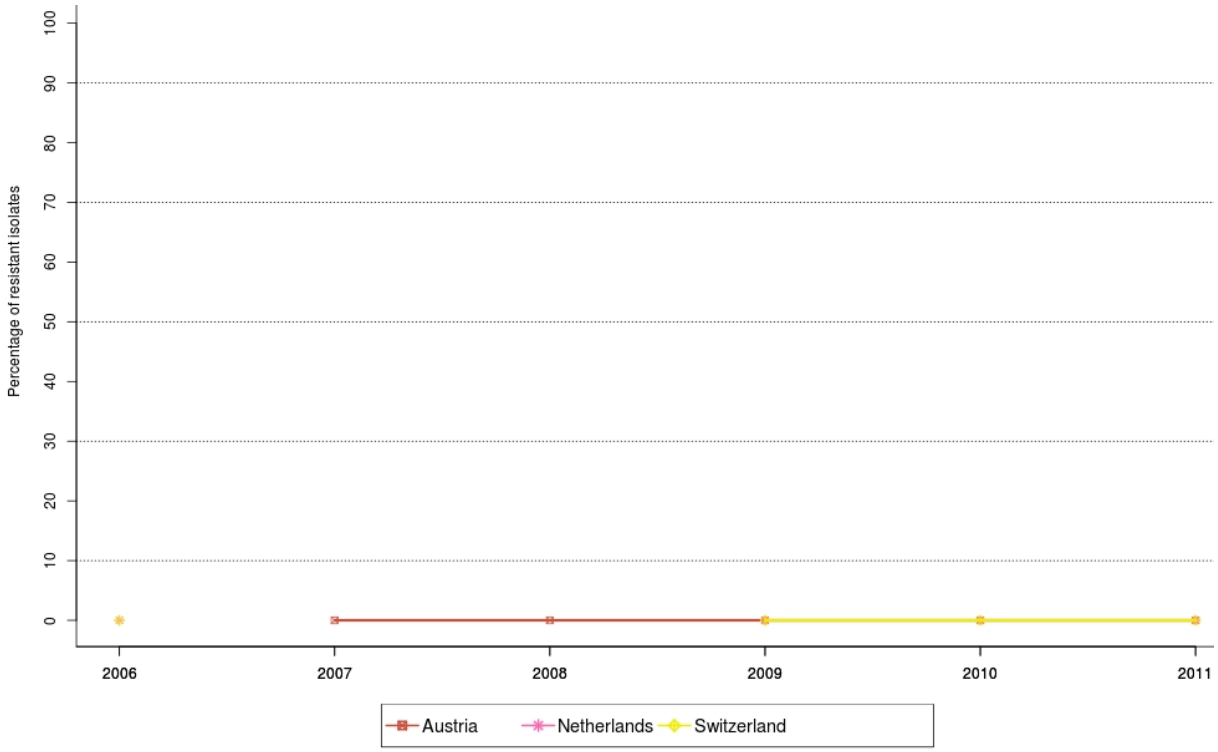
Note: A statistically significant decreasing trend over six years, as tested by a logistic regression model ($p \leq 0.05$), was observed in the Netherlands (↓).

Figure EN33. Trends in vancomycin resistance in Enterococcus faecium *from cattle in reporting MSs and one non-MS, 2006–2011, quantitative data*



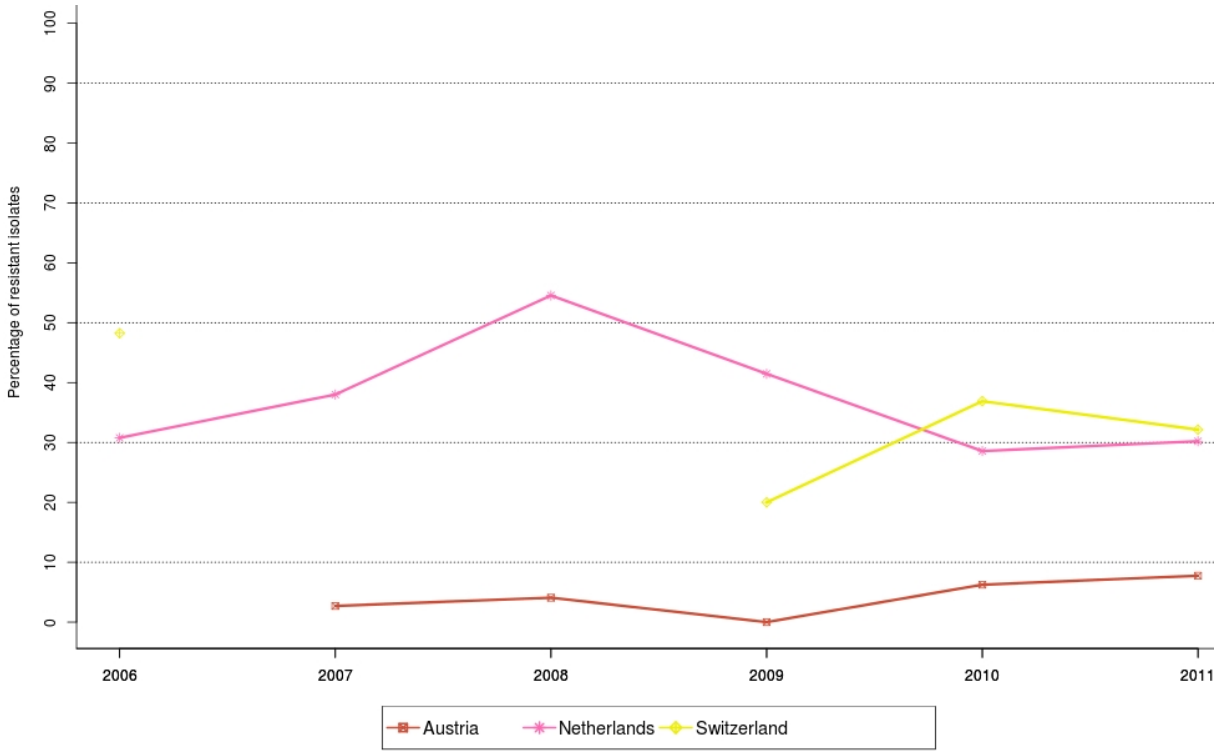
Note: A statistically significant decreasing trend over five years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Austria (↓).

Figure EN34. Trends in ampicillin resistance in* Enterococcus faecalis *from cattle in reporting MSs and one non-MS, 2006–2011, quantitative data



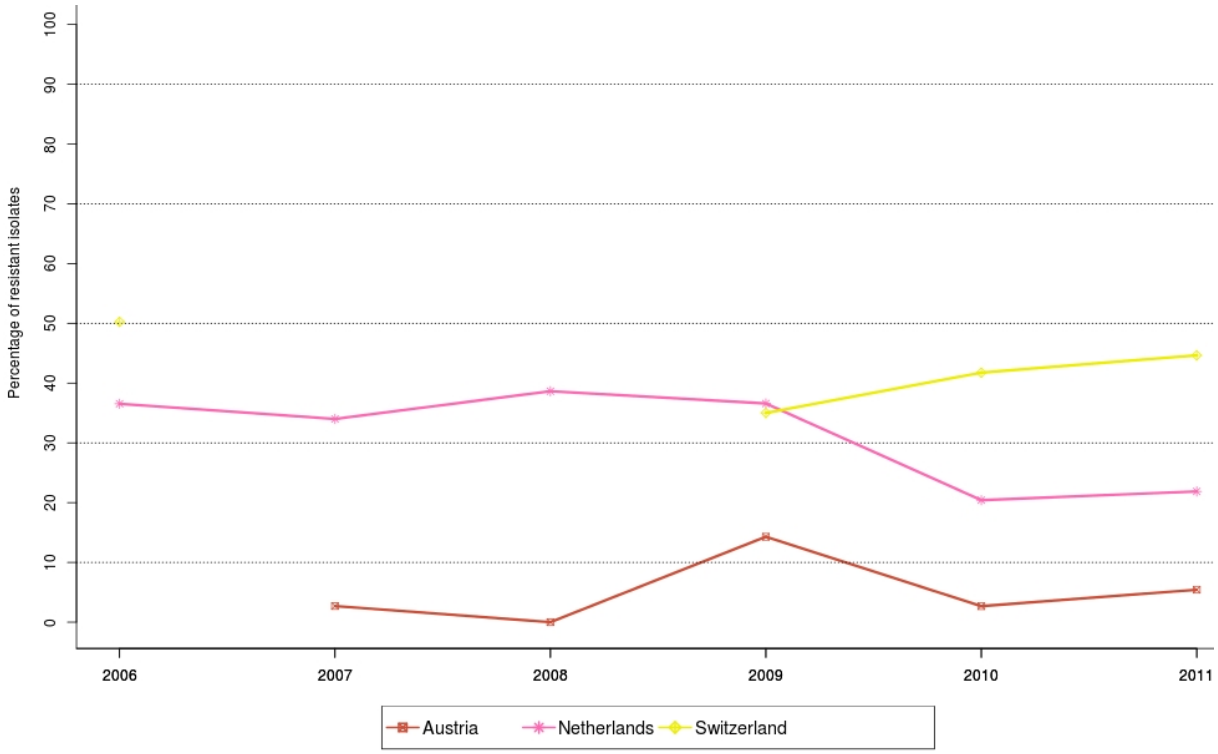
Note: No significant increasing or decreasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

Figure EN35. Trends in erythromycin resistance in* Enterococcus faecalis *from cattle in reporting MSs and one non-MS, 2006–2011, quantitative data



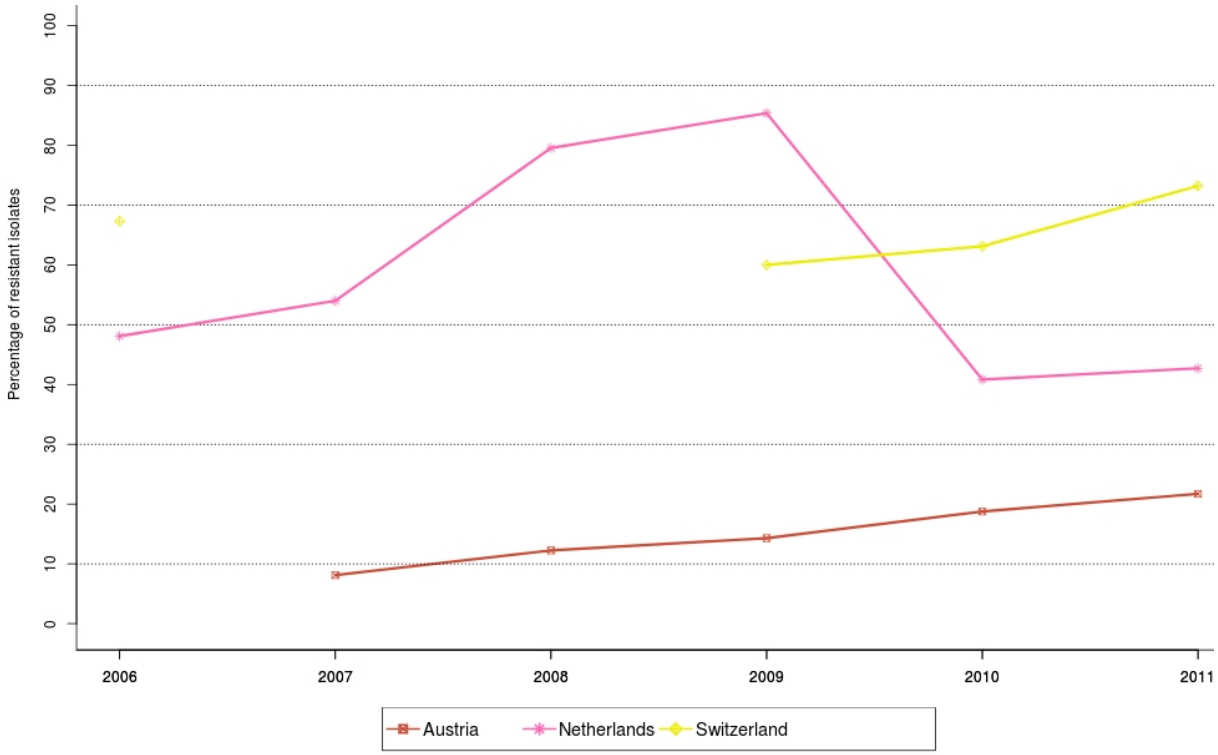
Note: No significant increasing or decreasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

Figure EN36. Trends in streptomycin resistance in* Enterococcus faecalis *from cattle in reporting MSs and one non-MS, 2006–2011, quantitative data



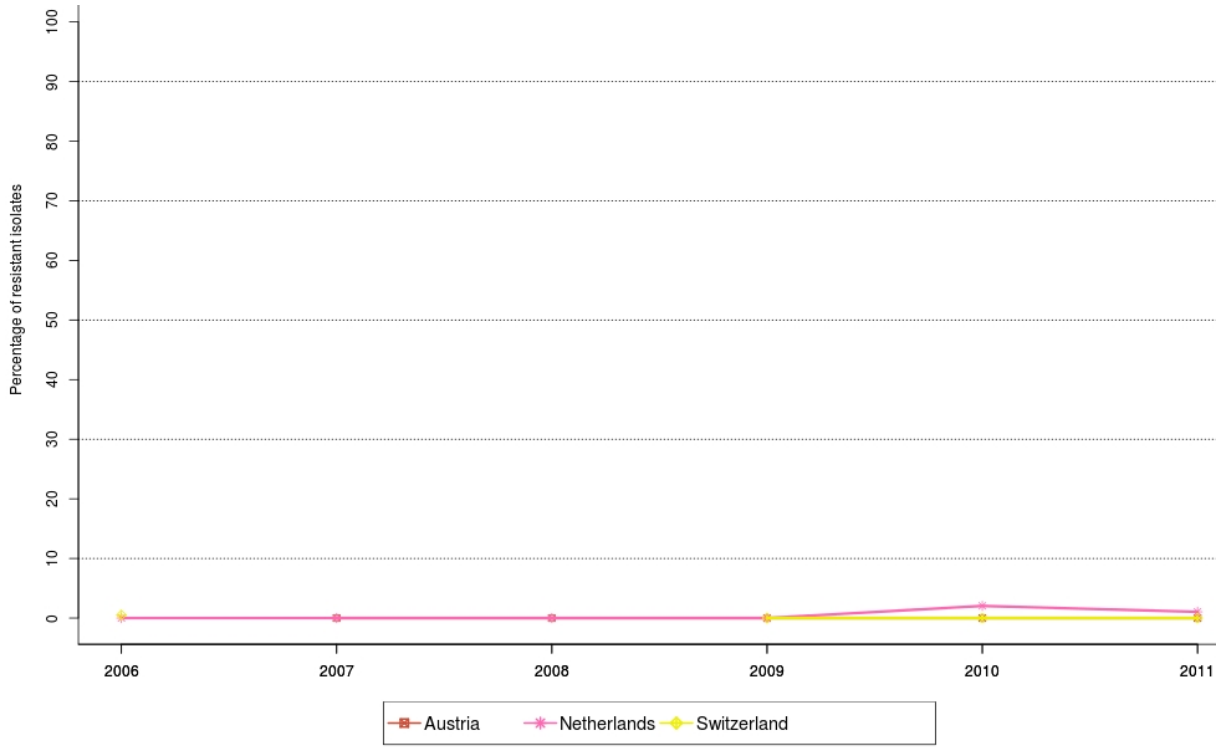
Note: A statistically significant decreasing trend over six years, as tested by a logistic regression model ($p \leq 0.05$), was observed in the Netherlands (↓).

Figure EN37. Trends in tetracycline resistance in* Enterococcus faecalis *from cattle in reporting MSs and one non-MS, 2006–2011, quantitative data



Note: A statistically significant increasing trend over five years, as tested by a logistic regression model ($p \leq 0.05$), was observed in Austria (↑).

Figure EN38. Trends in vancomycin resistance in* Enterococcus faecalis *from cattle in reporting MSs and one non-MS, 2006–2011, quantitative data



Note: No significant increasing or decreasing trend over five or more years, as tested by a logistic regression model ($p \leq 0.05$), was observed in any of the reporting countries.

Spatial distribution of resistance among *Enterococcus faecium*

Relatively few countries have reported on *E. faecium* from cattle so it was not possible to identify any spatial patterns: for this reason spatial distributions of tetracycline, erythromycin and vancomycin resistance are not presented. It was noted, however, that Belgium and Spain reported the highest resistance levels to tetracyclines and erythromycin while Austria reported the lowest level of resistance to both. None of the countries reported any resistance to vancomycin.

Multi-resistance among enterococci isolates from cattle

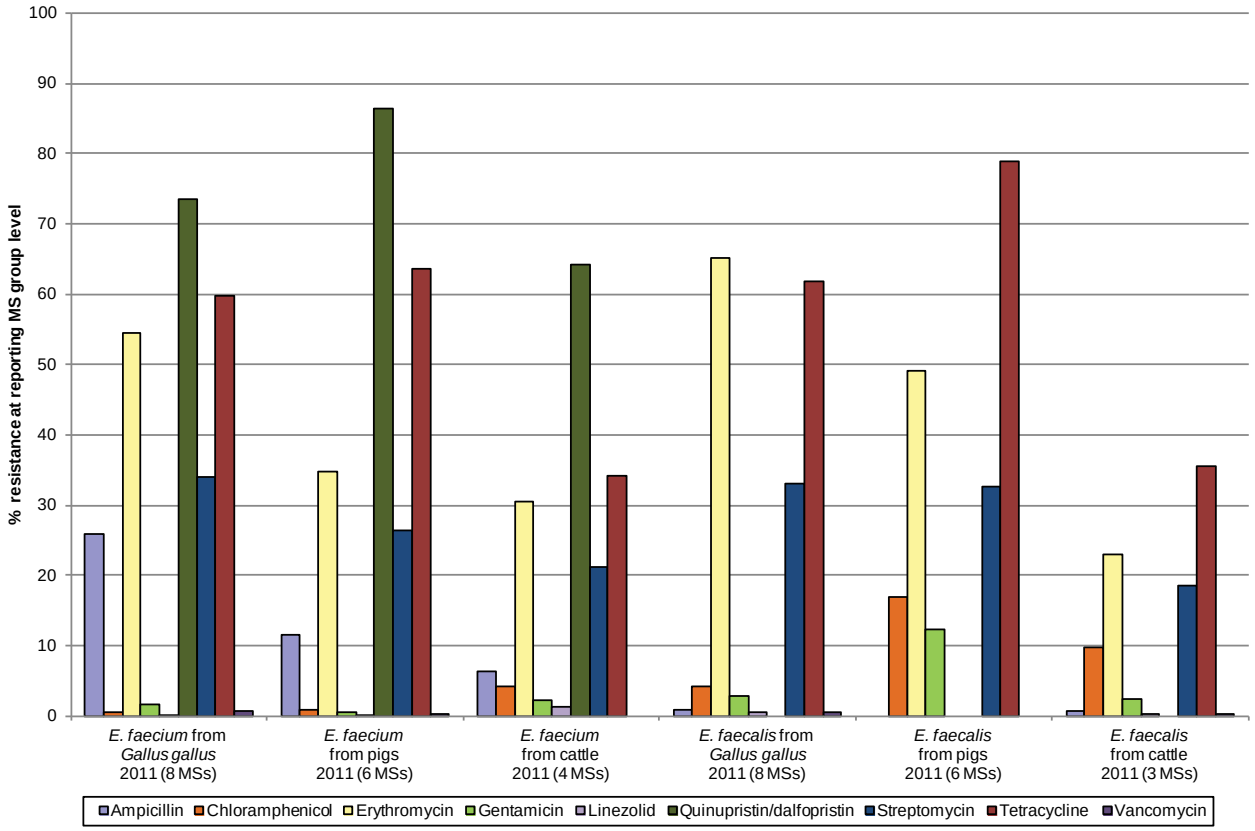
As fewer than four MSs reported multi-resistance isolate-based data on more than 10 isolates of enterococci in cattle, tables and graphs on multi-drug resistance are not presented.

7.3. Overview of the findings on enterococci resistance at reporting MS group level, 2011

Figure EN39 shows the resistance levels in the reporting MS group based on MIC data submitted in 2011 for the various food production animal species. It should be borne in mind that the data are derived from different numbers and groups of MSs.

As in 2010, resistance to erythromycin was higher among *E. faecalis* isolates than in *E. faecium* isolates from *Gallus gallus* and pigs, whereas the opposite was true for cattle. Resistance to tetracyclines was also higher among *E. faecalis* isolates than in *E. faecium* isolates from all species. As in the previous year, resistance to ampicillin was much higher among isolates of *E. faecium* for all three livestock species, with virtually no resistance being detected among *E. faecalis*. For quinupristin/dalfopristin, resistance was at a very high or extremely high level in *E. faecium* from all livestock species. Resistance to both chloramphenicol and gentamicin was generally at a low level, although moderate resistance levels were reported for *E. faecalis* from pigs and chloramphenicol resistance was slightly higher among *E. faecalis* than in *E. faecium* from all three livestock species. There was very little resistance to linezolid and vancomycin in either species of *Enterococcus*. The highest linezolid resistance levels were in *E faecium* from cattle, yet these levels were still very low, with a MS average of 1.4 %. More commonly, though, both *E. faecium* and *E. faecalis* isolates collected from *Gallus gallus* or pigs expressed greater resistance than isolates from cattle.

Figure EN39. Resistance to ampicillin, chloramphenicol, erythromycin, gentamicin, linezolid, quinupristin/dalfopristin (*E. faecium *only), streptomycin, tetracyclines and vancomycin in indicator* Enterococcus faecium *and* Enterococcus faecalis *from fowl, pigs and cattle at reporting MS group level in 2011



7.4. Discussion

Antimicrobial resistance in commensal *Enterococcus* isolates from animals and food is used as an indicator of the reservoir of resistance genes in the Gram-positive flora and which could be transferred to bacteria that are pathogenic for humans and/or animals. As with indicator *E. coli*, *Enterococcus* isolates can also be used to investigate the relationship between antimicrobial resistance levels and the extent of usage of antimicrobials in food-producing animal species. It is recommended that both *E. faecium* and *E. faecalis* are included in MSs' antimicrobial resistance monitoring programmes because, in some animal species, one of these bacterial species is much more common than the other, and changes in the prevalence of each enterococcal species to be monitored can also occur with age in some animal species. Both enterococcal species can cause human disease and they differ in the antimicrobials to which they show intrinsic (i.e. naturally occurring) resistance. One of the most important antimicrobials to monitor in these bacteria is vancomycin, and enterococcal species can differ in their propensity to carry resistance to this antimicrobial, as discussed in more detail below. Low-level intrinsic resistance to aminoglycosides is an inherent property of enterococci (Murray, 1990), accounting for the higher epidemiological cut-off values evident for these bacteria in comparison with the other bacteria monitored in this report (Table MM10).

In 2011, a total of 10 MSs and two non-MSs provided quantitative data on antimicrobial resistance in *Enterococcus* from animals and food; most of the countries provided information on both species of *Enterococcus* but two MSs only provided data for either *E. faecium* or *E. faecalis*. This is a marginal increase on the figures for 2010, when seven MSs and one non-MS provided data. Resistance levels tend to vary markedly between MSs. Only three MSs reported MIC data on isolates collected from food in 2011, one of which reported only on *E. faecalis* from pig meat. Countries usually used dilution methods to determine MIC values, in accordance with EFSA recommendations (EFSA, 2008a). However, Hungary tested *E. faecalis* from meat from bovine animals, broilers, pigs and turkeys using disc diffusion methods. As only one country provided qualitative data derived from a diffusion method, these data were not included in the present analysis.

In MSs which reported resistance to enterococcal isolates from **meat**, resistance levels tended to be higher in meat from broilers than in meat from pigs and bovine meat, particularly in the Netherlands. One exception was quinupristin/dalfopristin resistance among *E. faecium*, which Denmark reported to be higher in meat from pigs than in meat from broilers. In general, resistance levels in bovine meat were comparable to the levels in meat from pigs. Resistance levels were commonly lower in isolates from meat than in isolates from the corresponding source animal species, with the exception of resistance to vancomycin and linezolid, which was consistently very low, and isolates of *E. faecalis*, among which there was less discrepancy in resistance levels between those from meat and animals. In MSs which reported resistance to enterococcal isolates from broiler meat and broilers (Denmark and the Netherlands), there were (in general) parallel differences in the levels of resistance to *E. faecalis* and *E. faecium* from broiler meat and broilers within each of those MSs. Thus, resistance to erythromycin in *E. faecalis* from broilers in Denmark and the Netherlands was 14.5 % and 79.0 %, respectively, while it was 17.6 % and 62.2 % in isolates from broiler meat. The degree to which the isolates from meat reflect domestic animal production within a MS, as well as the relatively low sample size for some categories and the expected variation within a given sample size, are all likely to account for at least some of the observed variation between isolates from meat and animals.

When considering resistance in *E. faecium* at the reporting **MS group level**, the highest levels of resistance for all animal categories was recorded for quinupristin/dalfopristin (73.5 % for *Gallus gallus*, 86.5 % for pigs and 64.1 % for cattle). Resistance levels for quinupristin/dalfopristin in *E. faecalis* were not presented because of the intrinsic resistance in this species. Microbiological resistance to erythromycin, streptomycin and tetracyclines in farm animals was usually at a high level in both species of *Enterococcus* when using the ECOFFs, with resistance in some MSs reaching extremely high levels. There was often substantial variation in the levels of resistance observed in the reporting MSs, which could reflect variation in usage patterns or in the production types of livestock that were sampled. Resistance occurred more commonly in isolates from *Gallus gallus* and pigs than in isolates from cattle. Similarly, multi-resistance levels in *E. faecium* isolates from pigs differed substantially between the reporting countries. However, very few MSs reported data on the latter food-producing animal species, so the observed difference should be treated with caution.

This was the first year that data were presented separately for the **different production types** of each food-producing animal species. In the case of *Enterococcus*, this applied only to cattle. The Netherlands reported much higher resistance among isolates from fattening veal calves (typically of less than one year of age)

than in adult dairy cattle, whereas the other countries that reported on more than one age group (Austria and Switzerland) found much less disparity in resistance levels between young cattle of one to two years of age and adult cattle. As well as differences in age, differences in rearing and husbandry systems, and treatment regimes employed, may have also contributed to the different figures observed in fattening veal calves, young cattle and adult cattle.

Regarding *Enterococcus* isolates from *Gallus gallus*, 54.6 % of *E. faecium* and 65.2 % of *E. faecalis* from the reporting group of MSs expressed resistance to **erythromycin** (macrolides). This compares with 34.8 % of *E. faecium* and 49.0 % of *E. faecalis* from pigs, and 30.5 % of *E. faecium* and 22.9 % of *E. faecalis* from cattle. Resistance was also more common among isolates from broiler meat than bovine or pig meat, with the highest resistance of 66.7 % reported by the Netherlands for *E. faecium* from broiler meat. The high observed levels of resistance to macrolides are of importance, as these substances have been defined as critically important antimicrobials in human medicine. Differences in the occurrence of macrolide resistance in enterococcal isolates from poultry, calves and pigs have been considered to reflect the different levels and patterns of usage of antimicrobials in those species. This also probably accounts for the widespread occurrence of **tetracycline** resistance in *Gallus gallus* and pigs, which have frequently received treatment with this antimicrobial (van den Bogaard et al., 2000; Cauwerts et al., 2007). In 2011, 63.6 % of *E. faecium* isolates and 78.9 % of *E. faecalis* isolates from pigs expressed resistance to this antimicrobial, as well as 59.7 % of *E. faecium* and 61.9 % of *E. faecalis* isolates from *Gallus gallus*. This compares with only 34.2 % of *E. faecium* and 35.6 % of *E. faecalis* from cattle. All of the trends in erythromycin resistance among *Enterococcus* from *Gallus gallus* that were found to be statistically significant were increasing trends. In contrast, only decreasing trends were found to be statistically significant in isolates from either pigs or cattle. With respect to tetracyclines, there has been a mix of statistically significant increasing and decreasing trends from all livestock and *Enterococcus* species. In the Netherlands, there has been a statistically significant increase in resistance to both erythromycin and tetracyclines in *E. faecium* from *Gallus gallus* since 2006, whereas isolates from pigs and cattle have shown a significant decline in resistance to both of these antimicrobials.

Because cross-resistance occurs between avoparcin and the important human antimicrobial **vancomycin** (used for treating Gram-positive infections in humans), the use of avoparcin as an antimicrobial growth promoter was banned in the EU in 1997. All *Enterococcus* isolates collected from bovine, broiler and pig meat in 2011 were fully susceptible to vancomycin. In addition, none of the *E. faecium* isolates from cattle or *E. faecalis* isolates from pigs expressed resistance to this antimicrobial, and only 0.4-0.7 % of the remaining isolates were resistant. Only two or three countries usually identified resistance per species and livestock combination. Vancomycin resistance has generally been at a low, stable level in all countries since 2006, although Austria has shown a significant decline in resistance in *E. faecium* from both *Gallus gallus* and cattle while Switzerland has also shown a significant decline in the former. Fluctuations in the occurrence of vancomycin resistance in *E. faecium* from various animal species can be related to the spread of single clones of *E. faecium* carrying the *vanA* gene (Nilsson et al., 2009). The results reported here are in agreement with most other studies that have previously been carried out, which show that *vanA* resistance is more common in *E. faecium* isolates from animals and meat derived from those animals, whereas it is more rarely found in *E. faecalis*.

Resistance to **ampicillin** in *E. faecalis* isolates from *Gallus gallus*, pigs and cattle was uncommon or not observed in all reporting MSs, whereas it was much more widespread in isolates of *E. faecium* and was observed in a number of different MSs, in broilers, pigs and cattle. The highest levels of ampicillin resistance in *E. faecium* from broilers were observed in Ireland (74.8 %), the Netherlands (36.1 %) and Spain (36.1 %). Ampicillin resistance was also found to be common in a study of *E. faecium* from bacteraemias in the United Kingdom and Ireland between 2001 and 2006, with a significant increasing trend being identified as well as a strong association with vancomycin resistance (Brown et al., 2008). Enterococci tend to show a degree of intrinsic resistance to penicillins, probably because of their low affinity to penicillin-binding proteins (Murray, 1990). The ECOFF separates isolates with intrinsic resistance from those with acquired resistance.

Resistance to **linezolid** was rare for both *E. faecalis* and *E. faecium* in all of the host animal species considered. A low level of resistance was observed for *E. faecium* and *E. faecalis* from *Gallus gallus* in Belgium (6.1 % and 6.2 %, respectively) and in *E. faecium* in pigs from France (1.1 %). Low levels of resistance were also observed for *E. faecium* in cattle from the Netherlands (1.2 %) and Spain (8.0 %) and *E. faecalis* in cattle from the Netherlands (1.0 %). Levels of resistance to **chloramphenicol** and **gentamicin** at the reporting group level was low or very low for both *E. faecalis* and *E. faecium* isolates in all animal

categories considered, with the exception of *E. faecalis* isolates from pigs where resistance was reported at 17.0 % and 12.3 %, respectively.

A number of MSs showed significant increasing or decreasing trends to particular antimicrobials. Many of these changes are being observed against a background of initiatives either to reduce antimicrobial usage or to influence the prescribing of antimicrobials in certain ways. Correlation of trends with trends in usage has not been done in this report, but is the logical next step in analysing the resistance figures in more detail.

8. METHICILLIN-RESISTANT *STAPHYLOCOCCUS AUREUS* (MRSA)

8.1. Introduction

Methicillin-resistant *Staphylococcus aureus* (MRSA) has been recognised as an important cause of hospital-associated infections in humans for decades. Treatment of these infections has become an important public health matter owing to the development of resistance to many commonly used antimicrobials. Strains of MRSA have also emerged which are particularly associated with community-acquired infections in humans. Moreover, in recent years, MRSA has also been detected in several animal species including pigs, companion animals and other farm animal species. Hospital-associated MRSA and community-associated MRSA are those strains predominantly affecting humans, although livestock-associated MRSA may also be harboured by humans, especially where there is occupational contact with affected livestock. Antimicrobial susceptibility in European invasive *S. aureus* isolates is reported by the MSs to the European Antimicrobial Resistance Surveillance Network (EARS-Net) (ECDC, 2012). Molecular typing data are not reported and thus possible links to the animal reservoir can not easily be determined. Recent EARS-Net data showed decreasing or stabilising MRSA percentages in most European countries, which might indicate the impact of improved hospital infection control routines which have been implemented in several countries. However, MRSA remains a human public health priority, as the percentage of MRSA remains above 25 % in eight out of 28 countries, mainly in Southern Europe (ECDC, 2012).

Pigs are acknowledged as an important source of colonisation of a particular strain of MRSA (designated ST398-multi-locus sequence type 398) for pig farmers and veterinarians, and their families, through direct or indirect contact with pigs. This recently recognised strain, MRSA ST398, which appears to be primarily acquired by occupational exposure, can on occasion cause infections in humans and also on occasion be introduced into healthcare settings. In order to increase awareness and to assess the occurrence of MRSA in pig primary production across the EU, the occurrence and diversity of MRSA and MRSA ST398 in pig holdings in MSs were assessed through an EU-wide baseline survey (EFSA, 2009b, 2010b).

The EFSA's assessment of the public health significance of MRSA in animals and food (EFSA, 2009c) and the Joint scientific report of ECDC, EFSA and EMEA on MRSA in livestock, companion animals and food (EFSA, 2009a) provide more background information and recommendations on MRSA. A principal recommendation was that monitoring of food-producing animals, in particular intensively reared animals, is carried out periodically in conjunction with a systematic surveillance of MRSA in humans so that trends in the diffusion and evolution of zoonotically acquired MRSA in humans can be identified. In particular, isolate samples representative of various animal and food origins should be analysed for lineage determination, antimicrobial susceptibility and virulence-associated traits. These issues were reviewed in the recent EFSA Scientific Report presenting technical specifications for the harmonised monitoring and reporting of antimicrobial resistance in MRSA in food-producing animals and food (EFSA, 2012c). The technical specifications make recommendations to improve the harmonisation of the monitoring of the prevalence, genetic diversity and multi-resistance profile of MRSA in food-producing animals and food derived from those animals.

Molecular typing techniques, such as *spa*-typing and multi-locus sequence typing (MLST), are commonly used in *S. aureus* to sub-type strains and determine lineages. In *spa*-typing, different genetic types or strains of MRSA are designated by a number with the prefix t, while in MLST, strains are designated by a sequence type number. Using such typing results, often in conjunction with certain other virulence and antimicrobial resistance characteristics, it is possible to sub-divide strains of MRSA into groups characterised by differing epidemiology. These techniques are of particular relevance, for instance, in the investigation of outbreaks, such as in the case of hospital-associated MRSA, and of transmission events, for example of livestock-associated MRSA, and in the detection of emergence of strains showing new or multiple resistance patterns.

8.2. Methicillin-resistant *Staphylococcus aureus*–reports from individual MSs

Livestock-associated MRSA isolates are the principal focus of this chapter, which summarises the monitoring results of MRSA in various animal species and food reported by MSs to EFSA in 2011. Data on antimicrobial resistance of MRSA isolates and *S. aureus* from food and animal origin were reported by only two countries in 2011. The methods for the isolation of MRSA from animals and foods to date have not been harmonised at the EU level and, therefore, the methods used by individual reporting MSs may differ in sensitivity.

Six MSs–Belgium (*Gallus gallus*), Cyprus (food), Germany (cattle and food), Ireland (cattle, pigs, sheep, goats *Gallus gallus* and turkeys), the Netherlands (cattle, pigs, sheep, goats and *Gallus gallus*) and Spain (fattening pigs and food)–and Switzerland (dairy cattle and fattening pigs) submitted data on MRSA prevalence in animals and food in their national zoonoses reports for 2011 (Table MRSA1). This is a marked reduction compared with 2010, when 12 countries submitted MRSA prevalence data.

Table MRSA1. Overview of countries reporting data on MRSA in animals and food in 2011

Data	Total number of MSs reporting	Countries
Food	3	**MSs:** CY, DE, ES
Animals	5	**MSs:** BE, DE, ES, IE, NL
		Non-MS: CH

8.2.1. Methicillin-resistant *Staphylococcus aureus* in food

In 2011, three MSs-Cyprus, Germany and Spain-reported information regarding the occurrence of MRSA in food. The results are summarised in Table MRSA2.

Cyprus examined samples of meat from rabbits and products of animal origin used to make the local product τραχανάς,[19] and, to a larger extent, samples of cheeses made from a mixture of bovine, ovine or caprine milk for the presence of *S. aureus* and MRSA. Six of the cheese samples tested positive for MRSA of unspecified *spa*-type; the other samples were negative for MRSA.

Germany investigated a wide range of food for MRSA, among which a number of samples of red meat from various animal species, different kinds of poultry meat, wild boar meat and raw or low-heat-treated bovine milk cheeses tested positive for MRSA. The corresponding *spa*-typing data were not available.

Spain examined a range of food products for MRSA, and the single positive isolate obtained from fresh pig meat belonged to *spa*-type t011.

[19] τραχανάς (trachanas): is made by mixing flour, yoghurt or sour milk, and optionally cooked vegetables, salt, and spices (notably tarhana herb), letting the mixture ferment, then drying, and usually grinding and sieving the result.

Table MRSA2. MRSA in food, 2011

Food species/Country	Production type/ description (where specified)	Sample unit	Number of units tested	Number (%) positive for MRSA
Cheese				
Cyprus	pasteurised mixed milk, at processing plant, surveillance	Batch	1,483	6 (0.4)[1]
Germany	soft and semi-soft cheese from raw or low heat treated cow milk, at retail	Single	322	5 (1.6)[1]
Milk				
Spain	raw milk from cow	Single	7	0
	raw milk from goat	Single	15	0
Meat from bovine animals				
Germany	fresh meat at retail, monitoring	Single	509	41 (8.1)[1]
Spain	fresh meat(n=4)/mined meat(n=21)/meat products(n=2)	Single	27	0
Meat from broilers				
Germany	carcass at slaughterhouse, monitoring	Flock	331	160 (48.3)[1]
	fresh meat , at retail, monitoring	Single	404	107 (26.5)[1]
Spain	fresh meat(n=1)/mined meat(n=5)/meat products(n=1)	Single	7	0
Meat from pigs				
Spain	fresh meat	Single	42	1 (2.4)[2]
	minced meat	Single	13	0
	meat products	Single	50	0
Meat from rabbit				
Cyprus	chilled carcass at slaughterhouse, surveillance	Batch	10	0
Meat from turkey				
Spain	official sampling	Single	8	0
Meat from wild boar				
Germany	fresh meat, at retail, monitoring	Single	351	17 (4.8)[1]
Other foods				
Cyprus	other products of animal origin, at processing plant, surveillance (for the production of the local 'Trachanas')	Batch	30	0

1. *spa*-types unspecified.

2. spa-types t011.

8.2.2. Methicillin-resistant *Staphylococcus aureus* in animals

MRSA in food-producing animals

Belgium, Germany, Ireland, the Netherlands, Spain and Switzerland reported information on the prevalence of MRSA in food-producing animals and/or their immediate environment. The results are summarised in Table MRSA3. Of particular note is the extremely high MRSA prevalence recorded in fattening pigs in sampled at slaughter (nasal swabs) in Spain and in the Netherlands, and in cattle sampled at slaughter (nasal swabs) in the Netherlands in 2011.

Table MRSA3. MRSA in animals, 2011

Animal species/ Country	Production type/ description (where specified)	Sample unit	Number of units tested	Number (%) positive for MRSA	MLST: *spa*-types (number of isolates)
Poultry					
Belgium	Broilers, nasal swabs	Farm (20 animals per farm)	92	3 (3.3)	ST398: t011 (2) ST239: t037 (1)
	Laying hens, nasal swabs		280	0	Not applicable
Netherlands	Broilers at slaughter, nasal swabs	Flock (10 birds per flock)	48	14 (29.2)	Unspecified
Pigs					
Netherlands	Fattening pigs, at slaughter, nasal swabs	Herd (10 animals per herd)	110	88 (80.0)	Unspecified
Spain	Fattening pigs, at slaughter, nasal swabs	Slaughter batch	227	191 (84.1)	t011 (97) t034 (8) t108 (3) t1197 (7) t1451(5) t2346(3) Unspecified (68)
Switzerland	Fattening pigs, at slaughter, nasal swabs	Animals	392	22 (5.6)	ST398: t034 (19) ST398: t011 (1) ST49: t208 (1) ST1: t2279 (1)
Cattle					
Germany	Beef cattle, at slaughter, nasal swabs	Animals	288	25 (8.7)	Unspecified
Ireland	Dairy cattle, on farm, clinical mastitis investigations	Animals	76	1 (1.3)	Unspecified
Netherlands	Unspecified, at slaughter, nasal swabs	Animals (10 animals per herd)	100	83 (83.0)	Unspecified
Switzerland	Dairy cows, bulk milk	Herd	200	3 (1.5)	t011 (3)
Sheep and Goats					
Netherlands	Unspecified, on farm	Animal	564	0	Not applicable
Netherlands	Unspecified, on farm	Animal	214	0	Not applicable

MRSA in companion animals

Sweden was the only MS to report MRSA data for pets and companion animals. MRSA was confirmed in two horses and one cat in Sweden in 2011. The isolates from horses were of *spa*-type t011 and the isolate from the cat was of *spa*-type t022. All of these cases were isolated from clinical specimens sent for routine bacteriology.

Temporal occurrence in MRSA

Two countries reported consistently on the occurrence of MRSA in fattening pigs; over the period 2009–2011 for Switzerland and in both 2010 and 2011 for Spain (Table MRSA4). Methodological differences may occur between reporting countries, but where longitudinal studies have been performed then the same methods have usually been used, and this is the case for Spain and Switzerland. Spain sampled one animal (nasal swab) from slaughter batches containing 10 or more pigs and cultured swabs on Baird-Parker Chromogenic media, whereas Switzerland performed pre-enrichment in Mueller-Hinton broth supplemented with 6.5 % salt, then culture through selective broth containing cefoxitin and aztreonam and finally plating onto an MRSA–selective agar.

Table MRSA4. Temporal occurrence of MRSA in animals

Country	Year	Production type/ description (where specified)	Sample unit	Number of units tested	Number (%) positive for MRSA	MLST: *spa*-types (number of isolates)
Spain	2010	Fattening pigs, at slaughter, nasal swabs	Animals	276	159 (58.0)	t011 (121) t034 (3) t108 (17) Unspecified (18)
	2011	Fattening pigs, at slaughter, nasal swabs	Animals	227	191 (84.1)	t011 (97) t034 (8) t108 (3) t1197 (7) t1451(5) t2346(3) Unspecified (68)
Switzerland	2009	Fattening pigs, at slaughter, nasal swabs	Animals	405	8 (2.2)	Unspecified (8)
	2010	Fattening pigs, at slaughter, nasal swabs	Animals	392	23 (5.9)	t011 (1) t034 (17) ST49: t208(5)
	2011	Fattening pigs, at slaughter, nasal swabs	Animals	392	22 (5.6)	ST398: t034 (19) ST398: t011 (1) ST49: t208 (1) ST1: t2279 (1)

In Switzerland, the MRSA prevalence in 2009, 2010 and 2011 was 2.2 % (95 % CI 1.0–4.2 %), 5.9 % (95 % CI 3.8–9.7 %) and 5.6 % (95 % CI 3.6–8.4 %), respectively. There has therefore been a significant increase in the percentage of fattening pigs positive, although the percentage remains low. The continuing presence of ST49; t208 in pigs was also noted among the frequently prevalent ST398 MRSA strains.

Spain also reported results for fattening pigs in both 2010 and 2011, when 58 % of 276 slaughter pigs and 84 % of 227 nasal swab samples from pigs at slaughter were positive. In Spain, 76 % (121/159) isolates were *spa*-type t011 in 2010, and this remained the predominant type in 2011, accounting for 79 % (97/123) of the isolates typed.

8.2.3. Susceptibility testing of MRSA isolates

In 2011, data relating to the susceptibility of MRSA and *S. aureus* isolates were reported only by Belgium and Switzerland. Both countries used a broth dilution method and EUCAST ECOFFs to determine the susceptibility of isolates to beta-lactams (penicillin and oxacillin-only Switzerland), ciprofloxacin, chloramphenicol, cefotoxin (only Belgium), clindamycin, erythromycin, gentamicin, kanamycin, linezolid, fusidic acid, quinupristin/dalfopristin, mupirocin (only Belgium), rifampicin, streptomycin, tetracyclines, tiamulin, trimethoprim, vancomycin and sulfamethoxazole.

MRSA isolates from broilers

Of the three MRSA isolates from broilers in Belgium, two belonged to *spa*-type t011 and the remaining one to *spa*-type t037. All the three isolates were resistant to erythromycin, cefotoxin, penicillin and tetracyclines. Two of these isolates were resistant to chloramphenicol, clindamycin, kanamycin, rifampicin, streptomycin, sulfamethoxazole and trimethoprim, whereas the third isolate was resistant to ciprofloxacin, fusidic acid and gentamicin.

MRSA isolates from cow's bulk milk

The three MRSA isolates from cow's bulk milk reported by Switzerland all belonged to *spa*-type t011 and all were resistant to the beta-lactam compounds penicillin and oxacillin, as expected. Two of these isolates were resistant to gentamicin, kanamycin, tetracycline and trimethoprim, while the third was resistant to clindamycin, erythromycin, tiamulin, fusidic acid, quinupristin/dalfopristin, trimethoprim, streptomycin and sulfamethoxazole. Susceptibility results for methicillin/susceptible *S. aureus* (MSSA) from cow's bulk milk were also reported by Switzerland and of 31 isolates, 18 (58 %) were susceptible to the antimicrobials tested. Penicillin resistance was observed in seven isolates (23 %) and was the commonest resistance detected.

MRSA isolates from fattening pigs

Considering the susceptibility of MRSA isolates from fattening pigs reported by Switzerland, 15 isolates belonging to the most commonly detected genotype, ST398-t034-V, shared an identical resistance profile, which was resistance to beta-lactams, tetracycline, macrolides, lincosamides, trimethoprim, pleuromutilins, streptomycin and quinupristin/dalfopristin. Three additional isolates were resistant to all these antimicrobials except streptomycin whereas one isolate had additional resistance to all of the aminoglycosides tested.

Among MRSA isolates (N=22) from pigs in Switzerland, tested using the same methodology, breakpoints and panel of antimicrobials in 2011, resistance was detected to tetracyclines (100 % resistant), erythromycin, trimethoprim, tiamulin (90.9 % resistant) clindamycin, quinupristin/dalfopristin (86.4 % resistant), streptomycin (81.8 % resistant), gentamicin, kanamicin (9.1 % resistant), sulfhamethoxazole, ciprofloxacin (4.5 % resistant) and confirmed to beta-lactams (penicillin: 100 % resistant).

8.3. Discussion

Although food is not currently considered to be a source of MRSA infection or colonisation of humans (EFSA, 2009c), the monitoring of MRSA in various food products performed consistently in several MSs indicates that MRSA can be detected quite frequently in some foods. A very high MRSA prevalence in poultry meat was recorded by Germany in 2009, 2010 and 2011, while the prevalence was lower in meat from cattle and pigs. For broiler meat the prevalence observed in 2011 was similar to that reported in 2009. Broiler carcasses were frequently positive for MRSA at flock/batch level both in the Netherlands, where nasal swabs were collected, and in Germany, where carcasses were sampled.

The positive findings of MRSA in meat from wild boar might indicate cross-contamination during processing, as so far MRSA has not frequently been detected in wild boar. This needs to be elucidated further; cross-contamination of animals immediately prior to slaughter during transport and lairage and of products derived from animals after slaughter seems likely to account at least in part for the high prevalence obtained in some situations.

In 2011, MRSA was also detected in various kind of cheeses in Cyprus and Germany. Isolates from raw milk cheese (1.6 % positive) in Germany in 2011 were in line with the detection of MRSA in bulk tank milk in 2009 and 2010.

In Germany, MRSA was less frequently isolated from beef animals than from veal calves or pigs. Both Spain and the Netherlands reported extremely high MRSA prevalence in fattening pigs sampled through nasal swabs at slaughter. The prevalence of MRSA in slaughter pigs in Spain in 2011 was much higher than that observed 2010. Switzerland also recorded a significant increase in MRSA prevalence in fattening pigs sampled at slaughter, although the percentage colonised or transiently colonised animals remains low.

In 2011, Belgium performed an extensive monitoring of MRSA in laying hens and broilers; from 372 farms investigated, only three tested positive for MRSA.

A NOVEL *SPA*-TYPE OF MRSA REPORTED BY SWITZERLAND IN PIGS

*Switzerland also noted the continuing presence of ST49; t208 in pigs. Switzerland was the first country to describe the presence of this type of MRSA in pigs (Overesch et al., 2011). MRSA ST49; t208 is a previously undescribed clonal lineage of MRSA which has so far been detected only in pigs in Switzerland, giving rise to the suggestion that selection may have occurred within the Swiss pig population. Evidence to support the view that MRSA ST49; t208 may have emerged in pigs in Switzerland includes the observation that methicillin-**susceptible** S. aureus (MSSA) belonging to spa-type t208 had previously been described in Switzerland in pigs. This spa-type is otherwise rarely recorded in Europe, having been described in only one human infection in the United Kingdom and three cases of skin infection and laryngeal ulceration in wild squirrels (Overesch et al., 2011).*

Belgium and Switzerland were the only countries to report the susceptibility of MRSA isolates and used a broth dilution method and EUCAST ECOFFs to determine susceptibility in 2010 (Switzerland) and in 2011 (both countries). None of the three MRSA strains isolated from broilers in Belgium was resistant to more than four antimicrobials of the panel tested. In 2010 Switzerland reported results for MRSA of *spa*-type t011 from calves and in 2011 results for the same *spa*-type were reported for bovine bulk milk. The t011 isolates from calves in 2010 (n=5) were resistant to beta-lactams, clindamycin, erythromycin and tetracyclines, but, with the exception of one isolate, susceptible to the other antimicrobials tested. The susceptibility pattern of t011 observed in calves in 2010 therefore differs from that observed in the low number of isolates recovered from bovine bulk milk in 2011. MRSA isolates reported by Switzerland from bovine bulk milk were resistant to fewer antimicrobials than MRSA isolates and none was resistant to more than four antimicrobials in the panel tested.

S. AUREUS OF HUMAN AND BOVINE ORIGIN CARRYING A NOVEL *MECA* VARIANT GENE

Methicillin-resistant Staphylococcus aureus *typically gains resistance to methicillin (and most other beta-lactam antimicrobials) through possession of the* mecA *gene. Recently, a novel* mecA *homologue was identified in* S. aureus *isolates from cattle and humans in the United Kingdom and humans in Denmark, which also confers methicillin resistance. This has been designated* $mecA_{LGA251}$ *or* mecC *and is approximately 70 % related to the* mecA *gene; the gene* $mecA_{LGA251}$ *occurs in a previously unidentified genetic element, which has been designated SCCmec XI (Garcia-Alvarez et al., 2011). The novel* mecA *homologue has been confirmed in an archived human* S. aureus *isolate from 1975 from Denmark and has also been described in humans in Ireland (Shore et al., 2011) and Germany (Cuny et al., 2011).*

Isolates of S. aureus *carrying the novel* mecA *element have until recently not been detected by most methods currently employed to detect 'classical' MRSA. They have been associated with clinical disease in both cattle (mastitis in dairy cows) and humans. The* S. aureus *isolates carrying the novel* mecA *homologue identified thus far belong to either clonal complex 130 or ST 425 (Garcia-Alvarez et al., 2011; Shore et al., 2011). The extent to which transfer of these strains may occur between cattle and humans or vice versa is currently unknown. It is also not known whether cattle or humans form the primary host or the extent to which the populations of bacteria occurring in cattle and humans exist independently of each other. The observation that most previously reported CC130 isolates are from bovine sources has been considered to suggest that CC130 isolates are of bovine origin (Shore et al., 2011).*

In 2011, Sweden was the only MS to report findings relating to the divergent homologue mecC*, detecting this MRSA variant in milk samples from four dairy cows. The samples were analysed as part of a screening study for MRSA. One of the positive samples was collected in 2011 and three of the samples in 2010. These findings indicate that MRSA carrying the novel* mecA *variant gene occurs among animals in Sweden but that the prevalence so far is low.*

EFSA recently published a Scientific Report describing technical specifications for the harmonised monitoring and reporting of antimicrobial resistance in MRSA in food-producing animals and food in October 2012 (EFSA, 2012c). Currently, there are some issues relating to the differing methodology which MSs may use for the isolation of MRSA from foods, animals or the environment of animals in substrates such as dust. In circumstances where differing methodologies have been used, then the results obtained by different MSs may not be directly comparable. This is exemplified for example by the methods used in Switzerland, where a pre-enrichment salt broth culture stage was employed when culturing samples. The technical specifications should enable harmonised data to be collected from MSs on both the degree to which food-producing animals (and the food produced from them) are colonised with MRSA and the strains of MRSA involved. A new definition of MRSA proposed that it should include those strains harbouring *mecC* gene and the laboratoy methods adapted accordingly so that those strains can be also targeted by the harmonised routine monitoring. The situation with regard to MRSA and some food-producing animal species has changed substantially over the last decade; therefore, the proposed monitoring aims to provide a means to detect without undue delay further developments which may occur, in particular regarding the possible emergence of MRSA strains displaying particular virulence or resistance patterns and/or their potential exchange and diffusion between human and animal populations.

9. THIRD-GENERATION CEPHALOSPORIN RESISTANCE IN *E. COLI* AND *SALMONELLA*

9.1. Introduction

Extended-spectrum beta-lactamases (ESBLs) are considered to be an important emerging issue in Gram-negative bacteria of public health significance. Bacteria which possess ESBL resistance are usually resistant to third-generation cephalosporins, which are critically important antibiotic drugs for the treatment of systemic or invasive Gram-negative bacterial infections in humans. These drugs play a critical role in the treatment of certain invasive *Salmonella* infections, particularly in children, in whom the use of fluoroquinolones may not be favoured because of certain potential adverse effects. A low level of resistance may therefore still constitute an important finding. Commensal bacteria, such as indicator *E. coli*, may contribute to the dissemination of ESBL resistance because such resistance is usually transferable.

Salmonella and *E. coli* may develop resistance to third-generation cephalosporins by several different mechanisms. Among these different mechanisms, the most common is the acquisition of beta-lactamase enzymes on plasmids (small covalently closed circles of DNA which can be transferred between bacteria during bacterial conjugation). There are several different types of beta-lactamase which can confer resistance to third-generation cephalosporins. These are conveniently sub-divided into four classes, designated A to D: ESBL enzymes of the TEM, SHV and CTX-M families belong to class A, while class C includes the AmpC beta-lactamases.

Wild-type *Salmonella* isolates never possess a beta-lactamase of any class. For beta-lactamases to occur in *Salmonella*, acquisition must have happened by conjugation, usually with other Enterobacteriaceae through transfer of plasmids. Although all four different types of beta-lactamase classes have been described in *Salmonella* globally, within the EU the most important types of beta-lactamase resistance acquired by *Salmonella* are first ESBL resistance and, secondly, AmpC resistance. *E. coli* can acquire beta-lactamases from other bacteria, in a similar fashion to *Salmonella* but since it also possesses an endogenous AmpC beta-lactamase, in some circumstances this can be activated, conferring resistance to third-generation cephalosporins.

The EFSA guidelines for monitoring resistance in indicator *E. coli* (EFSA, 2008a) state that cefotaxime is a good substrate for what are currently the most common and important ESBLs in humans in Europe, the CTX-M enzymes, and can therefore be used as an indicator for ESBL resistance. Epidemiological cut-off values for *Salmonella* and *E. coli* for the antimicrobial cefotaxime facilitate detection of CTX-M ESBLs, but resistance to cefotaxime may, of course, be conferred by mechanisms of resistance other than ESBLs, such as certain other types of beta-lactamase, including AmpC beta-lactamases. In this chapter, the occurrence of resistance is given, where available, for cefotaxime and ceftazidime. As very few MSs reported data on resistance to ceftiofur, and because this compound is not considered optimal for the detection of ESBL enzymes, results for ceftiofur are not included in this chapter. Furthermore, because this report covers only phenotypic monitoring, it is not possible to determine the class or exact type of beta-lactamase enzyme which is likely to confer the resistance detected to third-generation cephalosporins.

The monitoring reported here and performed in accordance with EFSA's guidelines (EFSA, 2008a), does not utilise selective primary isolation media containing cephalosporins and so the results generally relate to organisms chosen effectively at random from primary culture media. In certain types of monitoring, selective media containing cephalosporins may be used to investigate the presence or absence of cephalosporin-resistant organisms in a particular sample (within the limit of detection) and, in that case, a different type of result would be obtained from such monitoring, which has a greater sensitivity. Ideally, the establishment of optimum phenotypic testing systems for sensitive, specific and rapid detection of ESBLs would be a very important component of antimicrobial resistance monitoring programmes.

These factors and others have been considered in detail in EFSA's Scientific Report on the harmonised monitoring and reporting of antimicrobial resistance in *Salmonella*, *Campylobacter* and indicator *E. coli* and *Enterococcus* spp. bacteria transmitted through food (EFSA, 2012b). In particular, detailed recommendations have been made for the isolation and identification of ESBL and AmpC *E. coli* and methods described which would promote a harmonised and therefore comparable approach to monitoring across the EU.

9.2. Third-generation cephalosporin resistance in *Salmonella* from food and animals

9.2.1. Third-generation cephalosporin resistance in *Salmonella* isolates from food

Eight MSs reported the results for resistance to cefotaxime in *Salmonella* spp. isolates recovered from meat from broilers (Table ESBL1). Resistance was reported at a low level in all MSs except the Netherlands, where the level of resistance was 31.9 % to both cefotaxime and ceftazidime; the figures for the Netherlands also represent an increase on the figures obtained for 2010, when 11 % and 8 % of isolates were resistant to cefotaxime and ceftazidime, respectively. In most MSs, the prevalence of resistance to cefotaxime was equal to that observed to ceftazidime; however, the figures differed slightly for Belgium and Romania, suggesting that enzymes which were preferentially cefotaximases or ceftazidimases may have been responsible.

Table ESBL1. Resistance (%) to cefotaxime and ceftazidime in* Salmonella *spp. isolates from meat from broilers tested by MSs in 2011

Country	Cefotaxime		Ceftazidime	
	N	% Res	N	% Res
Belgium	256	1.6	256	2.3
Germany	145	2.8	145	2.8
Greece	10	0	-	-
Hungary	170	0	-	-
Ireland	47	8.5	47	8.5
Latvia	20	0	-	-
Netherlands	47	31.9	47	31.9
Romania	172	1.2	172	0.6
Total (8 and 5 MSs)	**867**	**3.3**	**667**	**4.5**

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

The results of testing for third-generation cephalosporin resistance in *Salmonella* spp. isolates recovered from meat from pigs are shown in Table ESBL2. Resistance was either not detected or reported at a low level in all reporting MSs. The prevalence of resistance to cefotaxime was equal to that observed to ceftazidime for all MSs except Romania, where ceftazidime but not cefotaxime resistance was detected, suggesting that a ceftazidimase enzyme may have been responsible. In 2009, Belgium reported 4 % cefotaxime resistance and 3 % ceftazidime resistance, while Germany reported 1 % cefotaxime resistance and 0 % ceftazidime resistance. Belgium and Germany did not report resistance to either compound in *Salmonella* spp. isolates from pig meat in 2010, although resistance re-appeared in 2011 at a low level. The higher level of resistance to cefotaxime in Portugal (8.3 %) may be linked to the small sample size tested.

Table ESBL2. Resistance (%) to cefotaxime and ceftazidime in* Salmonella *spp. isolates from meat from pigs tested by MSs in 2011

Country	Cefotaxime		Ceftazidime	
	N	% Res	N	% Res
Belgium	244	0.4	244	0.4
Denmark	49	0	-	-
Estonia	22	0	-	-
Germany	115	2.6	115	2.6
Hungary	17	0	-	-
Ireland	139	0	139	0
Italy	67	3.0	67	3.0
Netherlands	15	0	15	0
Portugal	12	8.3	-	-
Romania	87	0	87	1.1
Total (10 and 6 MSs)	**767**	**0.9**	**667**	**1.0**

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

As shown in Table ESBL3, resistance to cefotaxime in *S.* Typhimurium from meat from pigs was not detected by any of the reporting MSs; the situation was similar in 2010.

Table ESBL3. Resistance (%) to cefotaxime in* S. *Typhimurium isolates from meat from pigs tested by MSs in 2011

Country	Cefotaxime		Ceftazidime	
	N	% Res	N	% Res
Belgium	103	0	103	0
Denmark	28	0	-	-
Germany	20	0	20	0
Hungary	12	0	-	-
Ireland	57	0	57	0
Italy	12	0	12	0
Romania	18	0	18	0
Total (7 and 5 MSs)	**250**	**0**	**210**	**0**

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

9.2.2. Third-generation cephalosporin resistance in *Salmonella* isolates from animals

Resistance to third-generation cephalosporins in *Salmonella* spp. from *Gallus gallus* is shown in Table ESBL4. A low level of resistance to cefotaxime, of 1.5 %, and to ceftazidime, of 1.4 %, was reported in *Salmonella* spp. isolates from all reporting MSs. The level of resistance to cefotaxime in *Salmonella* spp. from fowl in Ireland and the Netherlands was 1.5 % and 10.0 % respectively, which may be compared with the figures reported in 2010 of 6 % (Ireland) and 5 % (the Netherlands). Spain detected 26 % resistance to ceftazidime in *Salmonella* spp. in 2009; resistance was not detected to cefotaxime or ceftazidime in 2010 or 2011.

Table ESBL4. Resistance (%) to cefotaxime and ceftazidime in* Salmonella *spp. isolates from* Gallus gallus *tested by MSs in 2011

Country	Cefotaxime		Ceftazidime	
	N	% Res	N	% Res
Austria	176	1.1	176	1.1
Denmark	48	0	-	-
France	326	0	326	0
Germany	291	0.7	291	0.7
Greece	48	2.1	-	-
Hungary	249	2.0	249	0.8
Ireland	65	1.5	65	1.5
Italy	199	3.5	198	2.5
Latvia	12	0	-	-
Netherlands	180	10.0	180	10.0
Poland	340	0	340	0
Portugal	170	1.2	-	-
Slovakia	54	0	54	0
Spain	220	0	220	0
United Kingdom	221	0.9	-	-
Total (15 and 10 MSs)	**2,599**	**1.5**	**2,099**	**1.4**

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

The occurrence of resistance to cefotaxime and ceftazidime in *S.* Enteritidis isolates from *Gallus gallus* is shown in Table ESBL5. Eleven MSs reported results for cefotaxime and nine MSs reported results for ceftazidime; the overall level of resistance in all reporting MSs was 0.6 % for cefotaxime and 0.6 % for ceftazidime, Austria and Hungary being the only MSs to report resistance amongst the quantitative data submitted from all MSs for analysis. Resistance to third-generation cephalosporin was detected by Belgium and the Czech Republic in 2010; these MSs did not report results for *S.* Enteritidis isolates from *Gallus gallus* in 2011.

Table ESBL5. Resistance (%) to cefotaxime and ceftazidime in* Salmonella *Enteritidis isolates from* Gallus gallus *tested by MSs in 2011

Country	Cefotaxime		Ceftazidime	
	N	% Res	N	% Res
Austria	53	3.8	53	3.8
France	41	0	41	0
Germany	133	0	133	0
Greece	17	0	-	-
Hungary	32	6.3	32	6.3
Italy	15	0	15	0
Netherlands	31	0	31	0
Poland	274	0	274	0
Portugal	41	0	-	-
Slovakia	18	0	18	0
Spain	67	0	67	0
Total (11 and 9 MSs)	**722**	**0.6**	**664**	**0.6**

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

Resistance to cefotaxime and ceftazidime in *S.* Typhimurium isolates from *Gallus gallus* is shown in Table ESBL6. Six MSs reported results for cefotaxime and five MSs reported results for ceftazidime; the overall level of resistance in all reporting MSs was 0 % for both cefotaxime and ceftazidime, with no MSs reporting resistance. The situation was similar amongst reporting MSs in 2010.

Table ESBL6. Resistance (%) to cefotaxime and ceftazidime in* Salmonella *Typhimurium isolates from* Gallus gallus *tested by MSs in 2011

Country	Cefotaxime		Ceftazidime	
	N	% Res	N	% Res
France	33	0	33	0
Germany	29	0	29	0
Hungary	10	0	10	0
Netherlands	15	0	15	0
Poland	15	0	15	0
United Kingdom	10	0	-	-
Total (6 and 5 MSs)	**112**	**0**	**102**	**0**

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

Resistance to cefotaxime and ceftazidime in *Salmonella* spp. isolates from pigs is shown in Table ESBL7. Eight MSs reported results for cefotaxime and six MSs reported results for ceftazidime; the overall level of resistance in all reporting MSs was 1.0 % for cefotaxime and 1.1 % for ceftazidime, similar to the figures obtained in 2010 and 2009. Considering the number of MSs reporting resistance, the figures differ from those reported in 2010, when only Germany reported resistance to cefotaxime and ceftazidime, at 2 %, which was the same as the figure Germany reported in 2009.

Table ESBL7. Resistance (%) to cefotaxime and ceftazidime in* Salmonella *spp. isolates from pigs tested by MSs in 2011

Country	Cefotaxime		Ceftazidime	
	N	% Res	N	% Res
Denmark[1]	371	0.3	-	-
Denmark[2]	23	0	-	-
Estonia	17	0	-	-
Germany	614	1.3	614	1.3
Hungary	35	2.9	35	2.9
Ireland	39	0	39	0
Italy	86	1.2	86	0
Netherlands	19	0	19	0
Spain	82	2.4	82	1.2
Total (8 and 6 MSs)	**1,286**	**1.0**	**875**	**1.1**

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

1. Fattening pigs, pigs unspecified and mixed herds.

2. Breeding pigs.

Resistance to third-generation cephalosporins in *S.* Typhimurium from pigs is shown in Table ESBL8. Four MSs tested *S.* Typhimurium isolates for cefotaxime resistance and three for ceftazidime resistance. The overall level of resistance for all reporting MSs was 0.2 % for cefotaxime and 0 % for ceftazidime, identical to the figures obtained in 2010. Spain was the only country to report cefotaxime resistance in *S.* Typhimurium, at a level of 5.3 %, although the number of isolates was low. Germany reported cefotaxime resistance in 0.6 % of isolates in 2010, although no resistance was detected in 2011.

Table ESBL8. Resistance (%) to cefotaxime and ceftazidime in S. Typhimurium isolates from pigs tested by MSs in 2011

Country	Cefotaxime		Ceftazidime	
	N	% Res	N	% Res
Denmark	131	0	-	-
Germany	237	0	237	0
Ireland	17	0	17	0
Spain	19	5.3	19	0
Total (4 and 3 MSs)	**404**	**0.2**	**273**	**0**

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

Eight MSs and Norway tested *Salmonella* spp. isolates from cattle for cefotaxime resistance and the results are shown in Table ESBL9. No MSs reported cefotaxime or ceftazidime resistance in *Salmonella* spp. isolates from cattle in 2011.

Table ESBL9. Resistance (%) to cefotaxime and ceftazidime in* Salmonella *spp. isolates from cattle tested by MSs and non-MS in 2011

Country	Cefotaxime		Ceftazidime	
	N	% Res	N	% Res
Estonia	15	0	-	-
Finland	11	0	-	-
Germany	146	0	146	0
Ireland	44	0	44	0
Italy	28	0	28	0
Netherlands	69	0	69	0
Spain	13	0	13	0
Sweden	24	0	-	-
Total (8 and 5 MSs)	**350**	**0**	**300**	**0**
Norway	12	0	-	-

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

Resistance to cefotaxime and ceftazidime in *Salmonella* Typhimurium isolates from cattle is shown in Table ESBL10. Five MSs reported results for cefotaxime and three MSs reported results for ceftazidime; no resistance was detected to either antimicrobial.

Table ESBL10. Resistance (%) to cefotaxime and ceftazidime in* Salmonella *Typhimurium isolates from cattle tested by MSs in 2011

Country	Cefotaxime		Ceftazidime	
	N	% Res	N	% Res
Finland	11	0	-	-
Germany	37	0	37	0
Ireland	25	0	25	0
Netherlands	24	0	24	0
Sweden	10	0	-	-
Total (5 and 3 MSs)	**107**	**0**	**86**	**0**

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

9.2.3. *Salmonella* serovars from animals demonstrating resistance to third-generation cephalosporins

Third-generation cephalosporin resistance was identified in a range of *Salmonella* serovars in 2011. Reporting MSs do not necessarily list all of the *Salmonella* serovars identified, and so the list of affected serovars is likely to be incomplete. Among the serovars that were identified as resistant to third-generation cephalosporins was a monophasic *Salmonella,* 1,4,[5],12:i:-, which was identified in pigs from Germany. Similarly, in 2010, two monophasic serovars were identified in pigs from Germany, *Salmonella* 4,12:i:- and 4,5,12:i:-.

As was the case in 2010, in 2011 the following third-generation cephalosporin-resistant serovars from one or more sources (pigs, *Gallus gallus* and/or cattle) and from one or more MSs were identified: *S*. Derby, *S*. Enteritidis, *S*. Infantis, *S*. Kentucky, *S*. Livingstone, *S*. London, *S*. Java and *S*. Typhimurium. In addition, *S.* 1,9,12:l,v:-, *S.* Cholerae-suis, *S*. Lamberhurst, *S*. Montevideo and, *S.* Ordonez with third-generation cephalosporin resistance were identified in 2011. Isolates from turkeys (*S*. Bovismorbificans from France, *S*. Bredeney from Hungary and *S.* Muenchen from Spain) and domestic solipeds (*S.* Typhimurium, DT104 from Ireland) were also found to express resistance to third-generation cephalosporins in 2011.

9.3. Third-generation cephalosporin resistance in indicator *E. coli* from food and animals

9.3.1. Third-generation cephalosporin resistance in indicator *E. coli* isolates from food

The number of indicator *E. coli* isolates recovered from meat from animals in 2011 and tested by MSs for inclusion in the report was extremely low and so these data did not qualify for the inclusion in this report.

9.3.2. Third-generation cephalosporin resistance in indicator *E. coli* isolates from animals

Table ESBL11 summarises data on resistance in indicator *E. coli* isolates from *Gallus gallus* tested by ten reporting MSs, Norway and Switzerland. All reporting countries tested isolates for cefotaxime resistance and, in addition, six reporting MSs also tested isolates for ceftazidime resistance. Overall, for the reporting MS group, the observed resistance to cefotaxime was 6.4 %, similar to the figure of 5 % reported in 2010. However, the figures of 8.1 % and 7.7 % for the Netherlands and Germany represent a decline on the percentage resistance reported in 2010, when 18 % and 14 % resistance to cefotaxime was reported in *E. coli* from broilers in the Netherlands and Germany, respectively. The overall level of resistance to ceftazidime for all reporting MSs was 5.4 %

Table ESBL11. Resistance (%) to cefotaxime and ceftazidime in indicator* E. coli *isolates from* Gallus gallus *tested by MSs and non-MSs in 2011

Country	Cefotaxime		Ceftazidime	
	N	% Res	N	% Res
Austria	173	1.7	-	-
Belgium	419	19.1	-	-
Denmark	134	0.7	-	-
Finland	316	0	-	-
France	192	6.8	192	6.8
Germany[1]	246	7.7	246	7.3
Germany[2]	642	1.6	642	1.7
Ireland	154	3.9	154	4.5
Netherlands	283	8.1	283	8.1
Poland	154	3.2	154	3.2
Spain	101	20.8	101	17.8
Total (10 and 6 MSs)	**2,814**	**6.4**	**1,772**	**5.4**
Norway	244	0.4	244	2.0
Switzerland	176	2.3	176	2.3

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

1. Isolates from broilers.

2. Isolates from laying hens.

Table ESBL12 shows resistance to cefotaxime and ceftazidime in indicator *E. coli* from pigs. The overall level of resistance for all reporting MSs was 1.7 % for cefotaxime and 1.5 % for ceftazidime, with six MSs reporting results for ceftazidime. All reporting countries detected resistance in indicator *E. coli* from pigs.

Table ESBL12. Resistance (%) to cefotaxime and ceftazidime in indicator* E. coli *isolates from pigs tested by MSs and non-MSs in 2011

Country	Cefotaxime		Ceftazidime	
	N	% Res	N	% Res
Austria	162	1.2	-	-
Belgium	157	4.5	-	-
Denmark	157	1.3	-	-
Estonia	22	4.5	22	4.5
France	184	1.1	184	1.1
Germany	859	1.9	859	1.5
Netherlands	287	1.7	287	2.4
Poland	172	1.2	172	0.6
Spain	170	0.6	170	0.6
Sweden	167	0.6	-	-
Total (10 and 6 MSs)	**2,337**	**1.7**	**1,694**	**1.5**
Norway	192	0.5	192	0.5
Switzerland	175	1.1	175	1.7

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

The results of examinations for third-generation cephalosporin resistance in indicator *E. coli* from cattle are shown in Table ESBL13. Seven MSs tested indicator *E. coli* isolates from cattle for cefotaxime and/or ceftazidime resistance. The overall occurrence of resistance to cefotaxime was 0.9 % and to ceftazidime was 0.6 % in all reporting MSs, a decrease on the figures of 3 % and 4 % reported in 2010. Austria, Denmark and Spain did not detect cefotaxime resistance in indicator *E. coli* from cattle in 2011, and in the remaining MSs a low or very low level (0.4-3.7 %) of resistance to both antimicrobials was detected. Resistance to cefotaxime in isolates from young meat production animals (1-2 years) was 0.4 % in Germany in 2011, a marked difference with figures reported in 2010, when all isolates derived from veal calves and the occurrence of resistance to cefotaxime and ceftazidime was 10 % and 8 %, respectively.

Table ESBL13. Resistance (%) to cefotaxime and ceftazidime in indicator* E. coli *isolates tested from cattle by MSs and non-MS in 2011

Country	Cefotaxime		Ceftazidime	
	N	% Res	N	% Res
Austria	172	0	-	-
Belgium	188	3.7	-	-
Denmark	93	0	-	-
Germany	909	0.4	909	0.6
Netherlands	431	1.2	431	0.9
Poland	173	1.2	173	0.6
Spain	109	0	109	0
Total (7 and 4 MSs)	**2,075**	**0.9**	**1,622**	**0.6**
Switzerland	182	0	182	0.5

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

9.4. Discussion

In 2011, as in 2010, resistance to third-generation cephalosporins was generally detected at only low levels in *Salmonella* and indicator *E. coli* isolates recovered from food and animals. Among reporting MSs overall, the occurrence of resistance to third-generation cephalosporins, as determined by resistance to cefotaxime in *Salmonella* spp. from *Gallus gallus*, pigs and cattle, was 1.5 %, 1.0 % and 0 % respectively, very similar to the figures of 1 %, 0.8 % and 0.3 %, respectively, obtained in 2010, and 2 %, 0.7 % and 0.4 %, respectively, obtained in 2009. In *E. coli* the corresponding figures were 6.4 %, 1.7 % and 0.9 % in 2011, 5 %, 1 % and 3 % in 2010 and 9 %, 2 % and 0.7 % in 2009. Among *Salmonella* spp. in broiler and pig meat, the level of resistance was 3.3 % and 0.9 %, respectively, in 2011 and 4 % and 0.2 %, respectively in 2010.

Therefore, although the summary figures show limited fluctuation in the occurrence of resistance, some trends are evident in particular MSs. For example, eight MSs reported the results for resistance to cefotaxime in *Salmonella* spp. isolates recovered from meat from broilers (Table ESBL1). Resistance was reported at a low level in all MSs except the Netherlands, where the level of resistance was 31.9 % to both cefotaxime and ceftazidime; the figures also represent an increase on the figures obtained for 2010, when 11 % and 8 % of isolates were resistant to cefotaxime and ceftazidime, respectively. The figures for cefotaxime resistance in *Salmonella* spp. from *Gallus gallus* (Table ESBL4) show a much lower level of cefotaxime resistance (10.0 %) for the Netherlands than was observed for isolates from poultry meat. The reason for this difference is not known, but it might reflect issues such as sampling retail meat, which may include not only domestic poultry production, but also production from other countries, or, alternatively, cross-contamination of carcases at slaughter with resistant organisms.

The indicator *E. coli* population in healthy animals may constitute a reservoir of resistance genes which can be transferred to zoonotic organisms such as *Salmonella*, and this process may be particularly enhanced in some circumstances (for example, under selection pressure resulting from antimicrobial usage). Once *Salmonella* isolates have acquired plasmids which carry genes conferring resistance to third-generation cephalosporins (either ESBL or AmpC resistance genes) then dissemination of such resistant *Salmonella* clones will also play a major part in influencing the occurrence of third-generation cephalosporin resistance. Considering the prevalence of resistance to cefotaxime resistance in MSs to *Salmonella* spp. and *E. coli* in *Gallus gallus*, then in all reporting MSs, with the exception of the Netherlands, the prevalence of resistance is higher in *E. coli* than it is in *Salmonella* spp. The reason for this difference is not known, but it might reflect the dissemination of cefotaxime-resistant clones in poultry in the Netherlands, for example serovars such as *Salmonella* Java.

The situation is similar considering cefotaxime resistance in isolates from pigs: in all MSs with the exception of Spain, the prevalence of cefotaxime resistance is higher in *E. coli* isolates, than it is in *Salmonella* spp. In cattle, all *Salmonella* spp. isolates were susceptible to cefotaxime, whereas for MSs also reporting resistance to *E. coli*, resistance in *E. coli* was detected in all of those MSs. Therefore, in most MSs, it appears that *E. coli* is a reservoir of beta-lactamase resistance, which is less frequently observed in *Salmonella* spp.

In most MSs, in both *Salmonella* spp. and *E. coli*, the prevalence of resistance to cefotaxime was equal to that observed to ceftazidime; however, the figures differed slightly in some cases, suggesting that beta-lactamase enzymes which were preferentially cefotaximases or ceftazidimases may have been responsible.

Resistance to cefotaxime in *Salmonella* spp. from broiler meat was 3.3 %, whereas it was 0.9 % in meat from pigs. In general, cefotaxime resistance was therefore more common in *Salmonella* isolates from broilers than from pigs, and this was particularly marked in some countries, for example the Netherlands, where 31.9 % of isolates from broiler meat were resistant, whereas resistance was not detected in isolates from pig meat. The small sample size may account for some of this variation; however, it does reflect findings described for *E. coli* in the literature: when the occurrence of cephalosporin-resistant *E. coli* from retail broiler meat and pig meat were compared in the Netherlands, the ESBL prevalence was found to be 79.8 % in broiler meat and 1.8 % in pork (Overdevest et al., 2011).

Considering the *Salmonella* serovars of particular public health importance, no resistance to cefotaxime was detected in *S.* Typhimurium in meat from pigs in 2010 or 2011. Austria and Hungary detected cefotaxime resistance in *S.* Enteritidis from *Gallus gallus* in 2011; Austria also reported data for *S.* Enteritidis from *Gallus gallus* in 2010, but did not detect cefotaxime resistance. In 2010, cefotaxime resistance in *S.* Enteritidis from *Gallus gallus* was reported only by the Czech Republic.

A noteworthy trend is that the number of MSs reporting cefotaxime resistance in *Salmonella* spp. from pigs has increased. Resistance to cefotaxime in *E. coli* from young meat production animals (1-2 years) in Germany, was 0.4 % in 2011; a marked difference with the figures reported in 2010 when all isolates originated from veal calves and the occurrence of resistance to cefotaxime and ceftazidime was 10 % and 8 %, respectively. Reporting the results by animal production type provides a means where differences in the occurrence of resistance which are related to husbandry methods, age or stage of production may become apparent, and this is the first year in which animal production type has been included in this way.

Spain detected 26 % resistance to ceftazidime in *Salmonella* spp. from *Gallus gallus* in 2009; however, resistance was not detected to cefotaxime or ceftazidime in 2010 or 2011. Such fluctuations in the occurrence of resistance could be related to a number of factors, including the general measures which are applied throughout the EU to control *Salmonella* in poultry.

Resistance to third-generation cephalosprins was detected in a number of serovars of particular public health importance, including *S*. Typhimurium, *S*. Enteritidis, *S*. Infantis, *S*. Kentucky, *S*. Java and monophasic *Salmonella*. Previous outbreaks of ESBL-producing salmonellae affecting poultry and humans have occurred, for example involving *S.* Virchow (Weill et al., 2004; Bertrand et al., 2006), and it is important that the monitoring performed can identify such serovars. It may be assumed, that even though the monitoring has not been designed to detect outbreaks, it should hopefully reflect indirectly serovars involved in large outbreak(s).

EFSA recently published a report providing detailed recommendations and discussions relating to how future surveillance for third-generation cephalosporin, ESBL, AmpC and carbapenem resistance monitoring could be enhanced. The introduction provides further details on the methods by which surveillance could be revised in the future.

10. FARM-TO-FORK ANALYSIS

10.1. Introduction

A number of MSs reported the occurrence of antimicrobial resistance in *Salmonella* and *Campylobacter* in humans, animals and food products derived from those animals in 2011. This chapter collates and summarises the available data, showing the occurrence of resistance which was reported along the food chain and in humans. This is the third year in which this type of analysis has been included in the EU Summary Report on antimicrobial resistance. The aim is to highlight potential connections or associations which may exist between resistance occurring in the bacterial isolates from animals, foods derived from those animals and humans. The direct comparison of the figures along the food chain for a MS is likely to simplify the complexity of the inputs which determine the occurrence of resistance observed in human isolates (for example, no account may have been taken of imported foods or infections resulting from foreign travel). Also, because the breakpoints used to assess the resistance of human isolates have not yet been fully harmonised, inter-country comparisons may not always be valid. For this reason, this analysis should perhaps best be viewed as an exploratory investigation, which will hopefully provide a degree of stimulus towards greater harmonisation.

In addition to differences in the methodology and breakpoints used, direct comparison of the occurrence of resistance in animals food and man, may also be problematic because of some differences in the methods by which isolates have been collected, for example in the case of food-producing animals, whether they were collected during routine surveillance, random sampling of carcasses at slaughterhouses, or through diagnostic clinical work. On the human side, similar considerations apply, relating to whether the isolate has been examined and typed for treatment purposes or as part of antimicrobial resistance surveillance. Ideally, the methodology and breakpoints used for the testing of isolates from humans, food and animals should be standardised and systematic screening of representative strains (i.e. involving a random sample of isolates and an appropriate sample size) undertaken. In relation to isolates from food, a further difficulty in interpreting data is the relative importance of antimicrobial-resistant organisms in imported food in relation to human infection, as compared to the contribution of domestically-produced food. The relative quantities of imported and domestically-produced food may therefore be relevant in relation to human infections for a particular MS. Many of these concerns have previously been addressed in the joint opinion on antimicrobial resistance focused on zoonotic infections, published in November 2009 (EFSA, 2009d). In some circumstances, even though the results obtained for humans, animals and food may not be directly comparable, they may indicate developing and consistent trends between the different types of samples examined. In this chapter, results from humans, animals and food have only been included where representative numbers of isolates are available from each sampling category for each country.

In this section of the report, antimicrobial resistance data from humans, animals and food stuffs (meat) are described for the following antimicrobial/micro-organism combinations:

- **Erythromycin** and **ciprofloxacin** in *C. jejuni* and *C. coli* from humans, poultry (*Gallus gallus*) and from food products derived from poultry, where relevant data are available.
- **Cefotaxime** and **ciprofloxacin** in *S.* Typhimurium from humans, poultry (*Gallus gallus*), meat from broilers, pigs, meat from pigs and cattle and in *S.* Enteritidis from humans, poultry and meat from broilers, where relevant data are available.

There were only data available from a few MSs for these combinations of antimicrobials from humans, animal and food. Human data are generally qualitative and cannot therefore be re-interpreted using an appropriate revised breakpoint. The majority of MSs reporting human data used CLSI methods and clinical breakpoints and in order to harmonise the farm-to-fork analysis for the above antimicrobial/micro-organism combinations, the quantitative MIC data from animals and food have been re-interpreted using the recent clinical breakpoints defined by CLSI and listed in the tables below. Therefore, the occurrence of resistance shown in this chapter for bacterial isolates from animals and food may differ from that shown in other chapters and that is because this chapter analyses the data using clinical breakpoints whereas the other quantitative chapters have used epidemiological cut-off values to analyse data. All MSs submitting quantitative data for animals or food for the selected antimicrobial organism combinations have been included in the tables; the corresponding data for humans from MSs for the respective relevant categories in

animals and/or food has been included wherever this is available. The human, animal and food data in this chapter has therefore been analysed for most MSs after applying CLSI clinical breakpoints; those breakpoints were selected to enable the inclusion of the greatest amount of data available. For the optimal detection of emerging resistance, analysis using the epidemiological cut-off values would have been preferable; however, the data have also been analysed after applying EUCAST epidemiological cut-off values wherever this is possible and the resulting figures are given in parentheses in the results tables below.

10.2. Breakpoints used for the farm-to-fork analysis

The clinical breakpoints (CBP) defined by CLSI (*Campylobacter* CLSI document M45-A, *Salmonella* CLSI document M100 S21) were used to re-analyse the quantitative MIC susceptibility data submitted by MSs for bacterial isolates obtained from animals and food for the analysis performed in this chapter. The CLSI clinical breakpoints are shown in Table FFA1, together with EUCAST clinical breakpoints and epidemiological cut-off values. Over the reporting period, some of the breakpoints have been revised and the pre-2011 CLSI breakpoints (CLSI documents M100 S17-S19) were used by some MSs and the post-2011 CLSI breakpoints (CLSI documents M100 S20-S21) by others for susceptibility testing of human isolates. The analysis used the more recent CLSI breakpoints, which are more congruent with the clinical breakpoints derived by EUCAST.

The data have also been analysed after applying EUCAST epidemiological cut-off values wherever this is possible and the resulting figures are given in parentheses in tables FFA3-10 below.

Table FFA1. CLSI Clinical breakpoints used for the farm-to-fork analysis

Organism	Antimicrobial	Pre-2011 CLSI MIC Breakpoint in mg/L (R≥)	Post-2011 CLSI MIC Breakpoint in mg/L (R≥)	EUCAST Clinical MIC Breakpoint in mg/L (R>)	EUCAST / EFSA Epidemiological Cut-off Value in mg/L (R>)
Salmonella	Ciprofloxacin	≥4	≥4	>1	>0.06
Salmonella	Cefotaxime	≥64	≥4	>2	>0.5
Campylobacter spp.	Ciprofloxacin	≥4	≥4	NA	>1
C. coli	Erythromycin	≥32	≥32	NA	>16
C. jejuni	Erythromycin	≥32	≥32	NA	>4

NA = not available at the time of production of the report.

Human isolates were tested mainly in accordance with CLSI disc diffusion recommendations. The breakpoints used to interpret human data are listed in Table FFA2 for the MSs that are included in this analysis.

Table FFA2. Breakpoints (mg/L) used for the analysis of human data for MSs also submitting data for animals or food, including equivalent MIC breakpoints for disc diffusion test results, where available.

Member State	*Salmonella*		*Campylobacter coli* and *C. jejuni*	
	Cefotaxime	Ciprofloxacin	Ciprofloxacin	Erythromycin
Austria	>2	>1	≥4	≥32
Denmark	>0.5	>0.06	-	-
Estonia	≥1	≥0.125	≥1	≥4
France	-	-	≥1	NS
Germany	>8	>2	-	-
Greece	≥4	≥4	-	-
Hungary	≥4	≥4	≥1	-
Ireland	>2	>1	-	-
Italy	≥64	≥4	≥4	≥32
Latvia	-	≥4	-	-
Lithuania	≥64	≥4	>1	>0.5
Luxembourg	≥4	≥4	≥1	≥4
Malta	-	≥2	≥1	≥4
Netherlands	>0.5	>0.06	-	-
Romania	≥4	≥4	-	-
Slovakia	≥64	≥4	≥4	≥32
Slovenia	≥4	≥4	≥4	≥32
Spain	≥4	≥4	≥4	≥32
United Kingdom	≥1	≥0.125	≥1	≥4

NS = Equivalent breakpoint concentration not stated in disc diffusion method.

10.3. *Campylobacter jejuni* and *C. coli*

Erythromycin and ciprofloxacin resistance were analysed in isolates of *C. jejuni* and *C. coli* from humans, animals and from food products derived from animals, where relevant data were available. The data are shown in tables FFA3-6.

Table FFA3. Resistance (%) to erythromycin in C. coli from humans, Gallus gallus, food derived from poultry and pigs in 2011, interpreted using CLSI clinical breakpoints for animals and food

Country	Erythromycin Resistance (CBP ≥32 mg/L)							
	Humans		*Gallus gallus*		Broiler meat		Pigs	
	N	% Res	N	% Res	N	% Res	N	% Res
Austria	36	8.3	48	6.3	47	2.1	-	-
Belgium	-	-	-	-	81	11.1	-	-
Czech Republic	-	-	24	4.2	-	-	-	-
Denmark	-	-	-	-	-	-	102	6.9
France	759	7.8	79	13.9	-	-	82	45.1
Germany	-	-	25	32.0	82	17.1	-	-
Hungary	-	-	35	0	61	3.3	76	15.8
Ireland	-	-	32	3.1	-	-	-	-
Italy	-	-	-	-	14	50.0	-	-
Lithuania	45	2.2	-	-	-	-	-	-
Luxembourg	60	23.3	-	-	-	-	-	-
Malta	40	7.5	-	-	-	-	-	-
Netherlands	-	-	18	11.1	42	21.4	156	22.4
Poland	-	-	-	-	157	0.6	-	-
Romania	-	-	-	-	59	16.9	-	-
Slovenia	42	7.1	-	-	-	-	-	-
Spain	51	33.3	81	33.3	-	-	81	63.0
Sweden	-	-	-	-	-	-	83	0
United Kingdom	61	14.8	-	-	-	-	-	-
Total MSs*	**1,094**	**10.0**	**342**	**15.5**	**543**	**9.8**	**580**	**24.5**
Switzerland	-	-	10	0	-	-	185	7.6

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

* = total MSs represents all MSs contributing to each column in this table.

Note: Table FFA2 shows the breakpoints used for human isolates. The CLSI breakpoint of ≥32 corresponds to the EUCAST ECOFF of >16 when a doubling dilution series is used to determine MIC values.

Table FFA4. Resistance (%) to erythromycin in C. jejuni from humans, Gallus gallus and food derived from poultry in 2011, interpreted using CLSI clinical breakpoints for animals and food

Country	Erythromycin Resistance (CBP ≥32 mg/L)					
	Humans		*Gallus gallus*		Broiler meat	
	N	% Res	N	% Res	N	% Res
Austria	393	0.3	116	0 (0)	84	0 (0)
Belgium	-	-	-	-	259	7.7(7.7)
Czech Republic	-	-	57	0(0)	-	-
Denmark	-	-	43	0(0)	61	0 (0)
Estonia	183	2.2	-	-	-	-
France	4,278	1.6	51	0(0)	-	-
Finland	-	-	40	0(0)	-	-
Germany	-	-	59	3.4(3.4)	188	0.5(0.5)
Hungary	-	-	36	5.6(5.6)	33	0(0)
Ireland	-	-	114	0.9(0.9)	-	-
Italy	189	6.3	-	-	-	-
Lithuania	296	0.3	-	-	-	-
Luxembourg	623	0.6	-	-	-	-
Malta	149	0.7	-	-	-	-
Netherlands	-	-	104	0(1.9)	83	3.6(3.6)
Poland	-	-	-	-	174	0(0)
Romania	-	-	-	-	52	9.6(9.6)
Slovakia	962	0.5	-	-	-	-
Slovenia	882	1.0	-	-	-	-
Spain	166	4.8	55	3.6(3.6)	-	-
United Kingdom	687	2.2	-	-	-	-
Total MSs*	**8,808**	**1.5**	**685**	**1.0(1.6)**	**947**	**3.1(3.1)**
Switzerland	-	-	150	2.0(5.3)	-	-
Iceland	121	0	-	-	-	-
Norway	-	-	48	0(0)	-	-

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

* = total MSs represents all MSs contributing to each column in this table.

Note: Table FFA2 shows the breakpoints used for human isolates. Figures in parentheses indicate the occurrence of resistance determined using EUCAST epidemiological cut-off values.

Table FFA5. Resistance (%) to ciprofloxacin in* C. coli *from* humans, Gallus gallus*, food derived from poultry in 2011, interpreted using CLSI clinical breakpoints for animals and food

Country	Ciprofloxacin Resistance (CBP ≥4 mg/L)					
	Humans		*Gallus gallus*		Broiler meat	
	N	% Res	N	% Res	N	% Res
Austria	36	69.4	48	75.0(79.2)	47	48.9(55.3)
Belgium	-	-	-	-	81	61.7(63.0)
Czech Republic	-	-	24	87.5(87.5)	-	-
France	759	57.8	79	67.1(67.1)	-	-
Germany	-	-	25	92.0(92.0)	82	86.6(86.6)
Hungary	-	-	35	85.7(85.7)	61	86.9(90.2)
Ireland	-	-	32	37.5(40.6)	-	-
Italy	-	-	-	-	14	71.4(71.4)
Lithuania	39	74.4	-	-	-	-
Luxembourg	60	75.0	-	-	-	-
Malta	40	55.0	-	-	-	-
Netherlands	-	-	18	44.4(44.4)	42	78.6(78.6)
Poland	-	-	-	-	157	81.5(82.2)
Romania	-	-	-	-	59	79.7(79.7)
Slovenia	42	52.4	-	-	-	-
Spain	51	78.4	81	93.8(93.8)	-	-
United Kingdom	61	47.5	-	-	-	-
Total MSs*	**1,088**	**59.8**	**342**	**75.7(76.6)**	**543**	**76.4(77.7)**
Switzerland	-	-	10	20.0(20.0)	-	-

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

* = total MSs represents all MSs contributing to each column in this table.

Note: Table FFA2 shows the breakpoints used for human isolates. Figures in parentheses indicate the occurrence of resistance determined using EUCAST epidemiological cut-off values.

Table FFA6. Resistance (%) to ciprofloxacin in* C. jejuni *from humans,* Gallus gallus *and food derived from poultry in 2011, interpreted using CLSI clinical breakpoints for animals and food

Country	Ciprofloxacin Resistance (CBP ≥4 mg/L)					
	Humans		*Gallus gallus*		Broiler meat	
	N	% Res	N	% Res	N	% Res
Austria	393	65.4	116	69.0(69.0)	84	53.6(53.6)
Belgium	-	-	-	-	259	36.7(36.7)
Czech Republic	-	-	57	52.6(54.4)	-	-
Denmark	-	-	43	23.3(23.3)	61	11.5(11.5)
Estonia	183	58.5	-	-	-	-
France	4,278	51.3	51	56.9(56.9)	-	-
Finland	-	-	40	0(0)	-	-
Germany	-	-	59	62.7(62.7)	188	64.9(64.9)
Hungary	27	59.3	36	86.1(86.1)	33	81.8(84.8)
Ireland	-	-	114	39.5(40.4)	-	-
Italy	162	69.8	10	60.0(60.0)	13	76.9(76.9)
Lithuania	260	83.1	-	-	-	-
Luxembourg	623	51.8	-	-	-	-
Malta	147	69.4	-	-	-	-
Netherlands	-	-	104	66.3(67.3)	83	63.9(63.9)
Poland	-	-	-	-	174	89.1(90.2)
Romania	-	-	-	-	52	84.6(84.6)
Slovakia	868	20.9	-	-	-	-
Slovenia	882	67.2	-	-	-	-
Spain	166	87.3	55	94.5(94.5)	-	-
United Kingdom	658	44.1	-	-	-	-
Total MSs*	**8,647**	**52.5**	**685**	**56.8(57.2)**	**947**	**58.9(59.2)**
Switzerland	-	-	150	40.7(40.7)	-	-
Iceland	120	45.8	-	-	-	-
Norway	-	-	48	4.2(4.2)	-	-

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

* = total MSs represents all MSs contributing to each column in this table.

Note: Table FFA2 shows the breakpoints used for human isolates. Figures in parentheses indicate the occurrence of resistance determined using EUCAST epidemiological cut-off values.

10.4. *Salmonella* Enteritidis and *S.* Typhimurium

Cefotaxime and ciprofloxacin resistance were analysed in isolates of *S.* Typhimurium from humans, poultry (*Gallus gallus*), meat from broilers, pigs, meat from pigs and cattle and in *S.* Enteritidis from humans, poultry and meat from broilers, where relevant data are available. The data are shown in tables FFA7-10.

Table FFA7. Resistance (%) to cefotaxime in S. Typhimurium from humans, Gallus gallus, meat from broilers, pigs, meat from pigs and cattle in 2011, interpreted using CLSI clinical breakpoints for animals and food

Country	Cefotaxime Resistance (CBP ≥4 mg/L)											
	Humans		*Gallus gallus*		Broiler meat		Pigs		Pig meat		Cattle	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	302	1.3	-	-	-	-	-	-	-	-	-	-
Belgium	-	-	-	-	34	0(0)	-	-	103	0(0)	-	-
Denmark	244	0.4	-	-	-	-	131	0(0)	28	0(0)	-	-
Estonia	38	0	-	-	-	-	-	-	-	-	-	-
Finland	-	-	-	-	-	-	-	-	-	-	11	0(0)
France	-	-	33	0(0)	-	-	-	-	-	-	-	-
Germany	811	1.1	29	0(0)	-	-	237	0(0)	20	0(0)	37	0(0)
Hungary	320	0	10	0(0)	-	-	-	-	12	0(0)	-	-
Ireland	87	0	-	-	-	-	17	0(0)	57	0(0)	25	0(0)
Italy	412	2.7	-	-	-	-	-	-	12	0(0)	-	-
Lithuania	174	0	-	-	-	-	-	-	-	-	-	-
Luxembourg	31	0	-	-	-	-	-	-	-	-	-	-
Netherlands	314	0	15	0(0)	-	-	-	-	-	-	24	0(0)
Poland	-	-	15	0(0)	-	-	-	-	-	-	-	-
Romania	94	1.1	-	-	-	-	-	-	18	0(0)	-	-
Slovakia	21	4.8	-	-	-	-	-	-	-	-	-	-
Slovenia	56	0	-	-	-	-	-	-	-	-	-	-
Spain	274	0.7	-	-	-	-	19	0(5.3)	-	-	-	-
Sweden	-	-	-	-	-	-	-	-	-	-	10	0(0)
United Kingdom	2,147	1.2	10	0(0)	-	-	-	-	-	-	-	-
Total MSs*	**5,325**	**1.0**	**112**	**0(0)**	**34**	**0(0)**	**404**	**0(0.2)**	**250**	**0(0)**	**107**	**0(0)**

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

* = total MSs represents all MSs contributing to each column in this table.

Note: Table FFA2 shows the breakpoints used for human isolates. Figures in parentheses indicate the occurrence of resistance determined using EUCAST epidemiological cut-off values.

Note: Data for *Gallus gallus* includes *S.* Typhimurium isolates from broiler flocks and laying hen flocks.

Table FFA8. Resistance (%) to ciprofloxacin in S. Typhimurium from humans, Gallus gallus, meat from broilers, pigs, meat from pigs and cattle in 2011, interpreted using CLSI clinical breakpoints for animals and food

Country	Ciprofloxacin Resistance (CBP ≥4 mg/L)											
	Humans		*Gallus gallus*		Broiler meat		Pigs		Pig meat		Cattle	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Austria	302	0	-	-	-	-	-	-	-	-	-	-
Belgium	-	-	-	-	34	0(11.8)	-	-	103	0(3.9)	-	-
Denmark	244	4.9	-	-	-	-	131	0(0)	28	0(0)	-	-
Estonia	39	0	-	-	-	-	-	-	-	-	-	-
Finland	-	-	-	-	-	-	-	-	-	-	11	0(0)
France	-	-	33	0(0)	-	-	-	-	-	-	-	-
Germany	811	0.4	29	0(0)	-	-	237	0(3.8)	18	0(10.0)	37	0(2.7)
Greece	54	0	-	-	-	-	-	-	-	-	-	-
Hungary	320	0	10	0(10.0)	-	-	-	-	12	0(8.3)	-	-
Ireland	87	0	-	-	-	-	17	0(23.5)	57	0(7.0)	25	0(0)
Italy	486	13	-	-	-	-	-	-	12	0(25.0)	-	-
Lithuania	194	0	-	-	-	-	-	-	-	-	-	-
Luxembourg	31	3.2	-	-	-	-	-	-	-	-	-	-
Malta	24	4	-	-	-	-	-	-	-	-	-	-
Netherlands	314	12.7	15	0(0)	-	-	-	-	-	-	24	0(0)
Poland	-	-	15	0(73.3)	-	-	-	-	-	-	-	-
Romania	94	0	-	-	-	-	-	-	18	5.6(33.3)	-	-
Slovakia	29	10.3	-	-	-	-	-	-	-	-	-	-
Slovenia	56	0	-	-	-	-	-	-	-	-	-	-
Spain	273	0	-	-	-	-	19	0(26.3)	-	-	-	-
Sweden	-	-	-	-	-	-	-	-	-	-	10	0(0)
UK	2,196	6.6	10	0(0)	-	-	-	-	-	-	-	-
Total MSs*	**5,554**	**4.8**	**112**	**0(10.7)**	**34**	**0(11.8)**	**404**	**0(4.5)**	**250**	**0.4(8.0)**	**107**	**0(0.9)**

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

* = total MSs represents all MSs contributing to each column in this table.

Note: Table FFA2 shows the breakpoints used for human isolates. Figures in parentheses indicate the occurrence of resistance determined using EUCAST epidemiological cut-off values.

Note: Data for *Gallus gallus* includes *S.* Typhimurium isolates from broiler flocks and laying hen flocks.

Table FFA9. Resistance (%) to cefotaxime in S. Enteritidis from humans, Gallus gallus and meat from broilers in 2011, interpreted using CLSI clinical breakpoints for animals and food

Country	Cefotaxime Resistance (CBP ≥4 mg/L)					
	Humans		*Gallus gallus*		Broiler meat	
	N	% Res	N	% Res	N	% Res
Austria	1,266	0.2	53	3.8(3.8)	-	-
Belgium	-		-	-	57	0(0)
Denmark	288	0.7	-	-	-	-
Estonia	185	1.1	-	-	-	-
France	-		41	0(0)	-	-
Germany	191	0	133	0(0)	16	0(0)
Greece	39	0	17	0(0)	-	-
Hungary	20	0	32	6.3(6.3)	-	-
Ireland	58	0	-	-	-	-
Italy	120	1.7	16	0(0)	-	-
Lithuania	1,496	0.2	-	-	-	-
Luxembourg	30	0	-	-	-	-
Netherlands	317	0	31	0(0)	-	-
Poland	-	-	274	0(0)	-	-
Portugal	-	-	41	0(0)	-	-
Latvia	-	-	-	-	19	0(0)
Romania	120	0	-	-	-	-
Slovakia	169	3	18	0(0)	-	-
Slovenia	210	0	-	-	-	-
Spain	613	0.2	67	0(0)	-	-
United Kingdom	2,566	0.3	-	-	-	-
Total MSs*	**7,688**	**0.3**	**723**	**0.6(0.6)**	**92**	**0(0)**

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

* = total MSs represents all MSs contributing to each column in this table.

Note: Table FFA2 shows the breakpoints used for human isolates. Figures in parentheses indicate the occurrence of resistance determined using EUCAST epidemiological cut-off values.

Note: Data for *Gallus gallus* includes *S.* Typhimurium isolates from broiler flocks and laying hen flocks.

Table FFA10. Resistance (%) to ciprofloxacin in S. Enteritidis from humans, Gallus gallus and meat from broilers in 2011, interpreted using CLSI clinical breakpoints for animals and food

Country	Ciprofloxacin Resistance (CBP ≥4 mg/L)					
	Humans		*Gallus gallus*		Broiler meat	
	N	% Res	N	% Res	N	% Res
Austria	1,266	0.1	53	0(5.7)	-	-
Belgium	-	-	-	-	57	0(1.8)
Denmark	288	23.6	-	-	-	-
Estonia	217	1.4	-	-	-	-
France	-	-	41	0(2.4)	-	-
Germany	191	0	133	0(0)	16	0(25.0)
Greece	111	0	17	0(11.8)	-	-
Hungary	20	0	32	0(9.4)	-	-
Ireland	58	0	-	-	-	-
Italy	148	15.5	16	0(6.3)	-	-
Latvia	97	0	-	-	19	0(15.8)
Lithuania	1,464	0.6	-	-	-	-
Luxembourg	30	3.3	-	-	-	-
Malta	47	6.4	-	-	-	-
Netherlands	317	9.1	31	0(6.5)	-	-
Poland	-	-	274	0(47.4)	-	-
Portugal	-	-	41	0(90.2)	-	-
Romania	120	0	-	-	-	-
Slovakia	172	1.7	18	0(0)	-	-
Slovenia	210	0	-	-	-	-
Spain	613	0.2	67	0(65.7)	-	-
United Kingdom	2,596	33.7	-	-	-	-
Total MSs*	**7,965**	**12.8**	**723**	**0(30.8)**	**92**	**0(8.7)**

N = number of isolates tested.

% Res = percentage of resistant isolates.

- = no data reported.

* = total MSs represents all MSs contributing to each column in this table.

Note: Table FFA2 shows the breakpoints used for human isolates. Figures in parentheses indicate the occurrence of resistance determined using EUCAST epidemiological cut-off values.

10.5. Resistance data from the Netherlands relating to Verotoxigenic *E. coli* O157

In 2010 and 2011 the Netherlands voluntarily submitted data on the occurrence of resistance in verotoxigenic *E. coli* isolates from cattle, meat and humans in 2010 and from a number of sources in 2011. The results provide a good illustration of how antimicrobial resistance results may be used to investigate possible relationships between bacteria occurring in different epidemiological niches and whether organisms are being shared between those different niches. Use of antimicrobial resistance data in this way provides a means by which potential sources of human infection can be identified or eliminated from investigations. In this case, the striking similarity between the prevalence of resistance in isolates cattle, meat and humans, supports the view that cattle are a probable source, via the food chain for at least some of the human infections. In combination with other secondary typing methods, the antimicrobial resistance data therefore provides a powerful investigatory screening tool and can support (as in this case) or refute current thinking on the likely epidemiology of infection.

Table FFA11. Resistance (%) to antimicrobials in verotoxigenic* E. coli *O157 from cattle, cattle hides and humans from the Netherlands in 2010, interpreted using ECOFFs

Antimicrobial	Humans		Cattle Hides		Calves < 1 Year	
	N	% Res	N	% Res	N	% Res
Chloramphenicol	58	2	35	6	67	4
Tetracyclines	58	5	35	11	67	15
Ciprofloxacin	58	0	35	0	67	0
Nalidixic acid	58	0	35	0	67	0
Trimethoprim	58	2	35	6	67	6
Streptomycin	58	10	35	11	67	12
Gentamicin	58	0	35	0	67	0
Ampicillin	58	5	35	6	67	7
Cefotaxime	58	2	35	0	67	0
Ceftazidime	58	3	35	0	67	0
Sulfonamides	58	10	35	11	67	16

N = number of isolates tested.

% Res = percentage of resistant isolates.

In this case, the resistance figures are broadly similar from the different sources which were examined; however, particular resistances (for example to third generation cephalosporins in the human isolates) might assist further tracing in case investigations.

Table FFA12. Resistance (%) to antimicrobials in verotoxigenic* E. coli *O157 from diverse sources in the Netherlands in 2011, interpreted using Breakpoints[1] as shown

Antimicrobial Breakpoint Used (R>x mg/L)	Vegetables at Retail		Fruits at Retail		Herbs at Retail		Bovine Meat at Retail		Bovine Meat (Veal) at Retail		Ovine meat at Retail		Porcine Meat at Retail		Meat from Turkeys at Retail		Meat from Broilers at Retail	
	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res	N	% Res
Chloramphenicol 16 mg/L	56	0	9	0	33	24.2	224	3.1	31	12.9	7	0	178	6.2	46	23.9	191	16.2
Tetracyclines 8 mg/L	56	3.6	9	0	33	42.4	224	14.7	31	45.2	7	28.6	178	30.3	46	69.6	191	52.9
Ciprofloxacin 0.06 mg/L	56	1.8	9	0	33	33.3	224	4.0	31	6.5	7	0	178	2.8	46	39.1	191	56.5
Nalidixic acid 16 mg/L	56	1.8	9	0	33	21.2	224	4.0	31	6.5	7	0	178	2.2	46	37.0	191	52.4
Trimethoprim 2 mg/L	56	1.8	9	0	33	33.3	224	13.8	31	29.0	7	14.3	178	24.2	46	34.8	191	40.8
Streptomycin 16 mg/L	56	1.8	9	0	33	36.4	224	15.2	31	35.5	7	14.3	178	25.8	46	50.0	191	55.0
Gentamicin 2 mg/L	56	0	9	0	33	6.1	224	0.4	31	0	7	0	178	5.1	46	13.0	191	13.1
Ampicillin 8 mg/L	56	1.8	9	0	33	33.3	224	11.6	31	32.3	7	14.3	178	23.0	46	76.1	191	66.0
Cefotaxime 0.25 mg/L	56	0	9	0	33	0	224	1.8	31	3.2	7	0	178	1.7	46	2.2	191	22.5
Ceftazidime 0.5 mg/L	56	1.8	9	0	33	3.0	224	1.8	31	0	7	0	178	2.2	46	2.2	191	20.9
Sulfonamides 64 mg/L	56	1.8	9	0	33	33.3	224	21.0	31	32.3	7	28.6	178	33.7	46	56.5	191	58.1

N = number of isolates tested.

% Res = percentage of resistant isolates.

1. The breakpoints used equate to EUCAST ECOFFs for *E. coli* described in the EFSA recommendations (EFSA, 2008b) except for ciprofloxacin and sulfonamides where breakpoints differing from those described in the EFSA recommendations were used.

10.6. Discussion

This chapter reports the occurrence of resistance obtained for isolates of *S.*Typhimurium and *S.* Enteritidis as well as for *C. jejuni* and *C. coli* from humans, animals and food. Results have been included wherever these are available from the reporting MSs, subject to certain criteria relating to minimum numbers of isolates tested. There are numerous gaps in the data available reported by MSs in relation to the reporting of isolates from humans or from the various animal or food categories; few countries reported data for isolates from man, animals and food. In addition, data were only available for a small number of isolates for many of these combinations. The relative importance of imported foods (for example in relation to pathogen prevalence, occurrence of resistance and relative quantity of food imported) within a given MS for human infections occurring in that MS has not been considered and will play a role in the resistance figures obtained for isolates of *Salmonella* and *Campylobacter* originating from humans. Likewise, the impact on the results of travel-acquired human infections from other countries where antimicrobial resistance can differ from that in the EU has not been considered.

A major problem encountered in the analysis is the difference in interpretative criteria applied to human isolates from different MSs. Different MSs apply differing breakpoints to interpret their susceptibility test results and this makes comparative analysis of the data for bacterial isolates originating from different sources complex, because the human data is qualitative. The tables have attempted to interpret the findings using CLSI clinical breakpoints, which are used by a number of MSs to interpret their data, as well as by EUCAST ECOFFs. However, not all MSs use EUCAST or CLSI breakpoints to interpret the susceptibility of isolates from humans, particularly for *Campylobacter*. The usefulness of reporting quantitative resistance values for isolates from animals and food, in accordance with EFSA's recommendations (EFSA, 2007), is underlined in that this has enabled the occurrence of resistance to be re-evaluated in accordance with the relevant CLSI breakpoints (which have been used to generate the results for human isolates in a number of MSs). Some data gaps remain in relation to certain methodological aspects (for example, the methods used to collect some samples may not have been reported) and this will influence the overall degree of harmonisation attained; no account has been taken of such factors.

The influence of differences in the breakpoint used to interpret the results can be clearly seen in relation to the tables showing the level of resistance to ciprofloxacin in *S.* Typhimurium and *S.* Enteritidis, where little or no resistance is reported using the CLSI clinical breakpoint in any isolates from food or animals, whereas the situation is often quite different when the EUCAST epidemiological cut-off value is applied to the same isolates to determine resistance. This is particularly evident in Table FFA 10 in relation to ciprofloxacin resistance. Breakpoint differences are much less marked when erythromycin or ciprofloxacin resistance in *C. jejuni* or *C. coli* are considered and although the cefotaxime CLSI breakpoint and EUCAST ECOFF differ, the effect of these disparities is also slight in relation to the data for *S.* Typhimurium and *S.* Enteritidis, because cefotaxime resistance is rare.

In relation to ciprofloxacin resistance in *S.* Typhimurium, resistance was rare in animal or food isolates from when the figures were interpreted using the CLSI breakpoint, although some resistance was detected in human isolates. This could indicate other sources of human infection for these resistant isolates such as infection through consumption of other alimentary sources than pork, chicken or beef, consumption of imported foods, infection associated with foreign travel or contact with pets. The higher level of resistance observed in human isolates from Denmark, the Netherlands and the United Kingdom, is a reflection of the low breakpoint used in these MSs. Similar considerations can also be applied to *S.* Enteritidis.

Spain reported an occurrence of erythromycin resistance in *C. coli* from *Gallus gallus* of 33.3 % and the same figure in humans, while considering *C. coli* isolates from pigs 63 % were resistant. Spain was the only MS which reported the breakpoints used for human *C. coli* isolates, reported results for isolates from man and which also tested isolates from *Gallus gallus* and pigs in accordance with EFSA's recommendations. Erythromycin resistance in isolates of *C. jejuni* from *Gallus gallus* and humans were 3.6 % and 4.8 % respectively; similar figures and perhaps to be expected in that poultry are considered a major source of *C. jejuni*. Spain was also the only MS for which all relevant data was available in relation to ciprofloxacin resistance in *C. jejuni* and *C. coli* isolates from *Gallus gallus* and humans. While 87.3 % of *C. jejuni* from humans were resistant to ciprofloxacin, 94.5 % of isolates were resistant from *Gallus gallus*, a rather similar figure. There was a greater disparity between isolates of *C. coli* from humans and *Gallus gallus*, with 78.4 % and 93.8 % of isolates showing ciprofloxacin resistance respectively.

The Netherlands provided information on resistance to antimicrobials in verotoxigenic *E. coli* O157 isolates from a range of sources in 2011 and had also provided data from human and animal isolates in 2010. Isolates from different sources show differences in their resistance to certain antimicrobials, for example, resistance to cefotaxime and ceftazidime was observed in isolates from meat from broilers more frequently than in isolates from other sources.

There still remains much scope for refinement and improvement of the degree of harmonisation attained by reporting MSs to optimise the outputs and their comparability and also to maximise the inclusion of suitably harmonised data, particularly for human isolates, where the reporting of quantitative data is required to allow better analysis of the results. These fundamental improvements in monitoring need to be put in place before further development of the monitoring, such as investigating similarities in multi-drug resistance patterns between human, animal and food isolates can take place.

11. MATERIALS AND METHODS

11.1. Antimicrobial susceptibility data from humans available in 2011

MSs report results from antimicrobial susceptibility testing (AST) to ECDC through The European Surveillance System (TESSy). The data used in this report were submitted in connection to the annual data collection for the European Union Summary Report of Trends and Sources of Zoonoses and Zoonotic Agents.

11.1.1. *Salmonella* data of human origin

Nineteen MSs and Iceland provided data for 2011. The antimicrobials reported on for *Salmonella* are ampicillin, cefotaxime, chloramphenicol, ciprofloxacin, gentamicin, kanamycin, nalidixic acid, streptomycin, sulfonamides, tetracyclines and trimethoprim. Some countries reported on all of these and others on only a few. Countries reported qualitative data, i.e. interpreted AST results for tested isolates (susceptible (S), intermediate (I) or resistant (R)), but no quantitative data on minimum inhibitory concentration (MIC) values or zone diameters.

The public health reference laboratories were asked via e-mail to provide an update about which methods and which guidelines were being used for testing and interpretation. It should be noted that the public health reference laboratories in many countries type only a fraction of the isolates. The remaining isolates are typed by hospitals or local laboratories, and the methods used by these are often unknown. Six MSs plus Iceland used disc diffusion methods, six other MSs used dilution methods and another six MSs used a combination of the two, depending on the situation and the antimicrobial (Table SA1). The guidelines used for the interpretation differed between countries (Table MM1). Many countries employed a mixture of CLSI and EUCAST breakpoints. Eleven countries primarily used guidelines from the Clinical and Laboratory Standards Institute (CLSI), where these were available. Four countries used guidelines with generally more sensitive breakpoints (i.e. lower threshold to classify an isolate as resistant) or even lower epidemiological cut-off values (ECOFFs) from the European Committee on Antimicrobial Susceptibility Testing (EUCAST), which compares the isolates with the wild-type population. For four of the 11 antimicrobials addressed, the CLSI MIC breakpoints and EUCAST ECOFFs are equivalent: chloramphenicol, nalidixic acid, sulfonamides and tetracyclines (i.e. resistance defined as ≥32 mg/L in CLSI and as >16 mg/L in EUCAST guidelines; see Table MM1). For three antimicrobials (cefotaxime, ciprofloxacin and gentamicin), the MIC values or zone diameters differ markedly between the clinical breakpoints and the ECOFFs. This is particularly the case for ciprofloxacin, for which the ECOFF is three times more sensitive than the EUCAST clinical breakpoint and five times more sensitive than the CLSI clinical breakpoint (Figure SA1). Results for these three antimicrobials must therefore be interpreted with caution, and no direct comparison between countries should be made.

Results are shown only for countries reporting data for more than 20 isolates for the antimicrobial in question. Trend lines for 2007–2011 are shown for those countries where data were available for at least four years. Countries reporting 0 % resistance during this period are mentioned but are not shown in the graphs.

The AST results of a total of 14 serovars, including the top 10 serovars in humans in 2010 and 2011 and some additional serovars of importance in animals, are presented separately.

In order to assess whether there were any differences in resistance levels between human *Salmonella* infections acquired within the EU/EEA and infections acquired when travelling outside the EU/EEA, resistance data were presented by region based on most likely country of infection.

Table MM1. Breakpoints used by MSs[1] for the interpretation of 2011 susceptibility data on* Salmonella *of human origin

Country	Ampicillin		Cefotaxime		Chloramphenicol		Ciprofloxacin		Gentamicin		Kanamycin		Comment
	MIC	mm	MIC	mm	MIC	mm	MIC	mm	MIC	mm	MIC	mm	
Austria	-	≤13	-	≤17	-	≤16	-	≤18	-	≤13	-	≤13	EUCAST 2011 for AMP, CTX, CHL, CIP, GEN, TRI. CLSI 2011 for KAN, NAL, STR, SSS, TCY
Denmark	>8	-	>0.5	-	>16	-	>0.06	-	>2	-	>4	-	EUCAST ECOFFS. CIP is Danmap, KAN is NEO.
Estonia	≥32	≤13	≥1	≤27	≥32	≤12	≥0.125	≤18	≥16	≤12	≥64	≤13	CLSI, EUCAST *Enterobacteriaceae* for CIP, DTU Food/CLSI for STR
Germany	>8	-	>8	-	NA	NA	>2	-	>4	-	>16	-	German standard. For NAL CLSI.
Greece	-	≤13	-	≤22	-	≤12	-	≤15	-	≤12	-	≤13	CLSI 2011
Hungary	-	≤13	-	≤22	-	≤12	-	≤15	-	≤12	-	≤13	CLSI 2011
Ireland	>8	-	>2	-	>8	-	>1	-	>4	-	≥64	-	EUCAST (where available, otherwise CLSI; Streptomycin = EFSA)
Italy	≥32	≤13	≥64	≤14	≥32	≤12	≥4	≤15	≥16	≤12	≥64	≤13	CLSI M100 S17 S19
Latvia[2]	≥32	≤13	NA	NA	NA	NA	≥4	≤15	NA	NA	NA	NA	CLSI
Lithuania[2]	≥32	≤13	≥64	≤14	≥32	≤12	≥4	≤15	≥16	≤12	≥64	≤13	CLSI M100-S17-S19. According to earlier survey use disc diffusion.
Luxembourg	-	≤13	-	≤22	-	≤12	-	≤15	-	≤12	-	≤13	CLSI 2011
Malta	≥16	-	NA	NA	NA	NA	≥2	-	≥8	-	NA	NA	Biomerieux Vitek system, EUCAST 2010.
Netherlands	>4	-	>0.5	-	>16	-	>0.06	-	>2	-	NA	NA	EUCAST ECOFFS from 2007. For STR EFSA and SSS CLSI.
Romania	≥32	≤13	≥4	≤22	≥32	≤12	≥4	≤15	≥16	≤12	≥64	≤13	CLSI 2012 for disc diffusion and E-test.
Slovakia[2]	≥32	≤13	≥64	≤14	≥32	≤12	≥4	≤15	≥16	≤12	NA	NA	CLSI M100-S19. For KAN and STR 2003 (STR MIC from Sensitrite)
Slovenia	-	≤13	-	≤22	-	≤12	-	≤15	-	≤12	-	≤13	CLSI M100-S21
Spain	-	≤13	-	≤22	-	≤12	-	≤15	-	≤12	-	≤13	CLSI M100-S-20
United Kingdom	≥8	-	≥1	-	≥8	-	≥0.125	-	≥4	-	≥16	-	HPA methodology based on Frost 1994.
Iceland [2]	-	≤13	NA	NA	-	≤12	-	≤15	NA	NA	NA	NA	In lab survey mention CLSI for disc diffusion.

Table continued overleaf.

- = this method is not used for the antimicrobial in question.

NA = not applicable since this antimicrobial is not reported to TESSy or fewer than 20 isolates tested.

1. Cyprus provided data for only one isolate tested for one antimicrobial and no information was provided regarding interpretive criteria. Cyprus is therefore not represented in the table.

2. Clinical breakpoints and comments shown are from the 2010 report; clinical breakpoints for 2011 were not reported.

Table MM1 (continued). Breakpoints used by MSs[1] for the interpretation of 2011 susceptibility data on* Salmonella *of human origin

Country	Naladixic acid		Streptomycin		Sulfonamides		Tetracyclines		Trimethoprim		Comment
	MIC	mm	MIC	mm	MIC	mm	MIC	mm	MIC	mm	
Austria	-	≤13	-	≤11	-	≤12	-	≤11	-	≤14	EUCAST 2011 for AMP, CTX, CHL, CIP, GEN, TRI. CLSI 2011 for KAN, NAL, STR, SSS, TCY
Denmark	>16	-	>16	-	>256	-	>8	-	>2	-	EUCAST ECOFFS. CIP is Danmap, KAN is NEO.
Estonia	≥32	≤13	≥32	≤11	≥512	≤12	≥16	≤11	≥16	≤10	CLSI, EUCAST *Enterobacteriaceae* for Cipro, DTU Food/CLSI for STR
Germany	>16	-	>16	-	NA	NA	NA	NA	ND	-	German standard. For NAL CLSI.
Greece	-	≤13	-	≤11	NA	NA	-	≤11	-	≤10	CLSI 2011
Hungary	-	≤13	-	≤11	-	≤12	-	≤11	-	≤10	CLSI 2011
Ireland	>16	-	>32	-	≥512	-	≥16	-	>4	-	EUCAST (where available, otherwise CLSI; Streptomycin = EFSA)
Italy	≥32	≤13	-	≤11	≥512	≤12	≥16	≤11	≥16	≤10	CLSI M100 S17 S19
Latvia[2]	NA	NA	NA	NA	NA	NA	NA	NA	≥16	≤10	CLSI
Lithuania[2]	≥32	≤13	-	≤11	≥512	≤12	≥16	≤11	≥16	≤10	CLSI M100-S17-S19. According to earlier survey use disc diffusion.
Luxembourg	-	≤13	-	≤11	-	≤12	-	≤11	-	≤10	CLSI
Malta	NA	NA	NA	NA	NA	NA	≥16	-	-	-	Biomerieux Vitek system, EUCAST 2010.
Netherlands	>16	-	>32	-	-	-	>8	-	NA	NA	EUCAST ECOFFS. For STR EFSA and SSS CLSI.
Romania	≥32	≤13	≥32	≤11	≥512	≤12	≥16	≤11	≥16	≤10	CLSI 2012 for disc diffusion and E-test.
Slovakia[2]	NA	NA	NA	NA	≥512	≤12	≥16	≤14	NA	NA	CLSI M100-S19. For KAN and STR 2003 (STR MIC from Sensitrite)
Slovenia	-	≤13	-	≤11	-	≤12	-	≤11	-	≤10	CLSI M100-S21
Spain	-	≤13	-	≤11	-	-	-	≤11	-	-	CLSI M100-S-20
United Kingdom	≥16	-	≥16	-	≥64	-	≥8	-	≥2	-	HPA methodology based on Frost 1994.
Iceland[2]	-	≤13	NA	NA	NA	NA	NA	NA	-	≤10	In lab survey mention CLSI for disc diffusion.

- = this method is not used for the antimicrobial in question.

NA = not applicable since this antimicrobial is not reported to TESSy or fewer than 20 isolates tested.

ND = not detected.

1. Cyprus provided data for only one isolate tested for one antimicrobial and no information was provided regarding interpretive criteria. Cyprus is therefore not represented in the table.
2. Clinical breakpoints and comments shown are from the 2010 report; clinical breakpoints for 2011 were not reported.

11.1.2. *Campylobacter* data of human origin

Thirteen MSs and Iceland provided data for 2011. The antimicrobials reported on for *Campylobacter* were amoxicillin, ampicillin, ciprofloxacin, erythromycin, gentamicin, nalidixic acid and tetracyclines. Some countries reported on all of these and others on only a few. Countries reported qualitative data, i.e. interpreted AST results for tested isolates (S, I or R), but no MIC values or zone diameters.

National reference laboratories were asked to provide the methods and guidelines used for testing and interpretation. As for *Salmonella*, the methods and guidelines used for AST in local laboratories are often unknown, but could represent a high proportion of the data submitted to TESSy. Eight countries primarily used disc diffusion for their routine testing, while six countries used dilution or gradient strip (Table CA1). Three countries used both disc diffusion and dilution, depending on the circumstances. The few guidelines that were used by several countries were the CLSI M45-A criteria (covering the three most clinically important antimicrobials) and recommendations from the French Society for Microbiology (CA-SFM). The guidelines used for the interpretation differed between countries (Table MM2). CA-SFM, CLSI and EUCAST breakpoints were all used, with mixtures being employed in some countries. Four countries primarily used guidelines from CLSI, where available. Five countries used guidelines from the French Society of Microbiology. Of the five antimicrobials reported on from both human and animal/food isolates, the EUCAST clinical breakpoints and ECOFFS were at the same MIC values except for ciprofloxacin and the combination *C. coli*/erythromycin, where the ECOFF was one dilution higher than the clinical breakpoint. No clinical breakpoints were available for gentamicin and nalidixic acid. The CA-SFM breakpoints were generally also in the same range or one dilution higher or lower than the ECOFF except for the combination *C. coli*/erythromycin, and tetracycline, where it was two dilution steps higher than the ECOFFs. The CLSI breakpoints were often set at up to two dilutions higher than the ECOFF (Figure CA1). Results for the antimicrobials for which there are major differences in the interpretive criteria should be interpreted with caution, and direct comparisons between countries should be avoided.

Results are shown only for countries reporting data for more than 20 isolates for the antimicrobial in question. Trend lines for 2007–2011 are shown for those countries where data were available for at least four years. Countries reporting 0 % resistance during this period are mentioned but not shown in the graphs.

Table MM2. Breakpoints used by MSs for the interpretation of 2011 susceptibility data on* Campylobacter *of human origin

Country	Amoxicillin		Ampicillin		Ciprofloxacin		Erythromycin		Gentamicin		Nalidixic acid		Tetracyclines		Comments
	MIC	mm	MIC	mm	MIC	mm	MIC	mm	MIC	mm	MIC	mm	MIC	mm	
Austria	≥32/ 16	-	>8[1] >16[2]	-	≥4	≤15	≥32	≤13	>1[1] >2[2]	NA	-	≤13	≥16	≤14	National guideline for disc diffusion and CLSI M45A dilution test for CIP, ERY, TCY and NAL; CLSI for AMC+ClA; EUCAST for AMP and GEN
Estonia	-	-	≥16	≤14	≥1	≤22	≥4	≤17	≥4	≤16	≥16	≤15	≥1	≤17	Disc diffusion, CASFM
France	-	-	-	≤19	-	≤22	-	≤22	-	≤18	-	≤20	NA	NA	CASFM
Italy	NA	NA	-	≤6	-	≤6	-	≤6	-	≤6	-	≤6	-	≤6	CLSI M45-A vol.26 no 19 for CIP and ERY. Local labs adapted same criteria for remaining ab. Disc diffusion.
Hungary	NA	NA	NA	NA	≥1	-	NA	NA	NA	NA	NA	NA	NA	NA	CLSI 2011 E test
Lithuania[3]	NA	NA	NA	NA	-	≤17	-	≤19	NA	NA	NA	NA	NA	NA	BSAC for disc diffusion. Local laboratories providing data for some antimicrobials now closed down, so impossible to get information.
Luxembourg	NA	NA	NA	NA	≥1	-	≥4	-	NA	NA	-	≤15	NA	NA	SFM, E-test for CIP, ERY
Malta	NA	NA	NA	NA	≥1	-	≥4	-	NA	NA	NA	NA	NA	NA	E-test (CA-SFM)
Romania	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	CASFM 2010
Slovakia[3]	NA	NA	NA	NA	≥4	-	≥32	-	NA	NA	NA	NA	≥16	-	CLSI for dilution test.
Slovenia	-	<14	-	<14	≥4	<22	≥32	<17	-	<16	-	<15	-	<17	AMC is AMC+clavulanic acid. CA-SFM 2010 for disc diffusion. CLSI M45-A for CIP and ERY
Spain	>16	-	NA	NA	≥4	-	≥32	-	≥4	-	NA	NA	≥16	-	CASFM for AMX, GEN, CLSI-2010 M45AE for CIP, ERY, TCY
United Kingdom	-	-	≥16	-	≥1	-	≥4	-	>1	-	>16	-	≥2	-	EUCAST
Iceland[3]	NA	NA	NA	NA	≥4	-	≥32	-	NA	NA	NA	NA	NA	NA	No reply 2011. In other survey mention CLSI for E-test.

- = this method is not used for the antimicrobial in question.

NA = not applicable since this antimicrobial is not reported to TESSy or fewer than 20 isolates tested.

1. Breakpoint used for *C. jejuni.*

2. Breakpoint used for *C. coli.*

3. Clinical breakpoints and comments shown are from the 2010 report; clinical breakpoints for 2011 were not reported.

11.1.3. Analysis of multi-drug resistance and co-resistance in human isolates

An analysis of multi-drug resistance, similar to that done for animal and food isolates (see section 11.4.2), was undertaken with the human data. Only countries which reported to TESSy the results of tests on the full range of antimicrobials in 10 or more isolates of *Salmonella* and *Campylobacter* were included in the analysis. Fully susceptible isolates were those susceptible to all of the antimicrobial substances. Non-susceptibility to an antimicrobial was defined as resistance or intermediate resistance to the antimicrobial drug when using clinical breakpoints as interpretive criteria (Magiorakos et al., 2012). Multi-drug resistance was defined as non-susceptibility to at least any three of the antimicrobials tested. Co-resistance to the most important drugs for human treatment was also calculated, independently of other resistance patterns. These co-resistance combinations were ciprofloxacin and cefotaxime for *Salmonella* spp. and ciprofloxacin and erythromycin for *Campylobacter* spp.

Resistance to nalidixic acid and ciprofloxacin was addressed together: in the event that an isolate was resistant or exhibited intermediate resistance to either of these antimicrobials, the isolate was classified as non-susceptible to the combined antimicrobial ciprofloxacin/nalidixic acid, as the two substances belong to the same antimicrobial family.

11.2. Antimicrobial susceptibility data from animals and food available in 2011

11.2.1. Data reported under Directive 2003/99/EC in 2011

MSs generated data on antimicrobial susceptibility through the testing of zoonotic and indicator bacteria isolated from various animal species/production types and food categories, sampled through a number of different national schemes. Isolates may have been collected by different monitoring approaches, either by active monitoring of animals and foods or, in some cases, by passive monitoring based on diagnostic submission of samples from clinical cases of disease in animals, or from foods sampled as part of investigatory work. In the case of passive monitoring, the isolates tested often constituted a sub-sample of the total isolates available at the National Reference Laboratory (NRL). Clinical investigation data were not accounted for in this report.

Dilution and disc diffusion testing methods were used by reporting MSs for susceptibility testing, and both quantitative and qualitative data were reported at the EU level.

- 'Quantitative data' derived from dilution methods consisted of the number of isolates having a specific MIC value (measured in mg/L) relative to the total number of isolates tested, for each antimicrobial agent and in each specific food/animal category.

- 'Quantitative data' derived from diffusion methods comprised the number of isolates having a specific zone diameter of inhibition (IZD measured in mm) relative to the total number of isolates tested, for each antimicrobial agent and in each food/animal category.

- 'Qualitative data' consisted of the number of isolates out of the total number of isolates that were resistant to each antimicrobial agent in each food/animal category; qualitative data can be generated either from MIC determination or from disc diffusion testing.

For the year 2011, 26 MSs and three non-MSs reported data on antimicrobial resistance in tested *Salmonella* and *Campylobacter*, commensal *E. coli* and commensal enterococci or methicillin-resistant *Staphylococcus aureus* isolates from food-producing animals and/or food. Data on antimicrobial resistance in tested *Salmonella* and *Campylobacter* have been reported on a mandatory basis under Directive 2003/99/EC and data on antimicrobial resistance in tested commensal *E. coli* and commensal enterococci or methicillin-resistant *Staphylococcus aureus* isolates have been reported by the MSs on a voluntary basis. An overview of the MSs and non-MSs reporting antimicrobial resistance data in 2011 is shown in Table MM3.

Table MM3. MSs reporting data in 2011 and description of data included in the report

Bacteria	Number of MSs and non-MSs reporting quantitative or qualitative data	Data included in the report	
		MIC dilution	Diffusion
Salmonella	24 MSs + 2 non-MSs	97,602	11,441
Campylobacter	20 MSs + 2 non-MSs	36,064	-
Indicator *E. coli*	16 MSs + 2 non-MSs	123,662	1,298
Indicator *Enterococci*	11 MSs + 2 non-MSs	69,166	1,848
MRSA[1,2]	1 MS +1 non-MS	450	-

1. Methicillin-resistant *Staphylococcus aureus*

2. In 2011, six MSs and one non-MS reported data on the occurrence of MRSA.

In 2011, 12 % of quantitative *Salmonella* antimicrobial resistance data from animals and/or food included in the report were submitted by reporting MSs as disc diffusion data; the corresponding figure in 2010 was 14 %. For *E. coli,* 1 % of quantitative data were obtained by disc diffusion, but these data were not included in the report as they were submitted only by one MS. For the purpose of this report, only quantitative dilution and quantitative disc diffusion data have been primarily considered.

Resistance data in *Salmonella* and *Campylobacter*

Quantitative (MIC) results on antimicrobial resistance in *Salmonella* isolates from animals and food were reported by 20 MSs and one non-MS (Norway) in 2011. The information collected by these countries was in accordance with EFSA's recommendations (EFSA, 2007); these data are described in Chapter 3. Norway reported results for only low numbers of isolates (fewer than 10); these data have been excluded from the analysis.

In 2011, 17 MSs and two non-MSs (Norway and Switzerland) reported data on antimicrobial resistance in *Campylobacter.* All *Campylobacter* results were reported as MIC values in accordance with EFSA's recommendations (EFSA, 2007). These data are described in Chapter 5.

Resistance data in indicator bacteria

For indicator (commensal) *E. coli*, a total of 12 MSs and two non-MSs (Norway and Switzerland) reported quantitative dilution (MIC) results from animals or meat derived from those animals: these data are described in Chapter 6. Some countries reported results for only low numbers of isolates (fewer than 10); these data have been excluded from the analysis. Hungary reported quantitative results for indicator *E. coli* isolates, tested according to CLSI recommendations and using the CLSI disc diffusion method. For indicator enterococci (*E. faecalis* and *E. faecium*), in total 10 MSs and two non-MSs (Norway and Switzerland) reported quantitative MIC data; these are described in Chapter 7. All countries reporting quantitative MIC data used the methods recommended by EFSA (EFSA, 2008a).

Resistance data to third-generation cephalosporins

In relation to third-generation cephalosporin resistance in indicator *E. coli* and *Salmonella* spp., EFSA's recommendations suggest the use of cefotaxime alone to detect important types of resistance (EFSA, 2007). Most MSs reported results for cefotaxime; some also reported results for ceftazidime. Cefotaxime is likely to detect the presence of most cefotaximases (CTX-M enzymes), which appear to be currently the most prevalent type of extended-spectrum beta-lactamase (ESBL) enzymes in bacteria isolated from food-producing animals in the EU. The use of cefotaxime will also detect the presence of AmpC enzymes in *Salmonella* or *E. coli*. Some ESBLs are ceftazidimases rather than cefotaximases (particularly enzymes in the TEM and SHV families of ESBLs). Although testing both cefotaxime and ceftazidime is therefore optimal for the detection of all ESBLs and AmpC enzymes, EFSA's guidelines have recommended testing cefotaxime to detect all CTX-M enzymes mainly for reasons of affordability.

Data on methicillin-resistant *Staphylococcus aureus* (MRSA)

Data relating to methicillin-resistant *Staphylococcus aureus* prevalence were reported by six MSs and one non-MS (Switzerland). Among these, Switzerland reported data on resistance in MRSA isolates from pigs and cattle, and Belgium in MRSA isolates from broilers. The methods for collecting and testing samples for MRSA are not harmonised between MSs and as a result MSs may use differing procedures. Owing to the variety of methods employed by MSs, these are explained in detail within Chapter 8 to enable readers to better follow the procedures carried out by individual countries.

There is an important difference between the methods used to isolate *Salmonella*, *Campylobacter, E. coli* and enterococci and that used to isolate MRSA. For the former group of organisms, there is no selective medium used to isolate from primary samples organisms possessing a particular resistance, whereas, for MRSA, antimicrobials are used to selectively isolate only those *Staphylococcus aureus* isolates which are resistant to methicillin. Some MSs may have sampled particular production types of animals (for example laying hens in *Gallus gallus* or veal calves in cattle), and this introduces another source of possible variation which may account for observed differences between MSs.

11.3. Antimicrobials used for susceptibility testing in animals and food

The antimicrobials incorporated in this summary analysis were selected based on their relative public health importance and as representatives of different antimicrobial classes, taking into account EFSA's reports and recommendations on the harmonised monitoring and reporting of antimicrobial susceptibility data (EFSA 2007, 2008a).

11.3.1. Antimicrobials for susceptibility testing of *Salmonella*

In 2011, both dilution and disc diffusion methods were used to test the susceptibility of *Salmonella* isolates from animals and food by MSs. Tables MM4 and MM5 show the antimicrobials selected by the different countries for susceptibility testing. Quantitative dilution results allowed MIC distributions to be reported for *Salmonella* for the following antimicrobials: ampicillin, apramycin, cefotaxime, ceftazidime, ceftiofur, chloramphenicol, ciprofloxacin, colistin, florfenicol, gentamicin, kanamycin, nalidixic acid, neomycin, spectinomycin, sulfonamides, trimethoprim and tetracyclines. For further information on reported MIC distributions and number of resistant isolates, refer to the Level 3 tables published on the EFSA website.

Data on *Salmonella* which were reported as disc diffusion data are presented in Appendix 1. Although results may not be directly comparable between MSs, it is anticipated that in most cases procedures will not have changed markedly over time within a country, and therefore comparisons of the proportion of resistant isolates over time in that country may be possible.

Table MM4. Antimicrobials selected for susceptibility testing of* Salmonella *isolates by MSs and one non-MS reporting quantitative data as MIC distributions, in 2011

Country	Ampicillin	Apramycin	Cefotaxime	Ceftazidime	Ceftiofur	Chloramphenicol	Ciprofloxacin	Colistin	Florfenicol	Gentamicin	Kanamycin	Nalidixic acid	Neomycin	Spectinomycin	Streptomycin	Sulfonamides	Trimethoprim	Tetracyclines
Austria	●		●	●		●	●	●	●	●	●	●			●	●	●	●
Belgium	●		●	●		●	●	●	●	●	●	●			●	●	●	●
Denmark	●	●	●		●	●	●	●	●	●		●	●	●	●	●	●	●
Estonia	●		●			●	●		●	●	●	●			●	●	●	●
Finland	●		●			●	●		●	●		●			●	●	●	●
France	●		●	●		●	●			●		●			●	●	●	●
Germany	●		●	●		●	●		●	●	●	●			●	●	●	●
Greece	●		●			●	●		●	●		●			●	●	●	●
Hungary	●		●	●		●	●			●		●			●	●	●	●
Ireland	●		●	●		●	●		●	●	●	●			●	●	●	
Italy	●		●	●		●	●		●	●	●	●			●	●	●	●
Latvia	●		●			●	●		●	●		●			●	●	●	●
Netherlands	●		●	●		●	●	●	●	●	●	●			●	●	●	●
Norway	●		●			●	●		●	●	●	●			●	●	●	
Poland	●		●	●		●	●		●	●		●			●	●	●	●
Portugal	●		●			●	●		●	●		●			●	●	●	●
Romania	●		●	●		●	●	●	●	●	●	●			●	●	●	●
Slovakia	●		●	●		●	●	●	●	●	●	●			●	●	●	●
Spain	●		●	●		●	●	●	●	●	●	●			●	●	●	●
Sweden	●		●			●	●		●	●	●	●			●	●	●	●
United Kingdom	●		●			●	●			●		●			●	●	●	●

Note: Sulfonamides may include a variety of substances.

Table MM5. Antimicrobials selected for susceptibility testing of* Salmonella *isolates by MSs reporting quantitative data as disc inhibition zones, in 2011

Country	Ampicillin	Apramycin	Cefotaxime	Ceftazidime	Ceftiofur	Chloramphenicol	Ciprofloxacin	Colistin	Florfenicol	Gentamicin	Kanamycin	Nalidixic acid	Neomycin	Spectinomycin	Streptomycin	Sulfonamides	Tetracyclines
Romania	●		●			●	●			●		●			●	●	●
Spain	●		●			●	●			●	●	●			●	●	●

Note: Sulfonamides may include a variety of substances.

11.3.2. Antimicrobials for susceptibility testing of *Campylobacter*

In 2011, all quantitative *Campylobacter* data were reported as MIC values, generated by dilution methods. Table MM6 shows the antimicrobials selected by the different countries for susceptibility testing of *Campylobacter* isolates. In this report, antimicrobial resistance was reported separately for *C. jejuni* and *C. coli*.

MIC distributions were analysed for the following antimicrobials: ciprofloxacin, chloramphenicol, erythromycin, gentamicin, nalidixic acid, streptomycin and tetracyclines. These antimicrobials were selected based on public health relevance and as representatives of different classes of antimicrobials. For further information on reported MIC distributions and number of resistant isolates, refer to the Level 3 tables published on the EFSA website.

Table MM6. Antimicrobials selected for susceptibility testing of* Campylobacter *isolates by MSs and non-MSs reporting quantitative data as MIC distributions, in 2011

Country	Amoxicillin	Ampicillin	Chloramphenicol	Ciprofloxacin	Clarithromycin	Colistin	Erythromycin	Gentamicin	Imipenem	Nalidixicacid	Neomycin	Streptomycin	Sulfonamides	Tetracyclines	Tulathromycin
Austria	●	●	●	●		●	●	●	●	●	●	●		●	
Belgium			●	●			●	●		●		●		●	
Czech Republic		●	●	●			●	●		●		●		●	
Denmark			●	●			●	●		●		●		●	
Estonia				●			●	●		●		●		●	
Finland				●			●	●		●		●		●	
France				●			●	●		●		●		●	
Germany			●	●			●	●		●		●		●	
Hungary			●	●			●	●		●		●		●	
Ireland			●	●			●	●		●		●			
Italy			●	●			●	●		●		●		●	
Netherlands		●	●	●	●		●	●		●	●	●	●	●	●
Norway				●			●	●		●		●			
Poland				●			●	●		●		●		●	
Portugal			●	●			●	●		●		●		●	
Romania			●	●			●	●		●		●		●	
Spain			●	●			●	●		●		●		●	
Sweden				●			●	●		●		●		●	
Switzerland			●	●			●	●		●		●		●	

Note: Sulfonamides may include a variety of substances.

11.3.3. Antimicrobials for susceptibility testing of *Escherichia coli*

In 2011, both dilution and disc diffusion methods were used to test the susceptibility of *E. coli* isolates from animals and food. Tables MM7 and MM8 show the antimicrobials selected by the different countries for susceptibility testing. In this report, susceptibility data from animal isolates are presented. Owing to the very small number of countries reporting susceptibility data from food isolates, data were available from only three MSs and are described in the text.

MIC distributions were analysed for the following antimicrobials: ampicillin, apramycin, cefotaxime, ceftazidime, ceftiofur, chloramphenicol, ciprofloxacin, colistin, florfenicol, gentamicin, imipenem, kanamycin, nalidixic acid, neomycin, spectinomycin, streptomycin, sulfonamides, trimethoprim and tetracyclines. These antimicrobials were selected based on their public health relevance and as representatives of different antimicrobial classes. For further information on reported MIC distributions and number of resistant isolates, refer to the Level 3 tables published on the EFSA website.

Table MM7. Antimicrobials selected for susceptibility testing of* Escherichia coli *isolates by MSs and non-MSs reporting quantitative data as MIC distributions, in 2011

Country	Ampicillin	Apramycin	Cefotaxime	Ceftazidime	Ceftiofur	Chloramphenicol	Ciprofloxacin	Colistin	Florfenicol	Gentamicin	Imipenem	Kanamycin	Nalidixic acid	Neomycin	Spectinomycin	Streptomycin	Sulfonamides	Trimethoprim	Tetracyclines
Austria	●		●			●	●			●	●		●			●	●	●	●
Belgium	●		●	●		●	●	●	●	●		●	●			●	●	●	●
Denmark	●	●	●		●	●	●	●	●	●			●	●	●	●	●	●	●
Estonia	●		●	●		●	●	●	●	●		●	●			●	●	●	●
Finland	●		●			●	●			●			●			●	●	●	●
France	●		●	●		●	●		●	●			●			●	●	●	●
Germany	●		●	●		●	●		●	●		●	●			●	●	●	●
Ireland	●		●	●		●	●		●	●		●	●			●	●	●	●
Netherlands	●		●	●		●	●		●	●		●	●	●		●	●	●	●
Norway	●		●	●		●	●	●	●	●		●	●			●	●	●	
Poland	●		●	●		●	●		●	●			●			●	●	●	●
Spain	●		●	●		●	●	●	●	●		●	●			●	●	●	●
Sweden	●		●			●		●	●	●		●	●			●	●	●	●
Switzerland	●		●	●		●	●	●	●	●		●	●			●	●	●	●

Note: Sulfonamides may include a variety of substances.

Table MM8. Antimicrobials selected for susceptibility testing of* Escherichia coli *isolates by one MS reporting quantitative data as disc inhibition zones, in 2011

Country	Ampicillin	Apramycin	Cefotaxime	Ceftazidime	Ceftiofur	Chloramphenicol	Ciprofloxacin	Colistin	Florfenicol	Gentamicin	Imipenem	Kanamycin	Nalidixic acid	Neomycin	Spectinomycin	Streptomycin	Sulfonamides	Trimethoprim	Tetracyclines
Hungary	●		●			●	●			●			●			●	●	●	●

Note: Sulfonamides may include a variety of substances.

11.3.4. Antimicrobials for susceptibility testing of enterococci

In 2011, for enterococci, only susceptibility data from dilution methods are presented by MSs, with the exception of Hungary, which reported resistance data in *E. faecalis* derived from diffusion methods. Table MM9 shows the antimicrobials selected by the different countries for susceptibility testing. Only susceptibility data from animal isolates are presented as very few countries reported susceptibility data for enterococcal isolates from food. Data were available from only three MSs and are described in the text.

MIC distributions were analysed for the following antimicrobials: tetracycline, chloramphenicol, ampicillin, erythromycin, streptomycin, vancomycin, quinupristin/dalfopristin and linezolid. For further information on reported MIC distributions and number of resistant isolates, refer to the Level 3 tables published on the EFSA website.

Table MM9. Antimicrobials selected for susceptibility testing of isolates of* Enterococcus faecium *and* Enterococcus faecalis*, by MSs and non-MSs reporting quantitative data as MIC distributions, in 2011

Country	Amoxicillin/Clavulanic acid	Ampicillin	Bacitracin	Chloramphenicol	Ciprofloxacin	Daptomycin	Erythromycin	Florfenicol	Gentamicin	Kanamycin	Lincomycin	Linezolid	Narasin	Neomycin	Nitrofurantoin	Penicillin	Quinupristin/dalfopristin	Salinomycin	Streptomycin	Teicoplanin	Tetracyclines	Tigecycline	Vancomycin	Virginiamycin
Austria		●		●	●	●	●		●			●					●		●		●		●	
Belgium		●		●	●		●	●	●			●					●	●	●		●		●	
Denmark		●		●	●		●		●	●		●				●	●	●	●	●	●	●	
Estonia		●	●	●			●		●	●		●	●						●		●		●	●
Finland		●		●			●		●			●							●		●		●	●
France		●		●	●	●	●		●			●					●		●		●	●	●	
Ireland		●		●			●		●										●		●		●	
Netherlands		●		●	●		●	●	●			●					●	●	●		●		●	
Norway		●	●	●			●		●	●		●	●						●				●	●
Spain		●		●	●		●	●	●		●	●				●	●		●		●		●	
Sweden		●	●	●			●		●	●		●	●						●		●		●	●
Switzerland	●	●	●	●	●		●	●	●			●		●	●		●	●	●		●		●	

11.3.5. Antimicrobials for susceptibility testing of MRSA

In 2011, Belgium reported data on susceptibility testing of MRSA isolates from broilers, and Switzerland from cattle and pigs. Details of the antimicrobials selected by Belgium and Switzerland are provided in Chapter 8. For further information on reported MIC distributions and number of resistant isolates, refer to the Level 3 tables published on the EFSA website.

11.4. Data description and analysis

11.4.1. Description and analysis of antimicrobial resistance data

Methods to interpret, describe and analyse antimicrobial resistance data were presented in detail in the 2004–2007 Community Summary Report on Antimicrobial Resistance (EFSA, 2010c).

Overview tables of the resistance data reported

Quantitative MIC data, generated by dilution methods recommended by EFSA, have been reported and analysed together; quantitative inhibition zone diameter (IZD) data, which constitute a relatively small fraction of the total data (12 % of the quantitative *Salmonella* data), have not been included in the analysis of quantitative data and have been described separately in Appendix 1. The IZD data reported by MSs under Directive 2003/99/EC for the years 2004–2007 were interpreted as described in previous Community Summary Reports. Some MSs reported antimicrobial resistance data as both quantitative and qualitative data; in that case, only the quantitative data have been included. Data generated from the antimicrobial susceptibility testing and reported as quantitative/qualitative by MSs, and data for which no details of the methodology used for testing were provided, have been described in the overview tables of individual chapters.

MIC distributions, ECOFFs and occurrence of resistance

For each combination of microorganism, antimicrobial and food or animal category tested, MIC distributions have been presented as frequency tables, giving the number of isolates tested having a given MIC at each test dilution (mg/L) of the antimicrobial. MIC distributions are available as Level 3 tables on the EFSA website.

Quantitative MIC data were, wherever possible, interpreted using epidemiological cut-off values (ECOFFs) as listed in Decision 2007/407/EC (corresponding to those published by EUCAST at the time of publication of the Decision) and presented in Table MM10. Subsequent amendments by EUCAST to the ECOFFs have not yet been incorporated; this will be achieved by issue of a revised Decision. An isolate was defined as 'microbiologically resistant' (i.e. displaying a decreased susceptibility) to a selected antimicrobial when its MIC value was above the epidemiological cut-off value. A more sensitive MIC breakpoint or epidemiological cut-off value (i.e. a lower MIC breakpoint or epidemiological cut-off value) might be expected to result in more isolates being defined as clinically or microbiologically resistant, respectively; the number of isolates affected in that way will of course depend on the distribution of MIC results.

The occurrence of resistance to a number of antimicrobials was determined (giving the percentage of isolates 'microbiologically resistant' out of those tested) for *Salmonella*, *Campylobacter*, indicator *E. coli* and enterococcal isolates from *Gallus gallus*, turkeys, pigs and cattle, and meat from *Gallus gallus,* pigs and cattle and are presented and analysed in tables on the occurrence of resistance in this report. These are the animal and food categories most frequently reported on by most MSs. Also, for the first time, data have been presented at production type level where possible. Data are included only if quantitative MIC data are provided by more than four MSs or disc diffusion data are provided by more than two MSs for the bacterium–animal/food category combination. An exception to this rule has nevertheless been made in the chapters on *Salmonella* serovars of public health importance (see below) and on MRSA. Data reported from fewer than 10 tested isolates per combination and per MS are not included. Data are reported in separate chapters dedicated to each microorganism and in Appendix 1 for *Salmonella* data obtained from disc diffusion. In addition, the occurrence of resistance (i.e. resistance levels) in reporting MS groups was calculated as totals (the total number of resistant isolates out of the total number of tested isolates across reporting MSs), and not the weighted means.

Resistance in *Salmonella* serovars of public health importance

In this report, antimicrobial resistance in tested *Salmonella* isolates were aggregated to give a value for *Salmonella* spp. for each country and food/animal category for 2011. In addition, whenever sufficient data were transmitted by MSs for a particular food/animal category, the most prevalent *Salmonella* serovars, *S.* Enteritidis and *S.* Typhimurium, were also reported separately for that food/animal category. An additional chapter has been included in this year's report to describe the occurrence of antimicrobial resistance among

Salmonella serovars of public health importance. In order to present a complete overview of the animal populations and food categories in which specific *Salmonella* serovars of public health importance have been recovered, data derived from the testing of fewer than 10 isolates and from fewer than four reporting countries, have been included.

Data description

Throughout the report, the following definitions apply:

- **level or occurrence of antimicrobial resistance** means the percentage of resistant isolates as a proportion of the isolates tested of that microorganism.
- **MS reporting group** means the MSs that provided data and were included in the relevant table of antimicrobial resistance for that bacterium–food or animal category–antimicrobial combination.

Terms used to describe the antimicrobial resistance levels are:

- rare:..... <0.1 %
- very low:..... 0.1 % to 1 %
- low:..... >1 % to 10 %
- moderate:..... >10 % to 20 %
- high: ..... >20 % to 50 %
- very high:..... >50 % to 70 %
- extremely high:..... >70 %

These terms are applied to all antimicrobials. However, the significance of a given level of resistance will depend on the particular antimicrobial and its importance in human and veterinary medicine.

Temporal trends in resistance

Where the minimum criteria were met for the inclusion of data in this report (i.e. more than 10 isolates tested by a MS and more than four MSs reporting results for that antimicrobial, microorganism, food or animal category), then temporal trend graphs were generated showing the resistance to different antimicrobials over the 2005–2011 period, by plotting the level of resistance for each year of sampling. Only countries which had reported for four or more years in the 2005–2011 period were included.

In order to assess the statistical significance of temporal trends, the proportions of resistance were modelled against time in a logistic regression. Results were provided only where there were five years or more of available data to use in the model, and where the likelihood ratio test suggested that the model was meaningful. This analysis was carried out in SAS9.2 using the PROC LOGISTIC function for each country where temporal trend data were presented in the report. The PROC LOGISTIC function uses a logit transform to model proportion of prevalence against year, and provides estimates for both intercepts and slope. Models resulting in a *p* value of <0.05 were considered to be significant.

For ciprofloxacin and nalidixic acid, resistance trends over time were visually explored for *Salmonella*, *Campylobacter*, indicator *E. coli* and enterococci by *trellis* graphs, using the *lattice* package in the R software (http://www.r-project.org). Graphs were created for those countries for which resistance data were available for four or more years, for at least one of the two antimicrobials. MS-specific resistance levels trend graphs use a unique scale and countries are shown in alphabetical order.

Spatial analysis of resistance through maps

MS-specific antimicrobial resistance levels for selected bacterium/food or animal category combinations were plotted in maps for 2011, using ArcGIS 9.3. In the maps, resistance levels are presented with colours reflecting the continuous scale of resistance to the antimicrobial of interest among reporting MSs, thus, there might be some apparent discrepancies between the colours and resistance levels between maps. Percentages shown in this map refer to countries that reported quantitative MIC data for more than 10 isolates in 2011. When quantitative 2011 data were not available, the 2010 level of resistance was used instead and referred by a footnote to the map. The countries labelled as 'qualitative data' therefore include those reporting IZD data, MIC data for fewer than 10 isolates, or purely qualitative data (as proportion of resistant isolates).

Table MM10. Epidemiological cut-off values used to interpret MIC distributions (mg/L) for bacteria from animals and food – the given values define the microbiologically resistant isolates

Antimicrobial agent	*Salmonella*	*E. coli*	*E. faecium*	*E. faecalis*	*C. jejuni*	*C. coli*
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Ampicillin	>4	>8	>4	>4		
Apramycin	>16	>16				
Avilamycin			>16	>8		
Cefotaxime	>0.5	>0.25				
Ceftazidime	>2	>0.5				
Ceftiofur	>2	>1				
Chloramphenicol	>16	>16	>32	>32	>16	>16
Ciprofloxacin	>0.06	>0.03			>1	>1
Erythromycin			>4	>4	>4	>16
Florfenicol	>16	>16				
Gentamicin	>2	>2	>32	>32	>1	>2
Linezolid			>4	>4		
Nalidixic acid	>16	>16			>16	>32
Neomycin	>4	>8				
Spectinomycin		>64				
Streptomycin	>32	>16	>128	>512	>2	>4
Sulfonamides	>256[1]	>64				
Quinupristin/dalfopristin			>1			
Tetracyclines	>8	>8	>2	>2	>2	>2
Trimethoprim	>2	>2				
Vancomycin			>4	>4		

1. Cut-off values wee not defined by EUCAST; instead cut-off values defined by the EU-RL on AMR (DTU) were used.

11.4.2. Analysis of multi-resistance and co-resistance data

As a consequence of the availability of antimicrobial resistance data at isolate-based level in an important number of MSs, the analysis of multi-resistance and co-resistance data becomes a feasible and important exercise, in the light of the public health relevance of the emergence of multi-resistant bacteria. As a matter of fact, the analysis and reporting on multi-resistance in the 2011 EUSR on antimicrobial resistance was previously recommended and endorsed by the Task Force on Zoonoses Data Collection at its meeting on AMR in March 2012.

The intention is to focus mainly on multi-resistance/co-resistance patterns involving critically important antimicrobials according to the bacterial species, such as cephalosporins, fluoroquinolones and macrolides, and to summarise important information in the EUSR. The occurrence of the isolates of a serotype/resistance pattern of interest is studied at MS level and at reporting MS group/EU level, as the overall picture for all MSs might show a more definite pattern of emergence and spread. In addition, the analysis of data may reveal the existence of new or emerging patterns of multi-resistance, particularly in *Salmonella* serotypes.

11.4.2.1. Analysis of multi-resistance patterns

Definitions

For the purpose of this analysis, a multi-resistant isolate is one defined as resistant to at least three different antimicrobial substances, belonging to any three antimicrobial families listed in the harmonised set of antimicrobials included in the EFSA recommendations (EFSA, 2007, 2008a). Table MM11 lists those recommended antimicrobials.

Resistance to nalidixic acid and ciprofloxacin is addressed together: an isolate that is resistant to either of the two will be termed resistant to the combined antimicrobial ciprofloxacin/nalidixic acid, as the two substances belong to the same antimicrobial family.

By contrast, a fully susceptible isolate is one defined as non-resistant to all of the antimicrobial substances included in the set of substances recommended for *Salmonella*, *Campylobacter*, indicator *E. coli* and indicator enterococci.

Table MM11. Harmonised set of antimicrobials listed in the EFSA recommendations

Zoonotic bacteria		Indicator bacteria	
Salmonella	***C. coli*/*C. jejuni***	***E. coli***	***E. faecium*/*E. faecalis***
Ampicillin (AMP)	Ciprofloxacin (CIP)	Ampicillin (AMP)	Ampicillin (AMP)
Cefotaxime (CTX)	Erythromycin (ERY)	Cefotaxime (CTX)	Chloramphenicol (CHL)
Chloramphenicol (CHL)	Gentamicin (GEN)	Chloramphenicol (CHL)	Erythromycin (ERY)
Ciprofloxacin (CIP)	Streptomycin (STR)	Ciprofloxacin (CIP)	Gentamicin (GEN)
Gentamicin (GEN)	Tetracycline (TET)	Gentamicin (GEN)	Linezolid (LZD)
Nalidixic acid (NAL)		Nalidixic acid (NAL)	Quinopristin/dalfopristin (Q/D)
Streptomycin (STR)		Streptomycin (STR)	Streptomycin (STR)
Sulfonamides		Sulfonamides	Tetracycline (TET)
Tetracycline (TET)		Tetracycline (TET)	Vancomycin (VAN)
Trimethoprim (TMP)		Trimethoprim (TMP)	

Data analysis

The frequency and percentage of isolates that are considered susceptible/resistant to all of the antimicrobials tested were determined for *Salmonella* (*Salmonella* spp., *S*. Enteritidis, *S*. Typhimurium and monophasic *S*. Typhimurium), *Campylobacter* species, indicator *E. coli* and indicator enterococcal species for each country and each animal population/food category. Isolates for which no susceptibility data were provided for some of the antimicrobial substances were disregarded. Data analysis was presented for a particular country only when the number of tested isolates was at least 10, except for monophasic *Salmonella* Typhimurium.

Summary indicators of multi-resistance

To illustrate the relative proportions of multi-resistant isolates and the diversity of the resistance to multiple antimicrobials, graphical illustration was chosen. The percentages of isolates susceptible and resistant to one, two, three, etc., antimicrobials are shown using a composite bar graph displaying stacked bars, but only for certain combinations of bacterium–animal population or food category–MS of particular interest.

The objective is first to give an overview of the situation on multi-resistance through summary indicators:

- the proportion of fully susceptible isolates,
- the proportion of multi-resistant isolates,
- an index/indices of diversity, such as the entropy measure,[21] summarising the distributions of isolate frequencies and, thus, the diversity among the different categories of multi-resistance (resistance to one, two, three, etc., antimicrobials).

The 'summary indicators' of multi-resistance can be calculated and reported yearly and, therefore, used to follow evolution of the multi-resistance situation across animal populations/food categories and MSs over time.

Diversity of multi-resistance

Resistance can be limited to resistance to only one or two antimicrobial substances, or resistance can be equally spread out from resistance from the lower to the higher number of antimicrobial substances. In other words, the frequencies across the categories resistant to one, two, three substances, and so on, can follow

[21] Weighted or un-weighted entropy measures may be considered.

different types of distributions: skewed to the right with higher frequencies for the lower numbers resistant; highly peaked or fully spread out; or even, at least in theory, with the higher frequencies for the larger numbers resistant. The entropy measure quantifies the degree of diversity of resistance. The standardised **unweighted entropy** takes values between 0 and 1. It takes the value 0 if all resistance is of one single type (e.g. resistance to exactly two antimicrobial substances) and takes the maximal value 1 if resistance to any number of antimicrobial substances is occurring equally often. The unweighted version does not take any order into account. So particular frequencies at the lower numbers resistant lead to the same entropy value when having these particular frequencies at the higher number resistant. The **weighted entropy** takes higher values if resistance appears to higher numbers of antimicrobial substances.

11.4.2.2. Analysis of co-resistance

The co-resistance patterns of interest

Co-resistance to cefotaxime and ciprofloxacin was estimated in *Salmonella* and *E. coli* isolates, as these two antimicrobials are of particular interest in human medicine. Co-resistance was addressed using both ECOFFs and clinical breakpoints in isolates of these bacteria. In *C. jejuni* and *C. coli* isolates, co-resistance to ciprofloxacin and erythromycin was estimated as these two antimicrobials are of particular interest in human medicine in the treatment of severe campylobacteriosis. The interpretative ECOFFs used to address co-resistance to ciprofloxacin and erythromycin were, for *C. jejuni*, CIP >1 mg/L and ERY >4 mg/L and, for *C. coli*, CIP >1 mg/L and ERY >16 mg/L. These values may be considered as very similar to clinical breakpoints.

12. REFERENCES

Aubry-Damon H and Courvalin P, 1999. Bacterial Resistance to Antimicrobial Agents Selected Problems in France, 1996-1998. Emerging and Infectious Disease, 5, 315-320.

Beutlich J, Rodríguez I, Schroeter A, Käsbohrer A, Helmuth R and Guerra B, 2010. A predominant multidrug-resistant *Salmonella enterica* serovar Saintpaul clonal line in German turkey and related food products. Applied and Environmental Microbiology, 76, 3657–3667.

Beutlich J, Jahn S, Malorny B, Hauser E, Hühn S, Schroeter A, Rodicio M, Appel B, Threlfall J, Mevius D, Helmuth R and Guerra B, 2011. Antimicrobial Resistance and Virulence Determinants in European *Salmonella* Genomic Island 1-Positive *Salmonella enterica* Isolates from Different Origins. Applied and Environmental Microbiology, 77, 5655–5664.

Beutlich J, Guerra B, Schroeter A, Arvand M, Szabo I and Helmuth R, 2012. Highly ciprofloxacin resistant *Salmonella* enterica serovar Kentucky isolates in turkey meat and a human patient. Berliner und Münchener tierärztliche Wochenschrift, 125(3-4), 89-95.

Bertrand S, Weill FX, Cloeckaert A, Vrints M, Mairiaux E, Praud K, Dierick K, Wildemauve C, Godard C, Butaye P, Imberechts H, Grimont PA and Collard JM, 2006. Clonal emergence of extended-spectrum beta-lactamase (CTX-M-2)-producing *Salmonella enterica* serovar Virchow isolates with reduced susceptibilities to ciprofloxacin among poultry and humans in Belgium and France (2000 to 2003). Journal of Clinical Microbiology, 44, 2897-2903.

Bonalli M, Stephan R, Käppeli U, Cernela N, Adank L and Hächler H, 2011. *Salmonella enterica* serotype Virchow associated with human infections in Switzerland: 2004-2009. BMC Infectious Diseases, 11, 49.

Boyle F, Morris D, O'Connor J, DeLappe N, Ward J and Cormican M, 2010. First report of extended-spectrum-β-lactamase-producing *Salmonella enterica* serovar Kentucky isolated from poultry in Ireland. Antimicrobial Agents and Chemotherapy, 54, 551–553.

Bremer V, Leitmeyer K, Jensen E, Metzel U, Meczulat H, Weise E, Werber D, Tchaepe H, Kreienbrock L, Glaser S and Ammon A, 2004. Outbreak of *Salmonella* Goldcoast infections linked to consumption of fermented sausage, Germany 2001. Epidemiology and Infection, 132, 881-887.

Brown DFJ, Hope R, Livermore DM, Brick G, Broughton K, George RC and Reynolds R, 2008. Non-susceptibility trends among enterococci and non-pneumococcal streptococci from bacteraemias in the UK and Ireland, 2001–2006. Journal of Antimicrobial Chemotherapy, 62(2), ii75-85.

Cauwerts K, Decostere A, De Graef EM, Haesebrouck F and Pasmans F, 2007. High prevalence of tetracycline resistance in *Enterococcus* isolates from broilers carrying the erm(B) gene. Avian Pathology, 36, 395–399.

Collard JM, Place S, Denis O, Rodriguez-Villalobos H, Vrints M, Weill FX, Baucheron S, Cloeckaert A, Struelens M and Bertrand S, 2007. Travel-acquired salmonellosis due to *Salmonella* Kentucky resistant to ciprofloxacin, ceftriaxone and co-trimoxazole and associated with treatment failure. Journal of Antimicrobial Chemotherapy, 60, 190–192.

Cuny C, Layer F, Strommenger B, Witte W, 2011. Rare occurrence of methicillin-resistant *Staphylococcus aureus* CC130 with a novel *mecA* homologue in humans in Germany. PLoS One, 6, e24360.

Denny J, Threlfall J, Takkinen J, Löfdahl S, Westrell T, Varela C, Adak B, Boxall N, Ethelberg S, Torpdahl M, Straetemans M and van Pelt W, 2007. Multinational *Salmonella Paratyphi* B variant Java (*Salmonella* Java) outbreak. Eurosurveillance, 12, 3332.

Dorn CA, Schroeter A, Miko D, Protz, and Helmuth R, 2001. Increasing number of *Salmonella Paratyphi B* isolations from broilers received at the National *Salmonella* Reference Laboratory. Berliner und Münchener tierärztliche Wochenschrift, 114, 179-183.

EARSS (European Antimicrobial Resistance Surveillance System), 2008. EARSS Annual Report 2008. Available from http://www.ecdc.europa.eu/en/activities/surveillance/EARS-Net/Documents/2008_EARSS_Annual_Report.pdf

ECDC (European Centre for Disease Prevention and Control) 2012. Antimicrobial resistance surveillance in Europe 2011. Annual Report of the European Antimicrobial Resistance Surveillance Network (EARS-Net). Stockholm: ECDC; 2012. Available from http://ecdc.europa.eu/en/publications/Publications/antimicrobial-resistance-surveillance-europe-2011.pdf

ECDC (European Centre for Disease Prevention and Control) and EFSA (European Food Safety Authority), 2012. Multi-country outbreak of *Salmonella* Stanley infections Update. EFSA Journal 2012;10(9):2893.

ECDC (European Centre for Disease Prevention and Control) 2013. Epidemiological update: multistate outbreak of *Salmonella* Stanley infection, 30 January 2013. Published 7 Feb 2013. Available at http://www.ecdc.europa.eu/en/press/news/Lists/News/ECDC_DispForm.aspx?List=32e43ee8-e230-4424-a783-85742124029a&ID=838

Echeita MA, Aladueña A, Cruchaga S and Usera MA, 1999. Emergence and spread of an atypical *Salmonella enterica* subsp. enterica serotype 4,5,12:i: strain in Spain. Journal of Clinical Microbiology, 37, 3425.

EFSA (European Food Safety Authority), 2007. Report of the Task Force of Zoonoses Data Collection including a proposal for harmonized monitoring scheme of antimicrobial resistance in *Salmonella* in fowl (*Gallus gallus*), turkeys, and pigs and *Campylobacter jejuni* and *C. coli* in broilers. The EFSA Journal 2007, 96, 1–46.

EFSA (European Food Safety Authority), 2008a. Report from the Task Force on Zoonoses Data Collection including guidance for harmonized monitoring and reporting of antimicrobial resistance in commensal *Escherichia coli* and *Enterococcus* spp. from food animals. The EFSA Journal 2008, 141, 1–44.

EFSA (European Food Safety Authority), 2008b. Report of the Task Force on Zoonoses Data Collection on the analysis of the baseline survey on the prevalence of *Salmonella* in turkey flocks, in the EU, 2006–2007 – Part A: *Salmonella* prevalence estimates. The EFSA Journal 2008, 134, 1-91.

EFSA (European Food Safety Authority), 2008c. Scientific report on analysis of the baseline survey on the prevalence of *Salmonella* in holdings with breeding pigs, in the EU, 2008, Part A: *Salmonella* prevalence estimates. EFSA Journal 2009;7(12):1377, 93 pp. doi:10.2903/j.efsa.2009.1377

EFSA (European Food Safety Authority), 2009a. Joint scientific report of ECDC, EFSA and EMEA on meticillin resistant *Staphylococcus aureus* (MRSA) in livestock, companion animals and foods. EFSA-Q-2009-00612 (EFSA Scientific Report (2009) 301, 1-10) and EMEA/CVMP/SAGAM/ 62464/2009.

EFSA (European Food Safety Authority), 2009b. Scientific report on the analysis of the baseline survey on the prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) in holdings with breeding pigs, in the EU, 2008. Part A: MRSA prevalence estimates. EFSA Journal 2009;7(11):1376, 82pp. doi:10.2903/j.efsa.2009.1376

EFSA (European Food Safety Authority), 2009c. Scientific opinion of the Panel on Biological Hazards on the assessment of the public health significance of meticillin resistant *Staphylococcus aureus* (MRSA) in animals and foods. The EFSA Journal 2009, 993, 1–73.

EFSA (European Food Safety Authority), 2009d. Joint opinion on antimicrobial resistance focused on zoonotic infections. Scientific opinion of the European Centre for Disease Prevention and Control; scientific opinion of the Panel of Biological Hazards. Opinion of the Committee for Medicinal Products for Veterinary Use. Scientific opinion of the Scientific Committee on Emerging and Newly Identified Health Risks. EFSA Journal 2009;7(11):1372, 78 pp. doi:10.2903/j.efsa.2009.1372

EFSA (European Food Safety Authority), 2010a. Scientific opinion of the Panel on Biological Hazards on the risk posed by broiler meat to human campylobacteriosis in the EU. EFSA Journal 2010;8(1):1437, 89 pp. doi:10.2903/j.efsa.2010.1437

EFSA (European Food Safety Authority), 2010b. Scientific report on the analysis of the baseline survey on the prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) in holdings with breeding pigs, in the EU, 2008. EFSA Journal 2010;8(6):1597, 67 pp. doi:10.2903/j.efsa.2010.1597

EFSA (European Food Safety Authority), 2010c. The Community Summary Report on antimicrobial resistance in zoonotic and indicator bacteria from animals and food in the European Union in 2004–2007. EFSA Journal 2010;8(4):1309, 306 pp. doi:10.2903/j.efsa.2010.1309

EFSA (European Food Safety Authority), 2010d. Panel on Biological Hazards (BIOHAZ); Scientific Opinion on monitoring and assessment of the public health risk of "*Salmonella* Typhimurium-like" strains. EFSA Journal 2010;8(10):1826, 48 pp. doi:10.2903/j.efsa.2010.1826

EFSA (European Food Safety Authority), 2012a Technical specifications for the analysis and reporting of data on antimicrobial resistance (AMR) in the European Union Summary Report. EFSA Journal 2012;10(2):2587, 53 pp. doi:10.2903/j.efsa.2012.2587

EFSA (European Food Safety Authority), 2012b Technical specifications on the harmonised monitoring and reporting of antimicrobial resistance in *Salmonella*, *Campylobacter* and indicator *Escherichia coli* and *Enterococcus* spp. bacteria transmitted through food. EFSA Journal 2012;10(6):2742, 64pp. doi:10.2903/j.efsa.2012.2742

EFSA (European Food Safety Authority), 2012c Technical specifications for the harmonised monitoring and reporting of antimicrobial resistance in MRSA in food-producing animals and food. EFSA Journal 2012;10(10):2897, 56 pp. doi:10.2903/j.efsa.2012.2897

EFSA (European Food Safety Authority), ECDC (European Centre for Disease Prevention and Control), 2011. The European Union summary report on trends and sources of zoonoses, zoonotic agents and food-borne outbreaks in 2009. EFSA Journal 2011;9(3):2090, 378 pp. doi:10.2903/j.efsa.2011.2090

EFSA (European Food Safety Authority) and ECDC (European Centre for Disease Prevention and Control), 2012. The European Union Summary Report on Trends and Sources of Zoonoses, Zoonotic agents and Food-borne Outbreaks in 2010. EFSA Journal 10(3):2597, 442 pp. doi:10.2903/j.efsa.2012.2597

EFSA (European Food Safety Authority) and ECDC (European Centre for Disease Prevention and Control), 2013. The European Union Summary Report on Trends and Sources of Zoonoses, Zoonotic agents and Food-borne Outbreaks in 2011. EFSA Journal 2013;11(4):3129, 250 pp. doi:10.2903/j.efsa.2013.3129.

Frost J, 1994. Testing for resistance to antibacterial drugs. Methods in Practical Laboratory Bacteriology (ed. H. Chart). New York: CRC Press, pp. 73–82.

García-Álvarez L, Holden MT, Lindsay H, Webb CR, Brown DF, Curran MD, Walpole E, Brooks K, Pickard DJ, Teale C, Parkhill J, Bentley SD, Edwards GF, Girvan EK, Kearns AM, Pichon B, Hill RL, Larsen AR, Skov RL, Peacock SJ, Maskell DJ and Holmes MA, 2011. Methicillin-resistant *Staphylococcus aureus* with a novel *mecA* homologue in human and bovine populations in the UK and Denmark: a descriptive study. Lancet Infectious Diseases, 11(8), 595–603.

Gibreel A and Taylor DE, 2006. Macrolide resistance in *Campylobacter jejuni* and *Campylobacter coli*. Journal of Antimicrobial Chemotherapy, 58, 243–255.

Hasman H, Mevius D, Veldman K, Olesen I and Aarestrup FM, (2005). Beta-Lactamases among extended-spectrum b-lactamase (ESBL)-resistant *Salmonella* from poultry, poultry products and human patients in The Netherlands. Journal of Antimicrobial Chemotherapy, 56, 115-121.

Hauser E, Hebner F, Tietze E, Helmuth R, Junker E, Prager R, Schroeter R, Rabsch, WFruth A and Malorny B, 2011. Diversity of *Salmonella enterica* serovar Derby isolated from pig, pork and humans in Germany. International Journal of Food Microbiolgy, 151, 141-149.

Health Protection Agency, 2005. International outbreak of *Salmonella* Goldcoast infection in tourists returning from Majorca, September-October 2005: final summary. CDR Weekly 2005, 15(49). Available online: http://www.hpa.org.uk/cdr/archives/2005/cdr4905.pdf

Hopkins KL, Kirchner M, Guerra B, Granier SA, Lucarelli C, Porrero MC, Jakubczak A, Threlfall EJ and Mevius DJ, 2010. Multiresistant *Salmonella enterica* serovar 4,[5],12:i: in Europe: a new pandemic strain? Eurosurveillance, 3;15(22),19580.

Kahlmeter G, Brown DF, Goldstein FW, MacGowan AP, Mouton JW, Osterlund A, Rodloff A, Steinbakk M, Urbaskova P and Vatopoulos A, 2003. European harmonization of MIC breakpoints for antimicrobial susceptibility testing of bacteria. Journal of Antimicrobial Chemotherapy, 52, 145–148.

Le Hello S, Hendriksen RS, Doublet B, Fisher I, Nielsen EM, Whichard JM, Bouchrif B, Fashae K, Granier SA, Jourdan-Da Silva N, Cloeckaert A, Threlfall EJ, Angulo FJ, Aarestrup FM, Wain J, Weill FX, 2011. International spread of an epidemic population of *Salmonella enterica* serotype Kentucky ST198 resistant to ciprofloxacin. Journal of Infectious Diseases, 204, 675-684.

Lenglet A, National Epidemiological Surveillance Network of Spain, 2005. E-alert 9 August: Over 2000 cases so far in *Salmonella* Hadar outbreak in Spain associated with consumption of pre-cooked chicken, July-August, 2005. Eurosurveillance. 10(32), 2770. Available online: http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=2770

Magiorakos AP, Srinivasan A, Carey RB, Carmeli Y, Falagas ME, Giske CG, Harbarth S, Hindler JF, Kahlmeter G, Olsson-Liljequist B, Paterson DL, Rice LB, Stelling J, Struelens MJ, Vatopoulos A, Weber JT, Monnet DL, 2012. Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: an international expert proposal for interim standard definitions for acquired resistance. Clinical Microbiology and Infection, 18(3), 268-81.

Maguire H, Cowden J, Jacob M, Rowe B, Roberts D, Bruce J, Mitchell E, 1992. An outbreak of *Salmonella* Dublin infection in England and Wales associated with a soft unpasteurized cows' milk cheese. Epidemiology and Infection, 109(3), 389-396.

Malorny M, Schroeter A and Helmuth R, 1999. Incidence of Quinolone Resistance over the period 1986 to 1998 in Veterinary *Salmonella* Isolates from Germany. Antimicrobial Agents and Chemotherapy, 43, 2278-2282.

MARAN 2009 (Monitoring of Antimicrobial Resistance and Antibiotic Usage in Animals in the Netherlands in 2009), 2011, online. Central Veterinary Institute of Wageningen University and Research Centre in collaboration with the Agricultural Economics Research Institute of Wageningen UR, the Food and Consumer Product Safety Authority, and the National Institute for Public Health and the Environment.

Miko A, Proes K, Schroeter A and Helmuth R, 2003. Multiple-drug resistance in D-tartrate-positive *Salmonella* enterica Serovar Paratyphi B isolates from poultry is mediated by class 2 integrons inserted into the bacterial chromosome. Antimicrobial Agents and Chemotherapy, 47, 3640-3643.

Mossong J, Marques P, Ragimbeau C, Huberty-Krau P, Losch S, Meyer G, Moris G, Strottner C, Rabsch W and Schneider F, 2007. Outbreaks of monophasic *Salmonella enterica* serovar 4,[5],12:i: in Luxembourg, 2006. Eurosurveillance, 12, 156-158.

Murray BE, 1990. The life and times of the *Enterococcus*. Clinical Microbiology Reviews, 3, 46-65.

Neidhardt FC, 1996. *Escherichia coli* and *Salmonella*: Cellular and Molecular Biology. ASM Press. Washington, DC, USA.

Nicolay N, Thornton L, Cotter S, Garvey P, Bannon O, McKeown P, Cormican M, Fisher I, Little C, Boxall N, De Pinna E, Peters TM, Cowden J, Salmon R, Mason B, Irvine N, Rooney P, O'Flanagan D, 2011. *Salmonella enterica* serovar Agona European outbreak associated with a food company. Epidemiology and Infection, 139(8),1272-1280.

Nilsson O, Greko C, Top J, Franklin A and Bengtsson B, 2009. Spread without known selective pressure of a vancomycin-resistant clone of *Enterococcus faecium* among broilers. Journal of Antimicrobial Chemotherapy, 63, 868–872.

Nógrády N, Tóth A, Kostyák A, Pászti J and Nagy B, 2007. Emergence of multidrug-resistant clones of *Salmonella* Infantis in broiler chickens and humans in Hungary. Journal of Antimicrobial Chemotherapy, 60, 645-648.

Nógrády N, Király M, Davies R, Nagy B, 2012. Multidrug resistant clones of *Salmonella* Infantis of broiler origin in Europe. International Journal of Food Microbiology, 157, 108-112.

Overdevest I, Willemsen I, Rijnsburger M, Eustace A, Xu L, Hawkey P, Heck M, Savelkoul P, Vandenbroucke-Grauls C, van der Zwaluw K, Huijsdens Xand Kluytmans J, 2011. Extended-Spectrum β-Lactamase genes of *Escherichia coli* in chicken meat and humans, the Netherlands. Emerging Infectious Diseases, 17(7), 1216-1222.

Overesch G, Büttner S, Rossano A and Perreten V, 2011. The increase of methicillin-resistant *Staphylococcus aureus* (MRSA) and the presence of an unusual sequence type ST49 in slaughter pigs in Switzerland. BMC Veterinary Research, 7, 30-39.

Papadopoulou C, Davies RH, Carrique-Mas JJ, Evans SJ, 2009. *Salmonella* serovars and their antimicrobial resistance in British turkey flocks in 1995 to 2006. Aavian Pathology, 38(5), 349-357.

Shore AC, Deasy EC, Slickers P, Brennan G, O'Connell B, Monecke S, Ehricht R and Coleman DC, 2011. Detection of staphylococcal cassette chromosome *mec* type XI carrying highly divergent *mecA*, *mecI*, *mecR1*, *blaZ*, and *ccr* genes in human clinical isolates of clonal complex 130 methicillin-resistant *Staphylococcus aureus*. Antimicrobial Agents and Chemotherapy, 55, 3765–3773.

Threlfall EJ, Hall MLM, Rowe B, 1986. *Salmonella* Goldcoast from outbreaks of food-poisoning in the British Isles can be differentiated by plasmid profiles. Journal of Hygiene (Cambridge), 97, 115-122.

Vaillant V, Haeghebaert S, Desenclos JC, Bouvet P, Grimont F, Grimont PA, Burnens AP, 1996. Outbreak of *Salmonella* Dublin infection in France, November – December 1995. Eurosurveillance, Volume 1, Issue 2.

van Asselt ED, Thissen JT and van der Fels-Klerx HJ, 2009. *Salmonella* serotype distribution in the Dutch broiler supply chain. Poultry Science, 88, 2695-2701.

van den Bogaard AEJM, London N and Stobberingh EE, 2000. Antimicrobial resistance in pig faecal samples from the Netherlands (five abattoirs) and Sweden. Journal of Antimicrobial Chemotherapy, 45, 663–671.

van Pelt W, Van der Zee H, Wannet WJB, Van de Giessen A, Mevius DJ, Bolder NM, Komijn RE and Van Duynhoven YTHP, 2003. Explosive increase of *Salmonella* Java in poultry in the Netherlands: consequences for public health. Eurosurveillance, 8, 31–35.

Veldman K, Cavaco LM, Mevius D, Battisti A, Franco A, Botteldoorn N, Bruneau M, Perrin-Guyomard A, Cerny T, De Frutos Escobar C, Guerra B, Schroeter A, Gutierrez M, Hopkins K, Myllyniemi A, Sunde M, Wasyl D and Aarestrup FM, 2011. International collaborative study on the occurrence of plasmid-mediated quinolone resistance in *Salmonella* enterica and *Escherichia coli* isolated from animals, humans, food and the environment in 13 European countries. Journal of Antimicrobial Chemotherapy 66, 1278-1286.

Velge P, Cloeckaert A and Barrow P, 2005. Emergence of *Salmonella* epidemics: The problems related to *Salmonella enterica* serotype Enteritidis and multiple antibiotic resistance in other major serotypes. Veterinary Research, 36, 267-288.

Wang HH, Manuzon M, Lehman M, Wan K, Luo H, Wittu T, Yousef A and Bakaletz LO, 2006. Food commensal microbes as a potentially important avenue in transmitting antibiotic resistance genes. FEMS Microbiological Letters, 254, 226–231.

Wasyl D and Hoszowski A, 2012. First isolation of ESBL-producing *Salmonella* and emergence of multiresistant *Salmonella* Kentucky in turkey in Poland. Food Research International, 45, 958–961.

Weill F-X, Lailler R, Praud K, Kérouanton A, Fabre L, Brisabois A, Grimont PAD and Cloeckaert A, (2004). Emergence of Extended-Spectrum-_-Lactamase (CTX-M-9)-Producing Multiresistant Strains of *Salmonella enterica* Serotype Virchow in Poultry and Humans in France. Journal of Clinical Microbiology, 42, 5767-5773.

Winokur PL, Vonstein DL, Hoffman LJ, Uhlenhopp EK and Doern GB, 2001. Evidence for transfer of CMY-2 AmpC beta-lactamase plasmids between *Escherichia coli* and *Salmonella* isolates from food, animals and humans. Antimicrobial Agents and Chemotherapy, 45, 2716–2722.

APPENDIX 1. ANTIMICROBIAL RESISTANCE IN *SALMONELLA*–QUALITATIVE DATA

1.1. Introduction

In 2011, two MSs reported on antimicrobial resistance in *Salmonella* from animals and food as quantitative disc diffusion data, which have been analysed as qualitative data and presented in this chapter. These disc diffusion data have been analysed using the breakpoints for resistance specified by the reporting MS and in accordance with the method used (Appendix Tables QSA1–QSA3).

No tables were generated for this chapter as only one country reported qualitative data by *Salmonella* species and sampling origin. Instead, all data are discussed in the text. Resistance to the following antimicrobial agents are described in detail below: tetracyclines, chloramphenicol, ampicillin, sulfonamides, gentamicin, ciprofloxacin and nalidixic acid.

Appendix Table QSA1. Overview of MSs reporting qualitative data on* Salmonella *spp. from animals and food in 2011

Origin	Quantitative disk diffusion data	
	Total number of MS reporting	Countries
Gallus gallus (fowl)	1	**MS:** RO
Turkeys	1	**MS:** RO
Pigs	1	**MS:** RO
Meat from broilers (*Gallus gallus*)	1	**MS:** ES
Meat from pig	1	**MS:** ES

Appendix Table QSA2. Overview of MSs reporting qualitative data on* Salmonella *Typhimurium from animals and food in 2011

Origin	Quantitative disk diffusion data	
	Total number of MS reporting	Countries
Gallus gallus (fowl)	1	**MS:** RO
Pigs	1	**MS:** RO
Meat from pig	1	**MS:** ES

Appendix Table QSA3. Overview of MSs reporting qualitative data on* Salmonella *Enteritidis from animals and food in 2011

Origin	Quantitative disk diffusion data	
	Total number of MS reporting	Countries
Gallus gallus (fowl)	1	**MS:** RO
Pigs	1	**MS:** RO

1.2. Antimicrobial resistance in *Salmonella* isolates from food (qualitative data)

1.2.1. Meat from broilers (*Gallus gallus*)

Resistance levels among *Salmonella*

Only Spain reported qualitative data on resistance among *Salmonella* spp. from meat from broilers in 2011. It tested nine isolates for resistance to most antimicrobials but only eight for resistance to tetracyclines. These isolates were fully susceptible to chloramphenicol, ciprofloxacin, gentamicin, sulfonamides and tetracyclines. However, there was a high level of resistance to ampicillin (22.2 %) and nalidixic acid (44.4 %).

1.3. Antimicrobial resistance in *Salmonella* isolates from animals (qualitative data)

1.3.1. Fowl (*Gallus gallus*)

Resistance levels among *Salmonella*

Romania was the only country to report disc diffusion data for isolates of *Salmonella* from *Gallus gallus*. It reported data for 1,005 isolates of *Salmonella* spp. and 162 isolates of *S.* Enteritidis. The resistance levels reported for the former tended to be somewhat higher than in the latter. Resistance to sulfonamides was extremely high in both *Salmonella* spp. (95.9 %) and *S.* Enteritidis (90.2 %). Resistance to nalidixic acid was also very high in *Salmonella* spp. (57.5 %) but at a moderate level in *S.* Enteritidis (17.9 %). There was also a high level of resistance to ampicillin among *Salmonella* spp. (23.0 %) but only a moderate level of resistance to ciprofloxacin (11.0 %) and gentamicin (13.2 %), and a low level of resistance to chloramphenicol (6.9 %). Among *S.* Enteritidis, there was only a low level of resistance to all four of these antimicrobials (ampicillin 6.8 %; chloramphenicol 1.9 %; ciprofloxacin 1.2 %; gentamicin 4.3 %). No data were reported concerning resistance to tetracyclines.

1.3.2. Pigs

Resistance levels among *Salmonella*

Romania was also the only country to report disc diffusion data for isolates of *Salmonella* spp. from pigs. It reported data for 41 isolates of *Salmonella* spp. and eight isolates of *S.* Typhimurium. In both cases, there was 100 % resistance to sulfonamides. Resistance to ampicillin was also very high in both *Salmonella* spp. (53.7 %) and *S.* Typhimurium (50.0 %). Nalidixic acid resistance was at a very high level in *Salmonella* spp. (53.7 %) and at a high level in *S.* Typhimurium (25.0 %). Resistance to chloramphenicol and gentamicin was less common, with 22.0 % of *Salmonella* spp. and 12.5 % of *S.* Typhimurium expressing resistance to the former, and 12.2 % of *Salmonella* spp. and 12.5 % of *S.* Typhimurium expressing resistance to the latter. None of the isolates expressed resistance to ciprofloxacin. No resistance data were reported for tetracyclines.

1.3.3. Cattle (bovine animals)

Resistance levels among *Salmonella*

No data were reported for isolates of *Salmonella* spp. from cattle in 2011.

1.4. Discussion

Very few countries reported qualitative data for *Salmonella* in 2011. Furthermore, it is difficult to accurately compare the data collected using disc diffusion techniques and those deriving from dilution methods and collected quantitatively as MIC data. Therefore, as in previous years, a detailed analysis and interpretation of the results has not been undertaken.

Romania and Spain both used CLSI disc diffusion methods to test the *Salmonella* isolates recovered from *Gallus gallus*, turkeys and pigs/meat from broilers and pigs respectively and interpreted the results using CLSI breakpoints. The results will not be directly comparable to the results obtained by MSs performing broth microdilution MIC determinations and applying EUCAST ECOFFs to interpret those results and have therefore been presented separately.

APPENDIX 2. MULTI-RESISTANCE

Appendix Table MDR1. Frequency distribution of completely susceptible isolates and resistant isolates to from one to nine antimicrobials, in* Salmonella *spp. from meat from pigs in MSs reporting isolate-based data, 2011

Country	Susceptible to all		Resistant to 1 AMB		Resistant to 2 AMB		Resistant to 3 AMB		Resistant to 4 AMB	
	n	%	n	%	n	%	n	%	n	%
Denmark (N=49)	9	18.4	4	8.2	4	8.2	6	12.2	19	38.8
Estonia (N=22)	16	72.7	0	0	0	0	0	0	3	13.6
Germany (N=115)	29	25.2	10	8.7	5	4.4	11	9.6	45	39.1
Ireland (N=139)	37	26.6	13	9.4	6	4.3	21	15.1	30	21.6
Italy (N=67)	18	26.9	15	22.4	4	6.0	7	10.5	11	16.4

Country	Resistant to 5 AMB		Resistant to 6 AMB		Resistant to 7 AMB		Resistant to 8 AMB		Resistant to 9 AMB	
	n	%	n	%	n	%	n	%	n	%
Denmark (N=49)	7	14.3	0	0	0	0	0	0	0	0
Estonia (N=22)	3	13.6	0	0	0	0	0	0	0	0
Germany (N=115)	9	7.8	3	2.6	3	2.6	0	0	0	0
Ireland (N=139)	15	10.8	15	10.8	2	1.4	0	0	0	0
Italy (N=67)	7	10.5	2	3.0	3	4.5	0	0	0	0

N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances.

n = number of resistant isolates per category of susceptibility or multiple resistance.

% = percentage of resistant isolates per category of susceptibility or multiple resistance.

AMB = antimicrobial substance(s).

Appendix Table MDR2. Frequency distribution of completely susceptible isolates and resistant isolates to from one to nine antimicrobials, in* Salmonella *spp. from broilers in MSs reporting isolate-based data, 2011

Country	Susceptible to all		Resistant to 1 AMB		Resistant to 2 AMB		Resistant to 3 AMB		Resistant to 4 AMB	
	n	%	n	%	n	%	n	%	n	%
Austria (N=90)	39	43.3	4	4.4	2	2.2	23	25.6	19	21.1
Denmark (N=43)	34	79.1	5	11.6	1	2.3	0	0	2	4.7
France (N=156)	94	60.3	27	17.3	0	0	9	5.8	21	13.5
Germany (N=39)	24	61.5	3	7.7	2	5.1	2	5.1	6	15.4
Ireland (N=63)	57	90.5	3	4.8	1	1.6	0	0	1	1.6
Italy (N=54)	24	44.4	9	16.7	1	1.9	5	9.3	9	16.7
Spain (N=40)	8	20.0	15	37.5	6	15.0	2	5.0	7	17.5
United Kingdom (N=23)	12	52.2	5	21.7	3	13.0	0	0	2	8.7

Country	Resistant to 5 AMB		Resistant to 6 AMB		Resistant to 7 AMB		Resistant to 8 AMB		Resistant to 9 AMB	
	n	%	n	%	n	%	n	%	n	%
Austria (N=90)	3	3.3	0	0	0	0	0	0	0	0
Denmark (N=43)	1	2.3	0	0	0	0	0	0	0	0
France (N=156)	4	2.6	1	0.6	0	0	0	0	0	0
Germany (N=39)	1	2.6	0	0	1	2.6	0	0	0	0
Ireland (N=63)	0	0	0	0	1	1.6	0	0	0	0
Italy (N=54)	4	7.4	1	1.9	0	0	1	1.9	0	0
Spain (N=40)	0	0	2	5.0	0	0	0	0	0	0
United Kingdom (N=23)	0	0	0	0	1	4.4	0	0	0	0

N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances.

n = number of resistant isolates per category of susceptibility or multiple resistance.

% = percentage of resistant isolates per category of susceptibility or multiple resistance.

AMB = antimicrobial substance(s).

Appendix Table MDR3. Frequency distribution of completely susceptible isolates and resistant isolates to from one to nine antimicrobials, in* Salmonella *spp. from laying hens in MSs reporting isolate-based data, 2011

Country	Susceptible to all		Resistant to 1 AMB		Resistant to 2 AMB		Resistant to 3 AMB		Resistant to 4 AMB	
	n	%	n	%	n	%	n	%	n	%
Austria (N=86)	77	89.5	7	8.1	0	0	1	0	1	1.2
France (N=165)	141	85.5	11	6.7	2	1.2	2	1.2	6	3.6
Germany (N=103)	89	86.4	2	1.9	2	1.9	0	0	7	6.8
Italy (N=88)	47	53.4	19	21.6	4	1.6	5	5.7	8	9.1
Spain (N=170)	112	65.9	45	26.5	4	2.4	3	1.8	4	2.4
United Kingdom (N=12)	7	58.3	1	8.3	0	0	2	16.7	2	16.7

Country	Resistant to 5 AMB		Resistant to 6 AMB		Resistant to 7 AMB		Resistant to 8 AMB		Resistant to 9 AMB	
	n	%	n	%	n	%	n	%	n	%
Austria (N=86)	1	1.2	0	0	0	0	0	0	0	0
France (N=165)	3	1.8	0	0	0	0	0	0	0	0
Germany (N=103)	2	1.9	0	0	0	0	1	1.0	0	0
Italy (N=88)	3	3.4	0	0	2	2.3	0	0	0	0
Spain (N=170)	1	0.6	1	0.6	0	0	0	0	0	0
United Kingdom (N=12)	0	0	0	0	0	0	0	0	0	0

N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances.

n = number of resistant isolates per category of susceptibility or multiple resistance.

% = percentage of resistant isolates per category of susceptibility or multiple resistance.

AMB = antimicrobial substance(s).

Appendix Table MDR4. Frequency distribution of completely susceptible isolates and resistant isolates to from one to nine antimicrobials, in* Salmonella *Enteritidis from laying hens in MSs reporting isolate-based data, 2011

Country	Susceptible to all		Resistant to 1 AMB		Resistant to 2 AMB		Resistant to 3 AMB		Resistant to 4 AMB	
	n	%	n	%	n	%	n	%	n	%
Austria (N=38)	35	92.1	3	7.9	0	0	0	0	0	0
France (N=39)	39	100	0	0	0	0	0	0	0	0
Germany (N=64)	64	100	0	0	0	0	0	0	0	0
Italy (N=14)	9	64.3	3	21.4	0	0	0	0	1	7.1
Spain (N=59)	21	35.6	34	57.6	2	3.4	2	3.4	0	0

Country	Resistant to 5 AMB		Resistant to 6 AMB		Resistant to 7 AMB		Resistant to 8 AMB		Resistant to 9 AMB	
	n	%	n	%	n	%	n	%	n	%
Austria (N=38)	0	0	0	0	0	0	0	0	0	0
France (N=39)	0	0	0	0	0	0	0	0	0	0
Germany (N=64)	0	0	0	0	0	0	0	0	0	0
Italy (N=14)	1	7.1	0	0	0	0	0	0	0	0
Spain (N=59)	0	0	0	0	0	0	0	0	0	0

N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances.

n = number of resistant isolates per category of susceptibility or multiple resistance.

% = percentage of resistant isolates per category of susceptibility or multiple resistance.

AMB = antimicrobial substance(s).

Appendix Table MDR5. Frequency distribution of completely susceptible isolates and resistant isolates to from one to nine antimicrobials, in* Salmonella *spp. from turkeys in MSs reporting isolate-based data, 2011

Country	Susceptible to all		Resistant to 1 AMB		Resistant to 2 AMB		Resistant to 3 AMB		Resistant to 4 AMB	
	n	%	n	%	n	%	n	%	n	%
Austria (N=22)	6	27.3	7	31.8	1	4.6	2	9.1	2	9.1
France (N=174)	64	36.8	36	20.7	8	4.6	14	8.1	19	10.9
Germany (N=78)	24	30.8	6	7.7	2	2.6	13	16.7	12	15.4
Ireland (N=14)	8	57.1	2	14.3	0	0	2	14.3	0	0
Italy (N=27)	5	18.5	2	7.4	2	7.4	2	7.4	8	29.6
Spain (N=154)	4	2.6	2	1.3	2	1.3	24	15.6	13	8.4

Country	Resistant to 5 AMB		Resistant to 6 AMB		Resistant to 7 AMB		Resistant to 8 AMB		Resistant to 9 AMB	
	n	%	n	%	n	%	n	%	n	%
Austria (N=22)	1	4.6	3	13.6	0	0	0	0	0	0
France (N=174)	29	16.7	4	2.3	0	0	0	0	0	0
Germany (N=78)	18	23.1	3	3.9	0	0	0	0	0	0
Ireland (N=14)	2	14.3	0	0	0	0	0	0	0	0
Italy (N=27)	4	14.8	2	7.4	2	7.4	0	0	0	0
Spain (N=154)	41	26.6	58	37.7	10	6.5	0	0	0	0

N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances.

n = number of resistant isolates per category of susceptibility or multiple resistance.

% = percentage of resistant isolates per category of susceptibility or multiple resistance.

AMB = antimicrobial substance(s).

Appendix Table MDR6. Frequency distribution of completely susceptible isolates and resistant isolates to from one to nine antimicrobials, in* Salmonella *spp. from fattening pigs in MSs reporting isolate-based data, 2011

Country	Susceptible to all		Resistant to 1 AMB		Resistant to 2 AMB		Resistant to 3 AMB		Resistant to 4 AMB	
	n	%	n	%	n	%	n	%	n	%
Denmark (N=371)	183	49.3	52	14.0	18	4.9	24	6.5	68	18.3
Estonia (N=17)	12	70.6	1	5.9	0	0	0	0	4	23.5
Germany (N=614)	90	14.7	31	5.1	34	5.5	33	5.4	237	38.6
Ireland (N=39)	15	38.5	2	5.1	0	0	0	0	8	20.5
Italy (N=86)	27	31.4	7	8.1	3	3.5	3	3.5	33	38.4
Spain (N=81)	18	22.2	8	9.9	4	4.9	13	16.1	22	27.2

Country	Resistant to 5 AMB		Resistant to 6 AMB		Resistant to 7 AMB		Resistant to 8 AMB		Resistant to 9 AMB	
	n	%	n	%	n	%	n	%	n	%
Denmark (N=371)	20	5.4	6	1.6	0	0	0	0	0	0
Estonia (N=17)	0	0	0	0	0	0	0	0	0	0
Germany (N=614)	131	21.3	47	7.7	11	1.8	0	0	0	0
Ireland (N=39)	3	7.7	7	18.0	3	7.7	1	2.6	0	0
Italy (N=86)	7	8.1	2	2.3	2	2.3	2	2.3	0	0
Spain (N=81)	5	6.2	6	7.4	2	2.5	3	3.7	0	0

N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances.

n = number of resistant isolates per category of susceptibility or multiple resistance.

% = percentage of resistant isolates per category of susceptibility or multiple resistance.

AMB = antimicrobial substance(s).

Appendix Table MDR7. Frequency distribution of completely susceptible isolates and resistant isolates to from one to nine antimicrobials, in* Salmonella *spp. from cattle in MSs and non-MS reporting isolate-based data, 2011

Country	Susceptible to all		Resistant to 1 AMB		Resistant to 2 AMB		Resistant to 3 AMB		Resistant to 4 AMB	
	n	%	n	%	n	%	n	%	n	%
Estonia (N=15)	15	100	0	0	0	0	0	0	0	0
Finland (N=11)	10	90.9	0	0	1	9.1	0	0	0	0
Germany (N=146)	91	62.3	6	4.1	2	1.4	4	2.7	34	23.3
Ireland (N=44)	17	38.6	1	2.3	0	0	4	9.1	8	18.2
Italy (N=28)	14	50.0	1	3.6	1	3.6	2	7.1	4	14.3
Spain (N=13)	11	84.6	1	7.7	1	7.7	0	0	0	0
Sweden (N=24)	18	75.0	1	4.2	2	8.3	2	8.3	1	4.2
Norway (N=12)	8	66.7	0	0	0	0	1	8.3	3	25.0

Country	Resistant to 5 AMB		Resistant to 6 AMB		Resistant to 7 AMB		Resistant to 8 AMB		Resistant to 9 AMB	
	n	%	n	%	n	%	n	%	n	%
Estonia (N=15)	0	0	0	0	0	0	0	0	0	0
Finland (N=11)	0	0	0	0	0	0	0	0	0	0
Germany (N=146)	7	4.8	2	1.4	0	0	0	0	0	0
Ireland (N=44)	13	29.6	1	2.3	0	0	0	0	0	0
Italy (N=28)	3	10.7	2	7.1	0	0	1	3.6	0	0
Spain (N=13)	0	0	0	0	0	0	0	0	0	0
Sweden (N=24)	0	0	0	0	0	0	0	0	0	0
Norway (N=12)	0	0	0	0	0	0	0	0	0	0

N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances.

n = number of resistant isolates per category of susceptibility or multiple resistance.

% = percentage of resistant isolates per category of susceptibility or multiple resistance.

AMB = antimicrobial substance(s).

Appendix Table MDR8. Frequency distribution of completely susceptible isolates and resistant isolates to from one to five antimicrobials, in* Campylobacter jenuni *from meat from broilers in MSs reporting isolate-based data, 2011

Country	Susceptible to all		Resistant to 1 AMB		Resistant to 2 AMB		Resistant to 3 AMB		Resistant to 4 AMB		Resistant to 5 AMB	
	n	%	n	%	n	%	n	%	n	%	n	%
Austria (N=84)	34	40.5	34	40.5	16	19.1	0	0	0	0	0	0
Denmark (N=61)	53	86.9	2	3.3	6	9.8	0	0	0	0	0	0
Germany (N=188)	52	27.7	49	26.1	82	43.6	5	2.7	0	0	0	0
Italy (N=13)	1	7.7	4	30.8	8	61.5	0	0	0	0	0	0

N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances.

n = number of resistant isolates per category of susceptibility or multiple resistance.

% = percentage of resistant isolates per category of susceptibility or multiple resistance.

AMB = antimicrobial substance(s).

Appendix Table MDR9. Frequency distribution of completely susceptible isolates and resistant isolates to from one to five antimicrobials, in* Campylobacter jejuni *from broilers in MSs and non-MSs reporting isolate-based data, 2011

Country	Susceptible to all		Resistant to 1 AMB		Resistant to 2 AMB		Resistant to 3 AMB		Resistant to 4 AMB		Resistant to 5 AMB	
	n	%	n	%	n	%	n	%	n	%	n	%
Austria (N=116)	33	28.5	65	56.0	18	15.5	0	0	0	0	0	0
Denmark (N=43)	32	74.4	3	7.0	7	16.3	1	2.3	0	0	0	0
Germany (N=59)	12	20.3	25	42.4	19	32.2	3	5.1	0	0	0	0
Ireland (N=114)	38	33.3	44	38.6	31	27.2	1	0.9	0	0	0	0
Spain (N=53)	2	3.8	5	9.4	38	71.7	6	11.3	2	3.8	0	0
Norway (N=48)	44	91.7	4	8.3	0	0	0	0	0	0	0	0
Switzerland (N=150)	71	47.3	51	34.0	22	14.7	4	2.7	1	0.7	1	0.7

N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances.

n = number of resistant isolates per category of susceptibility or multiple resistance.

% = percentage of resistant isolates per category of susceptibility or multiple resistance.

AMB = antimicrobial substance(s).

Appendix Table MDR10. Frequency distribution of completely susceptible isolates and resistant isolates to from one to five antimicrobials, in* Campylobacter coli *from broilers in MSs and non-MS reporting isolate-based data, 2011

Country	Susceptible to all		Resistant to 1 AMB		Resistant to 2 AMB		Resistant to 3 AMB		Resistant to 4 AMB		Resistant to 5 AMB	
	n	%	n	%	n	%	n	%	n	%	n	%
Austria (N=48)	3	6.3	15	31.3	24	50.0	6	12.5	0	0	0	0
Germany (N=25)	0	0	6	24.0	11	44.0	6	24.0	2	8.0	0	0
Ireland (N=32)	13	40.6	11	34.4	7	21.9	1	3.1	0	0	0	0
Spain (N=78)	0	0	1	1.3	22	28.2	27	34.6	24	30.8	4	5.1
Switzerland (N=10)	5	50	2	20.0	2	20.0	0	0	1	10.0	0	0

N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances.

n = number of resistant isolates per category of susceptibility or multiple resistance.

% = percentage of resistant isolates per category of susceptibility or multiple resistance.

AMB = antimicrobial substance(s).

Appendix Table MDR11. Frequency distribution of completely susceptible isolates and resistant isolates to from one to nine antimicrobials, in* E. coli *from broilers in MSs and non-MSs reporting isolate-based data, 2011

Country	Susceptible to all		Resistant to 1 AMB		Resistant to 2 AMB		Resistant to 3 AMB		Resistant to 4 AMB	
	n	%	n	%	n	%	n	%	n	%
Austria (N=173)	24	13.9	53	30.6	34	19.7	22	12.7	23	13.3
Denmark (N=134)	76	56.7	33	24.6	13	9.7	7	5.2	3	2.2
Germany (N=246)	22	8.9	21	8.5	20	8.1	38	15.5	32	13.0
Spain (N=101)	6	5.9	6	5.9	9	8.9	14	13.9	16	15.8
Norway (N=244)	96	39.3	97	39.8	26	10.7	11	4.5	9	3.7
Switzerland (N=176)	44	25.0	61	34.7	22	12.5	25	14.2	11	6.3

Country	Resistant to 5 AMB		Resistant to 6 AMB		Resistant to 7 AMB		Resistant to 8 AMB		Resistant to 9 AMB	
	n	%	n	%	n	%	n	%	n	%
Austria (N=173)	11	6.4	3	1.7	3	1.7	0	0	0	0
Denmark (N=134)	1	0.8	1	0.8	0	0	0	0	0	0
Germany (N=246)	50	20.3	37	15.0	23	9.4	3	1.2	0	0
Spain (N=101)	13	12.9	17	16.8	17	16.8	2	2.0	1	1.0
Norway (N=244)	3	1.2	1	0.4	1	0.4	0	0	0	0
Switzerland (N=176)	10	5.7	2	1.1	1	0.6	0	0	0	0

N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances.

n = number of resistant isolates per category of susceptibility or multiple resistance.

% = percentage of resistant isolates per category of susceptibility or multiple resistance.

AMB = antimicrobial substance(s).

Appendix Table MDR12. Frequency distribution of completely susceptible isolates and resistant isolates to from one to nine antimicrobials, in* E. coli *from fattening pigs in MSs and non-MSs reporting isolate-based data, 2011

Country	Susceptible to all		Resistant to 1 AMB		Resistant to 2 AMB		Resistant to 3 AMB		Resistant to 4 AMB	
	n	%	n	%	n	%	n	%	n	%
Austria (N=162)	51	31.5	33	20.4	33	20.4	21	13.0	11	6.8
Denmark (N=157)	76	48.4	25	15.9	14	8.9	10	6.4	15	9.6
Estonia (N=22)	6	27.3	5	22.7	3	13.6	1	4.6	3	13.6
Germany (N=859)	204	23.8	122	14.2	73	8.5	105	12.2	94	10.9
Spain (N=169)	6	3.6	12	7.1	8	4.7	24	14.2	34	20.1
Norway (N=192)	103	53.7	56	29.2	14	7.3	6	3.1	5	2.6
Switzerland (N=175)	59	33.7	28	16.0	14	8.0	25	14.3	21	12.0

Country	Resistant to 5 AMB		Resistant to 6 AMB		Resistant to 7 AMB		Resistant to 8 AMB		Resistant to 9 AMB	
	n	%	n	%	n	%	n	%	n	%
Austria (N=162)	10	6.2	3	1.9	0	0	0	0	0	0
Denmark (N=157)	13	8.3	4	2.6	0	0	0	0	0	0
Estonia (N=22)	3	13.6	1	4.6	0	0	0	0	0	0
Germany (N=859)	158	18.4	83	9.7	18	2.1	2	0.2	0	0
Spain (N=169)	30	17.8	37	21.9	18	10.7	0	0	0	0
Norway (N=192)	7	3.7	1	0.5	0	0	0	0	0	0
Switzerland (N=175)	18	10.3	7	4.0	2	1.1	1	0.6	0	0

N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances.

n = number of resistant isolates per category of susceptibility or multiple resistance.

% = percentage of resistant isolates per category of susceptibility or multiple resistance.

AMB = antimicrobial substance(s).

Appendix Table MDR13. Frequency distribution of completely susceptible isolates and resistant isolates to from one to nine antimicrobials, in* E. faecium *from broilers in MSs and one non-MS reporting isolate-based data, 2011

Country	Susceptible to all		Resistant to 1 AMB		Resistant to 2 AMB		Resistant to 3 AMB		Resistant to 4 AMB	
	n	%	n	%	n	%	n	%	n	%
Austria (N=72)	10	13.9	22	30.6	19	26.4	13	18.1	7	9.7
Denmark (N=107)	55	51.4	32	29.9	17	15.9	2	1.9	1	0.9
Spain (N=36)	0	0	0	0	6	16.7	11	30.6	9	25.0
Switzerland (N=13)	1	7.7	5	38.5	4	30.8	2	15.4	1	7.7

Country	Resistant to 5 AMB		Resistant to 6 AMB		Resistant to 7 AMB		Resistant to 8 AMB		Resistant to 9 AMB	
	n	%	n	%	n	%	n	%	n	%
Austria (N=72)	1	1.4	0	0	0	0	0	0	0	0
Denmark (N=107)	0	0	0	0	0	0	0	0	0	0
Spain (N=36)	9	25.0	1	2.8	0	0	0	0	0	0
Switzerland (N=13)	0	0	0	0	0	0	0	0	0	0

N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances.

n = number of resistant isolates per category of susceptibility or multiple resistance.

% = percentage of resistant isolates per category of susceptibility or multiple resistance.

AMB = antimicrobial substance(s).

Appendix Table MDR14. Frequency distribution of completely susceptible isolates and resistant isolates to from one to nine antimicrobials, in* E. faecium *from pigs in MSs and non-MS reporting isolate-based data, 2011

Country	Susceptible to all		Resistant to 1 AMB		Resistant to 2 AMB		Resistant to 3 AMB		Resistant to 4 AMB	
	n	%	n	%	n	%	n	%	n	%
Austria (N=61)	1	1.6	25	41.0	26	42.6	2	3.3	4	6.6
Denmark (N=116)	19	16.4	20	17.2	25	21.6	19	16.4	28	24.1
Spain (N=41)	1	2.4	2	4.9	4	9.8	7	17.1	25	61.0
Switzerland (N=25)	5	20.0	6	24.0	8	32.0	5	20.0	1	4.0

Country	Resistant to 5 AMB		Resistant to 6 AMB		Resistant to 7 AMB		Resistant to 8 AMB		Resistant to 9 AMB	
	n	%	n	%	n	%	n	%	n	%
Austria (N=61)	3	4.9	0	0	0	0	0	0	0	0
Denmark (N=116)	5	4.3	0	0	0	0	0	0	0	0
Spain (N=41)	2	4.9	0	0	0	0	0	0	0	0
Switzerland (N=25)	0	0	0	0	0	0	0	0	0	0

N = total number of isolates tested for susceptibility against the whole common set of antimicrobial substances.

n = number of resistant isolates per category of susceptibility or multiple resistance.

% = percentage of resistant isolates per category of susceptibility or multiple resistance.

AMB = antimicrobial substance(s).

APPENDIX 3. LEVEL 3 TABLES

Level 3 tables containing information on reported MIC distributions and data on the number of resistant isolates, are available on the EFSA website.

APPENDIX 4. List of abbreviations and definitions, Member States and other reporting countries, definitions

List of abbreviations

Abbreviation	Definition
AHVLA	Animal Health and Veterinary Laboratories Agency
AMR	antimicrobial resistance
AST	antimicrobial susceptibility testing
BIOHAZ	EFSA Panel on Biological Hazards
BSAC	British Society for Antimicrobial Chemotherapy
CA-SFM	French Society for Microbiology
CBP	clinical breakpoint
CIA	critically important antimicrobial
CLSI	Clinical and Laboratory Standards Institute
CTX-M	cefotaximase
Danmap	Danish Programme for surveillance of antimicrobial consumption and resistance in bacteria from animals, food and humans
DIN	Deutsches Institut für Normung
DNA	desoxyribonucleic acid
DTU	Technical University of Denmark
EC	European Commission
ECDC	European Centre for Disease Prevention and Control
ECOFF	epidemiological cut-off value
EEA	European Economic Area
EFSA	European Food Safety Authority
EMA	European Medicines Agency
ESBL	extended spectrum beta-lactamase
ETEC	enterotoxigenic *E. coli*
EU	European Union
EUCAST	European Committee on Antimicrobial Susceptibility Testing
EU-RL	European Union Reference Laboratory
HACCP	Hazard Analysis and Critical Control Point
HPA	Health Protection Agency (UK)
IZD	Inhibition Zone Diameter
MIC	Minimum Inhibitory Concentration
MLSB	Macrolide–lincosamide–streptogramin B
MRSA	Methicillin-resistant *Staphylococcus aureus*
MS	Member State
NCP	National Control Programme
NRL	National Reference Laboratory
PBP	Penicillin-binding protein
PCR	Polymerase Chain Reaction
SGRA-M	Subcommittee on methodology from the Swedish Reference Group for Antibiotics
spp.	Species
TESSy	The European Surveillance System
VTEC	Vero(cyto)toxigenic *E. coli*
WHO	World Health Organization

Member States of the European Union and other reporting countries in 2011

Member States of the European Union, 2011

Member State	Country abbreviations
Austria	AT
Belgium	BE
Bulgaria	BG
Cyprus	CY
Czech Republic	CZ*
Denmark	DK
Estonia	EE
Finland	FI
France	FR
Germany	DE
Greece	GR
Hungary	HU
Ireland	IE
Italy	IT
Latvia	LV
Lithuania	LT
Luxembourg	LU
Malta	MT
Netherlands	NL*
Poland	PL
Portugal	PT
Romania	RO
Slovakia	SK
Slovenia	SI
Spain	ES
Sweden	SE
United Kingdom	UK*

* In text, referred to as the Czech Republic, the Netherlands and the United Kingdom

Non-Member States reporting, 2011

Country	Country abbreviations
Iceland	IS
Norway	NO
Switzerland	CH

Definitions

Term	Definition and description
'Antimicrobial resistant isolate'.	In the case of quantitative data, an isolate was defined as 'resistant' to a selected antimicrobial when its MIC value (in mg/L) was above the cut-off value or the disc diffusion diameter (in mm) was below the cut-off value. The cut-off values used to interpret MIC distributions (mg/L) for bacteria from animals and food are shown in Table MM10. In the case of qualitative data, an isolate was regarded resistant when the country reported it as resistant using its own cut-off value or break point.
'Level of antimicrobial resistance':	The percentage of resistant isolates among the tested isolates.
'Reporting MS group':	Member States (MSs) that provided data and were included in the relevant table for antimicrobial resistance data for the bacteria–food/animal category–antimicrobial combination.
Terms used to describe the antimicrobial resistance levels	Rare: < 0.1 % Very low: 0.1 % to 1 % Low: >1 % to 10 % Moderate: >10 % to 20 % High: >20 % to 50 % Very high: >50 % to 70 % Extremely high: >70 %

APPENDIX 5. List of institutions contributing to AMR monitoring in animals and food

List of institutions contributing to AMR monitoring in animals and food

Member State	Institution
Austria	• Federal Ministry for Health • Austrian Agency for Health and Food Safety (AGES)
Belgium	• Veterinary and Agrochemical Research Centre (CODA-CERVA), Uccle • Institute of Public Health, Brussels • Federal Agency for the Safety of the Food Chain, Brussels
Bulgaria	• National Diagnostic and Research Veterinary Institute, Sofia • Bulgarian Food Safety Agency, Sofia
Cyprus	• Veterinary Services, Nicosia • Ministry of Agriculture, Nicosia
Czech Republic	• State Veterinary Institute, Prague and Olomouc • State Veterinary Administration of the Czech Republic, Prague
Denmark	• National Food Institute, Technical University of Denmark • Danish Veterinary and Food Administration
Estonia	• Estonian Veterinary and Food Laboratory, Tartu • Veterinary and Food Board, Tallinn
Finland	• EVIRA, Finnish Food Safety Authority, Helsinki
France	• ANSES, French Agency for Food, Environmental Occupational Health and Safety: Fougères Laboratory, Maisons-Alfort Laboratory, Ploufragan/Plouzané Laboratory • Ministère de l´agriculture, de l'alimentation, de la pêche, de la ruralité et de l'aménagement du terriroire, Direction Générale de l'Alimentation, Paris
Germany	• Federal Institute for Risk Assessment (BfR), Berlin
Greece	• Veterinary Laboratory, Chalkis • Ministry of Rural Development and Food, Athens
Hungary	• Central Agricultural Office, Veterinary Diagnostical Directorate, Budapest • Ministry of Rural Agriculture, Budapest
Ireland	• Central Veterinary Research Laboratory, Celbridge • Food Safety Authority of Ireland, Dublin
Italy	• Istituto Zooprofilattico Sperimentale delle Regioni Lazio e Toscana, Rome • Ministry of Health, Rome
Latvia	• Institute of Food Safety, Animal Health and Enviroment "BIOR", Animal Disease Diagnostic Laboratory, Riga • Food and Veterinary Service of Latvia, Riga
Lithuania	• National Food and Veterinary Risk Assessment Institute, Vilnius • State Food and Veterinary Service, Vilnius
Luxembourg	• Laboratoire de Médecine Vétérinaire, Luxembourg
Malta	• Ministry for Resources and Rural Affairs

Table continued overleaf.

List of institutions contributing to AMR monitoring in animals and food (continued)

Member State	Institution
Netherlands	• Central Veterinary Institute, part of Wageningen UR (CVI), Lelystad • National Institute of Public Health and the Environment (RIVM), Bilthoven • Ministry of Agriculture, Nature and Food Quality • Animal Health Service, Deventer
Poland	• National Veterinary Research Institute, Pulawy • General Veterinary Inspectorate, WARSAW
Portugal	• Laboratório Nacional de Investigação Veterinária, Lisbon • Direcção Geral de Veterinária, Lisbon
Romania	• Institute for Diagnostic and Animal Heath, Bucharest • Institute for Hygiene and Veterinary Public Heath, Bucharest • National Sanitary Veterinary and Food Safety Authority, Bucharest
Slovakia	• State Veterinary and Food Institute, Dolny Kubin and Bratislava • State Veterinary and Food Administration of the Slovak Republic
Slovenia	• National Veterinary Institute, Veterinary Faculty, Ljubljana • Ministry for Agriculture and Environment, Veterinary Administration, Ljubljana
Spain	• Laboratorio Central de Sanidad Animal de Santa Fe, Granada • Laboratorio Central de Veterinaria de Algete, Madrid • VISAVET Health Surveillance Center, Complutense University, Madrid • Ministerio de Agricultura, Alimentación y Medio Ambiente • Agencia Española de Seguridad Alimentaria y Nutrición
Sweden	• National Veterinary Institute (SVA), Department of Animal Health and Antimicrobial Strategies, Uppsala • National Food Administration, Uppsala
United Kingdom	• Animal Health and Veterinary Laboratories Agency (AHVLA)

Other reporting country	Institution
Norway	• Norwegian Veterinary Institute
Switzerland	• ZOBA–Centre for Zoonoses, Bacterial Animal Diseases and Antimicrobial Resistance–Institute of Veterinary Bacteriology, Vetsuisse Faculty, University of Bern • Swiss Federal Veterinary Office