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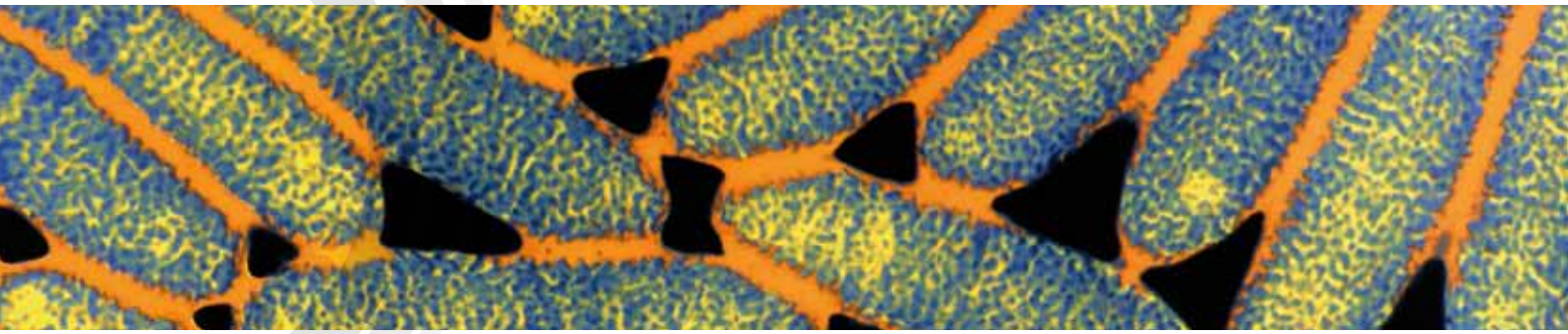
**SURVEILLANCE** REPORT



# Legionnaires' disease in Europe

2009

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This report of the European Centre for Disease Prevention and Control (ECDC) was written by Phillip Zucs.

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# Abbreviations

| | |
|---|---|
| CFR | Case-fatality ratio |
| CI | Confidence interval |
| ECDC | European Centre for Disease Prevention and Control |
| EEA | European Economic Area |
| ELDSNet | European Legionnaires' Disease Surveillance Network |
| EQA | External quality assurance |
| EU | European Union |
| EWGLINET | European Surveillance Scheme for Travel Associated Legionnaires' Disease |
| OR | Odds ratio |
| PCR | Polymerase chain reaction |
| ROC | Receiver operating characteristic |
| TESSy | The European Surveillance System |

# Executive summary

This surveillance report is based on Legionnaires' disease surveillance data collected from 25 EU Member States, Iceland and Norway for 2009. Altogether, 5 518 confirmed and probable cases of Legionnaires' disease were reported, resulting in a notification rate of 11.2 cases per million population. The slightly decreasing trend observed since 2006 was maintained, the notification rate remaining considerably below the estimated European incidence rate of 100 per million.

National notification rates ranged from close to zero in Poland, Romania and Slovakia to 32 per million in Slovenia, with France, Italy and Spain accounting for 66% of reported cases. The peak month of onset of Legionnaires' disease was September, with more than half of the cases experiencing their symptom onset between July and October. Seventy-seven percent of all cases were 50 years or older. In both genders, the notification rate increased with age. Overall, males were almost three times more frequently notified with Legionnaires' disease than were females.

More than two thirds of cases were reported to have been community-acquired. They were followed in decreasing frequency by cases presumably infected while travelling domestically, travelling abroad, staying in a hospital or infected while exposed to a non-hospital healthcare setting. Overall, 82% of cases were confirmed by urinary antigen detection and 9% by culture. Countries joining the EU/EEA after 2000 proved more likely not to report any confirmation by culture or polymerase chain reaction, but to have verified the majority of their cases by a single high antibody titre. Although the current EU case definition for Legionnaires' disease accepts cases verified by single high titres as 'probable cases', these should be treated with caution given the relatively high background prevalence of such titres in some countries and the known serological cross-reactivity of *Legionella* with other bacteria. Of the culture-confirmed cases, 99.1% were due to *Legionella pneumophila* and 87.6% to *L. pneumophila* serogroup 1.

An environmental investigation was carried out in 17% of cases with available information. The likelihood of such an investigation was two times higher in fatal compared with non-fatal cases and 12 times higher in clustered compared with sporadic cases. The reported overall case fatality of 11% was well within the expected range. In decreasing order of magnitude of association, *L. pneumophila* serogroups 6 and 10, older age and reporting country with low outcome reporting were found to be independent predictors of fatal outcome in confirmed cases of Legionnaires' disease. Onset of disease in autumn and winter increased the effect of the infection setting on disease outcome in community-acquired and travel-associated cases, but not in healthcare-associated cases. Gender was not independently associated with fatal outcome.

The 27 EU/EEA Member States reported 101 clusters of Legionnaires' disease involving 254 cases. The proportion of clustered cases represented 6.5% of all cases and the average cluster size was two cases to each cluster, continuing a trend in cluster size that had been decreasing since a peak in 2001. In decreasing order of magnitude of association, reporting country with incomplete cluster status reporting, travel history and patient age between 60 and 79 years were found to be independent predictors of clustering in confirmed cases of Legionnaires' disease. Gender was not independently associated with clustering. Causative *Legionella* species and serogroup could not be controlled for since all clustered confirmed cases with available information had been due to *L. pneumophila* serogroup 1 (or unknown serogroup).

This data analysis has two important limitations. Firstly, it is based on data from passive surveillance systems with rather incomplete reporting on some variables. Clinical outcome and cluster status were reported as unknown for approximately 30% of cases of Legionnaires' disease in 2009. Whether or not an environmental investigation was carried out was reported as unknown for 60% of the cases. Secondly, ELDSNet currently does not collect data on risk factors such as underlying conditions or smoking status, although they are crucial in understanding and explaining the epidemiology of Legionnaires' disease, especially its more severe outcomes.

Member States are well advised to think about ways to either integrate cluster and environmental investigation status, as well as sequence-based typing results, in their case databases or use record linkage methods to provide more complete information. Countries should also explore the possibility of encouraging relevant updates from their local and regional levels of public health administration for more complete reporting of clinical outcome. ELDSNet should consider identifying EU/EEA Member States that are already collecting underlying conditions and smoking status as part of their routine Legionnaires' disease surveillance and discuss the best way for them to report these important data to the European level. Since European retrospective passive Legionnaires' disease surveillance in annual intervals cannot be primarily geared towards fast-paced outbreak detection and control, an important strategic goal to consider could be to increase the ascertainment of cases of Legionnaires' disease, agreeing within ELDSNet on a notification rate (e.g. 100 cases per million population) as the target for Europe and monitoring the progress every year.

# 1 Background

As an infection, Legionnaires' disease is exceptional: it is not transmitted from human to human but through *Legionella*-contaminated aerosols emanating from man-made water systems [1]. Legionnaires' disease has been found to account for up to 4% of community-acquired [2] and nosocomial pneumonia [3]. In community-acquired cases, Legionnaires' disease frequently leads to hospitalisation and has been associated with a case fatality of 9–13% in Catalonian [4] and French [5] surveillance data spanning at least a decade. It was first described as a separate clinical entity in the aftermath of a large outbreak [6], and there have been several more large outbreaks since [7-9], attracting much professional and public attention.

Legionnaires' disease is notifiable at national level in all Member States of the European Union (EU) and the European Economic Area (EEA). It is also notifiable at European level [10]. Until 2010, European Legionnaires' disease surveillance was carried out by the European Surveillance Scheme for Travel Associated Legionnaires' Disease (EWGLINET). From 1995 onwards, this network also collected, analysed and published aggregate annual data of all cases of Legionnaires' disease that had been reported in the Member States, regardless of their travel history. Since April 2010, the network is coordinated by the European Centre for Disease Prevention and Control (ECDC). Its new name, European Legionnaires' Disease Surveillance Network (ELDSNet), and the change from collecting aggregate to collecting disaggregate data reflects the intention to enhance general Legionnaires' disease surveillance and put it on a more equal footing with the surveillance of travel-associated cases.

This is the first detailed annual Legionnaires' disease surveillance report published by ECDC.

# 2 Methods

## 2.1 Time, place and subject under surveillance

The data electronically transmitted from the nominated ELDSNet members in each country to the European Surveillance System (TESSy) database included all cases of Legionnaires' disease that had been reported to the 27 EU Member States, Iceland and Norway in 2009. To be taken into account, the cases had to meet the clinical, laboratory and epidemiologic criteria laid down in the EU case definition for confirmed and probable cases of Legionnaires' disease (see page 4)[11]. Travel-associated cases were to be reported only by their countries of residence. Cases were to be classified as travel-associated if they had stayed at an accommodation site away from home during their incubation period of two to 10 days prior to falling ill. Cases were to be reported as having formed part of a cluster if they had been exposed to the same suspected source as at least one other case with their dates of onset no more apart than two years. The other cluster case(s) did not have to have occurred in 2009.

## 2.2 Data analysis

To be included, cases not only had to be reported as fulfilling the EU case definition; the report also had to provide the information on the method used for diagnostic laboratory testing that would support the case classification. To ensure that the data analysis at European level is done based on the same date and thus the same number of cases as in each Member State, network members report their so-called 'date used for statistics' which can be the date of onset, diagnosis or notification. This analysis was restricted to cases with a date used for statistics from 2009.

The distribution of all cases and of the subsets of fatal and cluster cases by relevant independent variables was described. Univariate analysis served to screen the data for possible associations between these independent variables and the outcomes death and clustering. Finally, logistic regression modelling was used to adjust these associations for confounding. The models were fitted to confirmed cases by forward selection of variables testing significant at $p = 0.05$ by Wald test for dichotomous variables or by likelihood ratio test for nominal variables with more than two categories and for interaction terms. Each model's goodness-of-fit was assessed by the area under the receiver operating characteristic (ROC) curve plotting the model's sensitivity against the proportion of false positives with regard to the outcome.

Associations between independent and outcome variables were quantified by estimating odds ratios (OR) and calculating their 95% confidence intervals (CI). All analyses were carried out based on the cases where the variable(s) involved had no missing values.

## EU case definition of Legionnaires' disease [11]

**Clinical criteria:**

Any person with pneumonia.

**Laboratory criteria for case confirmation:**

At least one of the following three:

- Isolation of *Legionella* spp. from respiratory secretions or any normally sterile site;
- Detection of *Legionella pneumophila* antigen in urine;
- *Legionella pneumophila* serogroup 1 specific antibody response.

**Laboratory criteria for a probable case:**

At least one of the following four:

- Detection of *Legionella pneumophila* antigen in respiratory secretions or lung tissue, e.g. by DFA staining using monoclonal-antibody derived reagents;
- Detection of *Legionella* spp. nucleic acid in a clinical specimen;
- *Legionella pneumophila* non-serogroup 1 or other *Legionella* spp. specific antibody response;
- *L. pneumophila* serogroup 1, other serogroups or other *Legionella* species: single high titre in specific serum antibody.

**Epidemiological criteria:**

At least one of the following two epidemiological links:

- Environmental exposure;
- Exposure to the same common source.

**Case classification**

*Possible case*

NA

*Probable case*

Any person meeting the clinical criteria AND at least one positive laboratory test for a probable case OR an epidemiological link.

*Confirmed case*

Any person meeting the clinical and the laboratory criteria for case confirmation.

# 3 Results

## 3.1 Cases

For 2009, the 29 ELDSNet Member States reported 5 556 cases of Legionnaires' disease, 38 of which had to be excluded due to missing information on the diagnostic laboratory tests used. Among the excluded cases were all cases reported from Cyprus (n=3) and the Czech Republic (n=20) since both countries supplied the missing information only several months after the reporting deadline.

### 3.1.1 Data completeness

Reporting was more than 90% complete for date of onset, age, gender, importation status, probable country of infection, causative pathogen, and environmental findings and positive sampling site whenever an environmental investigation had been carried out (Table 1). Reporting was 60% to 90% complete for outcome, cluster status, exposure setting and matching clinical and environmental isolates. Reporting was 40% complete for environmental investigation status, and less than 1% complete for sequence-based typing results.

**Table 1 Completeness of reporting in 26 countries by variable**

| Variable | Overall completeness % | Minimum | | Maximum | |
|---|---|---|---|---|---|
| | | Completeness % | Countries n | Completeness % | Countries n |
| Date of onset | 96.5 | 0 | 1 | 100.0 | 20 |
| Age | 99.8 | 93.8 | 1 | 100.0 | 22 |
| Gender | 99.9 | 99.8 | 1 | 100.0 | 25 |
| Outcome | 67.6 | 0 | 2 | 100.0 | 15 |
| Cluster | 70.3 | 0 | 3 | 100.0 | 16 |
| Cluster Id[a] | 85.8 | 0 | 2 | 100.0 | 8 |
| Imported | 98.6 | 80.0 | 1 | 100.0 | 17 |
| Probable country of infection[b] | 97.6 | 0 | 1 | 100.0 | 12 |
| Pathogen | 94.2 | 0 | 2 | 100.0 | 13 |
| Sequence type | 0.8 | 0 | 23 | 32.5 | 1 |
| Setting | 89.6 | 0 | 4 | 100.0 | 7 |
| Environmental investigation | 40.0 | 0 | 7 | 100.0 | 9 |
| *Legionella* found[c] | 94.3 | 0 | 2 | 100.0 | 9 |
| Positive sampling site[d] | 96.9 | 0 | 1 | 100.0 | 13 |
| Matching isolates[e] | 73.6 | 0 | 4 | 100.0 | 11 |

[a] *Completeness determined in cases reported to have formed part of a cluster.*
[b] *Completeness determined in cases reported to have been imported.*
[c] *Completeness determined in cases reported to have prompted an environmental investigation.*
[d] *Completeness determined in cases for which positive findings in an environmental investigation were reported.*
[e] *Completeness determined in cases reported to have prompted an environmental investigation.*

### 3.1.2 Case classification and notification rate

Of the 5 518 cases included in the analysis, 5 089 (92.2%) met the EU definition of confirmed cases and 429 (7.8%) were probable cases. All probable cases were based on laboratory criteria, i.e. none of them was defined purely on epidemiologic grounds (contact with a confirmed case or exposure to an environment with laboratory-confirmed presence of *Legionella*).

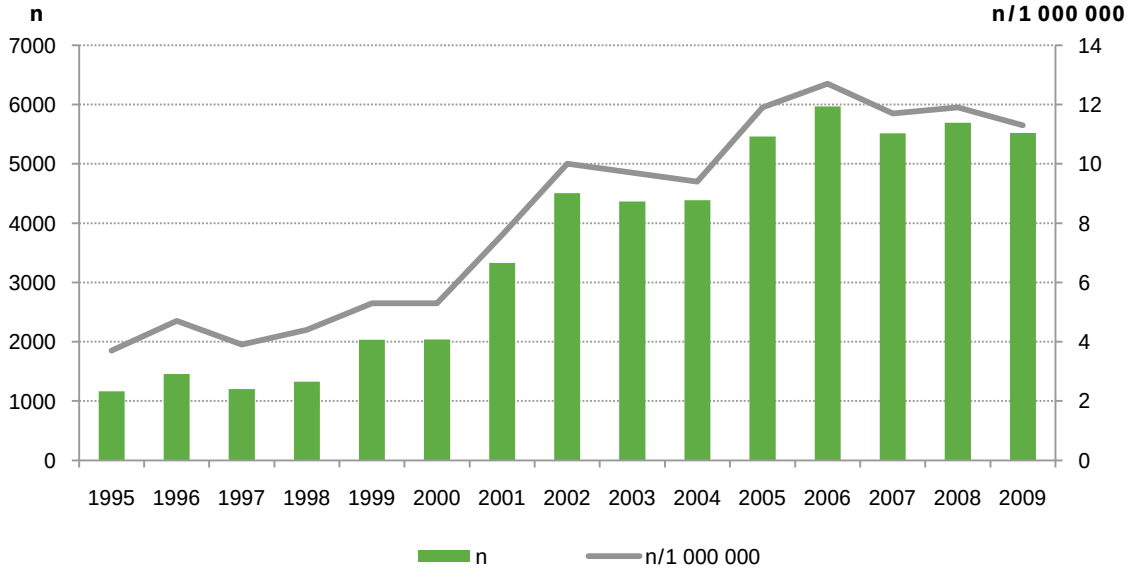
The notification rate in 2009 amounted to 11.2 per 1 000 000 population, continuing the slight decreasing trend observed since 2006 (Figure 1).

### 3.1.3 Time and place

Of 5 327 cases of Legionnaires' disease reported with a date of onset, between 197 and 773 cases occurred each month. The distribution showed a peak in September, as typically seen with this disease, and 50.6% of all cases experienced their symptom onset between July and October (Figure 2). The 5 518 cases were reported by 27 EU and EEA Member States, with France, Italy and Spain accounting for 65.9%. National notification rates ranged from close to zero in Poland, Romania and Slovakia to 32 per 1 000 000 in Slovenia (Table 2). The mean

notification rate was seven times higher in countries that joined the EU/EEA before 2000 (13.4/1 000 000, 95% CI 13.0–13.7) than in those joining after 2000[1] (1.8/1 000 000, 95% CI 1.6–2.1).

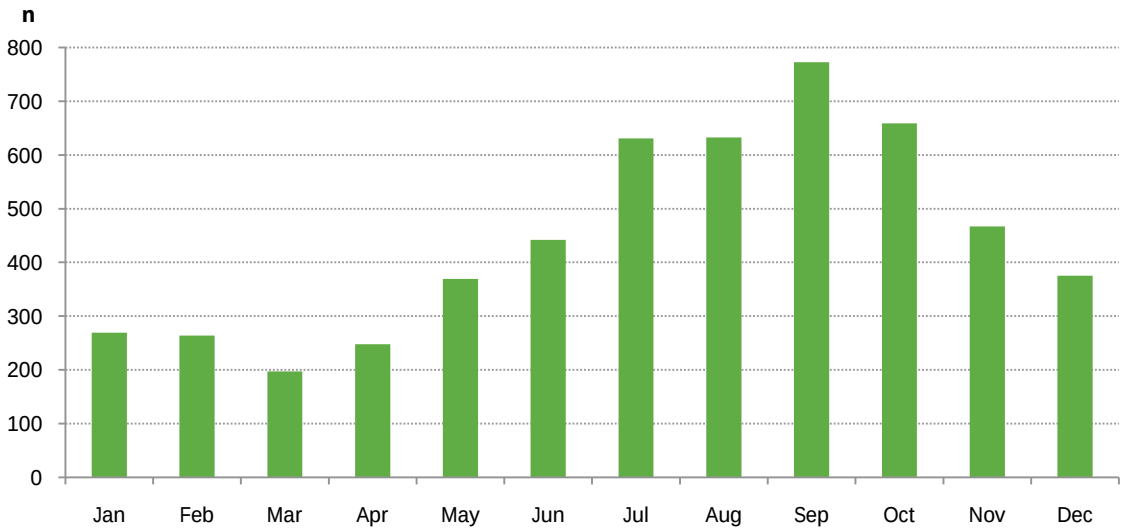
**Figure 1 Reported cases and notification rate of Legionnaires' disease in the EU/EEA[a] by year of reporting, 1995–2009**




| Participating countries (n), by year | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 18 | 18 | 21 | 23 | 23 | 24 | 27 | 28 | 28 | 28 | 28 | 28 | 29 | 27[b] |

[a] *EWGLINET member countries not belonging to the EU/EEA were excluded for 1995–2008.*
[b] *Complete data from Cyprus and the Czech Republic were supplied only after the reporting deadline and therefore could not be taken into account.*

**Figure 2 Reported cases of Legionnaires' disease in the EU/EEA by month of onset, 2009 (n=5 327)**




[1] EU Member States that joined after 2000: Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia.

**Table 2 Reported cases and notification rate of Legionnaires' disease by reporting country, EU/EEA, 2009**

| Country* | Cases (n) | Population (N) | Notification rate (n/million) |
|---|---|---|---|
| Slovenia | 65 | 2 032 362 | 32.0 |
| Spain | 1 231 | 45 828 172 | 26.9 |
| Denmark | 123 | 5 511 451 | 22.3 |
| Iceland | 7 | 319 368 | 21.9 |
| Italy | 1 197 | 60 045 068 | 19.9 |
| France | 1 206 | 64 366 962 | 18.7 |
| Netherlands | 251 | 16 485 787 | 15.2 |
| Sweden | 114 | 9 256 347 | 12.3 |
| Austria | 92 | 8 355 260 | 11.0 |
| Luxembourg | 5 | 493 500 | 10.1 |
| Malta | 4 | 413 609 | 9.7 |
| Portugal | 96 | 10 627 250 | 9.0 |
| Belgium | 80 | 10 666 866 | 7.5 |
| Norway | 34 | 4 799 252 | 7.1 |
| Hungary | 65 | 10 030 975 | 6.5 |
| Germany | 502 | 82 002 356 | 6.1 |
| United Kingdom | 374 | 61 179 260 | 6.1 |
| Estonia | 6 | 1 340 270 | 4.5 |
| Finland | 22 | 5 326 314 | 4.1 |
| Ireland | 7 | 4 450 030 | 1.6 |
| Greece | 15 | 11 260 402 | 1.3 |
| Latvia | 3 | 2 261 294 | 1.3 |
| Bulgaria | 4 | 7 606 551 | 0.5 |
| Slovakia | 2 | 5 412 254 | 0.4 |
| Poland | 10 | 38 135 876 | 0.3 |
| Romania | 3 | 21 498 616 | 0.1 |
| Lithuania | 0 | 3 349 872 | 0 |
| **Total** | **5 518** | **493 055 324** | **11.2** |

** Complete data from Cyprus and the Czech Republic were supplied only after the reporting deadline and therefore could not be taken into account.*

## 3.1.4 Age and gender

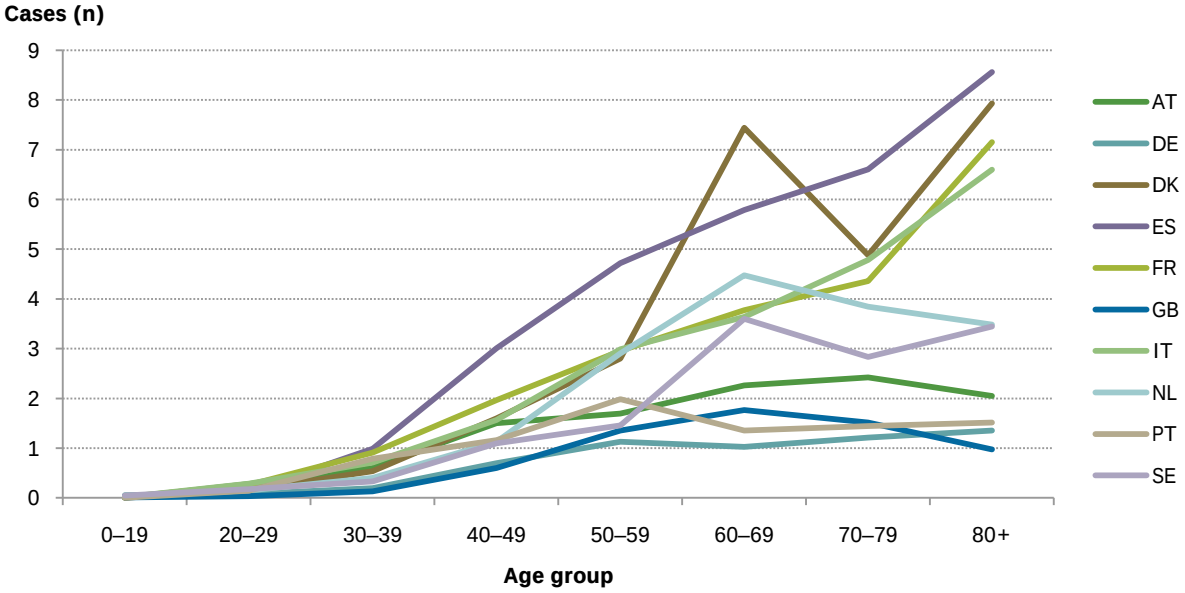
Age and gender were reported for 5 508 cases, 4 247 (77.1%) of which were 50 years or older. In both genders, the notification rate increased with age (Table 3). Overall, males were almost three times more frequently notified with Legionnaires' disease than were females. This gender difference could be seen in all age groups to varying degrees, but was most pronounced in the 30 to 39 year-olds with a male-to-female rate ratio of 4.7.

Age trends in the 10 EU/EEA countries with the highest numbers of reported cases of Legionnaires' disease were not congruent with two distinct age distribution patterns emerging (Figure 3). The notification rates of France, Italy and Spain, the countries accounting for two thirds of all reported cases, exhibited a steady, uninterrupted increase with age. The rates of most remaining countries peaked in the age group between 60 and 69, levelling off thereafter.

**Table 3 Reported cases and notification rate of Legionnaires' disease by gender and age group, EU/EEA, 2009**

| Age (years) | Male | | Female | | Total | |
|---|---|---|---|---|---|---|
| | Cases (n) | Notif. rate (n/million) | Cases (n) | Notif. rate (n/million) | Cases (n) | Notif. rate (n/million) |
| 0–19 | 14 | 0.3 | 10 | 0.2 | 24 | 0.2 |
| 20–29 | 63 | 1.9 | 20 | 0.6 | 83 | 1.3 |
| 30–39 | 266 | 7.5 | 55 | 1.6 | 321 | 4.6 |
| 40–49 | 664 | 18.0 | 167 | 4.5 | 831 | 11.3 |
| 50–59 | 923 | 28.9 | 276 | 8.3 | 1 199 | 18.4 |
| 60–69 | 879 | 36.2 | 332 | 12.4 | 1 211 | 23.7 |
| 70–79 | 694 | 41.4 | 320 | 14.6 | 1 014 | 26.2 |
| 80+ | 494 | 65.6 | 328 | 22.0 | 822 | 36.6 |
| **Total** | **3 997** | **16.6** | **1 508** | **6.0** | **5 505** | **11.2** |

**Figure 3 Notification rate of Legionnaires' disease in the 10 EU/EEA countries with the highest numbers of reported cases, by country and age group, 2009**




## 3.1.5 Presumable setting of infection

Information on the presumable setting of infection was available for 4 945 cases of Legionnaires' disease, more than two thirds of which were reported to have been community-acquired. They were followed in decreasing frequency by cases presumably infected while travelling domestically, travelling abroad, staying in a hospital or infected while exposed to a non-hospital healthcare setting (Table 4).

Comparing countries with more than 10 reported cases, the distribution of settings revealed considerable heterogeneity (Table 5). This was most pronounced in the proportion of cases associated with travelling abroad for which the highest value (Norway) differed 67-fold from the lowest (Italy). Nine countries, including four countries with more than 10 reported cases, reported no nosocomial case of Legionnaires' disease in 2009.

**Table 4 Reported cases of Legionnaires' disease by setting, EU/EEA, 2009**

| Setting | n | % |
|---|---|---|
| Community | 3 382 | 68.4 |
| Domestic travel | 554 | 11.2 |
| Travel abroad | 524 | 10.6 |
| Nosocomial | 333 | 6.7 |
| Non-hospital healthcare | 108 | 2.2 |
| Other | 44 | 0.9 |
| **Total** | **4 945** | **100.0** |

**Table 5 Reported cases of Legionnaires' disease by country and setting, EU/EEA, 2009**

| Country[a] | Setting | | | | | | Subtotal n | Unknown n (%) | Total n |
|---|---|---|---|---|---|---|---|---|---|
| | Community n (%[b]) | Domestic travel n (%[b]) | Travel abroad n (%[b]) | Nosocomial n (%[b]) | Other healthcare n (%[b]) | Other n (%[b]) | | | |
| Austria | 65 (70.7) | 5 (5.4) | 12 (13.0) | 7 (7.6) | 3 (3.3) | 0 | 92 | 0 | 92 |
| Belgium | 6 (12.0) | 3 (6.0) | 20 (40.0) | 1 (2.0) | 5 (10.0) | 15 (30.0) | 50 | 30 (37.5) | 80 |
| Bulgaria | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 (100.0) | 4 |
| Denmark | 63 (58.3) | 4 (3.7) | 35 (32.4) | 5 (4.6) | 1 (0.9) | 0 | 108 | 15 (12.2 | 123 |
| Estonia | 1 (25.0) | 0 | 0 | 3 (75.0) | 0 | 0 | 4 | 2 (33.3) | 6 |
| Finland | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 (100.0) | 22 |
| France | 812 (67.3) | 163 (13.5) | 68 (5.6) | 98 (8.1) | 65 (5.4) | 0 | 1 206 | 0 | 1 206 |
| Germany | 123 (48.8) | 21 (8.3) | 60 (23.8) | 30 (11.9) | 2 (0.8) | 16 (6.3) | 252 | 250 (49.8) | 502 |
| Greece | 10 (66.7) | 2 (13.3) | 2 (13.3) | 1 (6.7) | 0 | 0 | 15 | 0 | 15 |
| Hungary | 23 (85.2) | 1 (3.7) | 1 (3.7) | 2 (7.4) | 0 | 0 | 27 | 38 (58.5) | 65 |
| Ireland | 2 (33.3) | 0 | 4 (57.1) | 1 (16.7) | 0 | 0 | 7 | 0 | 7 |
| Iceland | 5 (71.4) | 0 | 0 | 2 (28.6) | 0 | 0 | 7 | 0 | 7 |
| Italy | 878 (73.5) | 174 (14.6) | 18 (1.5) | 104 (8.7) | 16 (1.3) | 4 (0.3) | 1 194 | 3 (0.3) | 1 197 |
| Latvia | 0 | 0 | 1 (100.0) | 0 | 0 | 0 | 1 | 2 (66.7) | 3 |
| Luxembourg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 (100.0) | 5 |
| Malta | 2 (50.0) | 0 | 1 (25.0) | 0 | 0 | 1 (25.0) | 4 | 0 | 4 |
| Netherlands | 117 (47.4) | 18 (7.3) | 107 (43.3) | 0 | 5 (2.0) | 0 | 247 | 4 (1.6) | 251 |
| Norway | 0 | 0 | 23 (100.0) | 0 | 0 | 0 | 23 | 11 (32.4) | 34 |
| Poland | 0 | 2 (28.6) | 5 (71.4) | 0 | 0 | 0 | 7 | 3 (30.0) | 10 |
| Portugal | 46 (85.2) | 5 (9.3) | 2 (3.7) | 0 | 1 (1.9) | 0 | 54 | 42 (43.8) | 96 |
| Romania | 0 | 0 | 1 (100.0) | 0 | 0 | 0 | 1 | 2 (66.7) | 3 |
| Slovakia | 2 (100.0) | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 |
| Slovenia | 65 (100.0) | 0 | 0 | 0 | 0 | 0 | 65 | 0 | 65 |
| Sweden | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 114 (100.0) | 114 |
| Spain | 989 (82.0) | 119 (9.9) | 20 (1.7) | 60 (5.0) | 10 (0.8) | 8 (0.7) | 1 206 | 25 (2.0) | 1 231 |
| UK | 173 (46.4) | 37 (9.9) | 144 (38.6) | 19 (5.1) | 0 | 0 | 373 | 1 (0.3) | 374 |
| **Total** | **3 382 (68.4)** | **554 (11.2)** | **524 (10.6)** | **333 (6.7)** | **108 (2.2)** | **44 (0.9)** | **4 945** | **433 (8.1)** | **5 378** |

[a] *Complete data from Cyprus and the Czech Republic were supplied only after the reporting deadline and therefore could not be taken into account.*

[b] *Row percentages with each subtotal as the denominator.*

## 3.1.6 Laboratory data

The 5 518 cases of Legionnaires' disease reported for 2009 were confirmed by 5 622 laboratory tests, 81.7% of which were urinary antigen detections and 9.3% were cultures (Table 6). The distribution of diagnostic laboratory methods was stable from 2005 to 2009 (Annex, Figure A). The distribution of most methods by reporting country varied substantially (Table 7). While all but three countries reported at least some case confirmations by urinary antigen test, countries that joined the EU/EEA after 2000 proved more likely not to report any confirmation by culture (OR=16.3; 95% CI=1.7–208.3) or polymerase chain reaction (PCR; OR=19.2; 95% CI=1.6–920.5), but to have confirmed the majority of their cases by a single high antibody titre (OR=8.0; 95% CI=0.5–445.4).

**Table 6 Reported diagnostic laboratory methods, EU/EEA, 2009 (more than one method per case possible)**

| Laboratory method | n | % |
|---|---|---|
| Urinary antigen test | 4 592 | 81.7 |
| Culture | 522 | 9.3 |
| Single high titre | 303 | 5.4 |
| Nucleic acid amplification, e.g. PCR | 132 | 2.3 |
| Fourfold titre rise | 69 | 1.2 |
| Direct immunofluorescence | 3 | 0.1 |
| Other | 1 | 0 |
| **Total** | **5 622** | **100.0** |

**Table 7 Reported diagnostic laboratory methods by reporting country, EU/EEA, 2009 (more than one method per case possible)**

| Country[a] | Laboratory method | | | | | | Total n |
|---|---|---|---|---|---|---|---|
| | Urinary antigen test n (%) | Culture n (%) | Single high titre n (%) | PCR n (%) | Fourfold titre rise n (%) | Direct immuno-fluorescence n (%) | |
| Austria | 63 (68.5) | 18 (19.6) | 6 (6.5) | 2 (2.2) | 3 (3.3) | 0 | 92 |
| Belgium | 52 (65.0) | 12 (15.0) | 10 (12.5) | 3 (3.8) | 3 (3.8) | 0 | 80 |
| Bulgaria | 3 (75.0) | 0 | 1 (25.0) | 0 | 0 | 0 | 4 |
| Denmark | 31 (25.2) | 66 (53.7) | 8 (6.5) | 14 (11.4) | 4 (3.3) | 0 | 123 |
| Estonia | 6 (100.0) | 0 | 0 | 0 | 0 | 0 | 6 |
| Finland | 5 (22.7) | 3 (13.6) | 14 (63.6) | 0 | 0 | 0 | 22 |
| France | 957 (79.4) | 220 (18.2) | 18 (1.5) | 2 (0.2) | 9 (0.7) | 0 | 1 206 |
| Germany[b] | 360 (69.4) | 23 (4.4) | 67 (12.9) | 61 (11.8) | 8 (1.5) | 0 | 519 |
| Greece | 15 (78.9) | 0 | 3 (15.8) | 1 (5.3) | 0 | 0 | 19 |
| Hungary | 14 (21.5) | 0 | 49 (75.4) | 0 | 0 | 2 (3.1) | 65 |
| Ireland | 7 (100.0) | 0 | 0 | 0 | 0 | 0 | 7 |
| Iceland | 4 (57.1) | 2 (28.6) | 0 | 1 (14.3) | 0 | 0 | 7 |
| Italy | 1 135 (94.8) | 22 (1.8) | 31 (2.6) | 1 (0.1) | 7 (0.6) | 1 (0.1) | 1 197 |
| Luxembourg | 5 (100.0) | 0 | 0 | 0 | 0 | 0 | 5 |
| Latvia | 0 | 0 | 0 | 0 | 3 (100.0) | 0 | 3 |
| Malta | 4 (100.0) | 0 | 0 | 0 | 0 | 0 | 4 |
| Netherlands | 207 (68.8) | 43 (14.3) | 17 (5.6) | 20 (6.6) | 14 (4.7) | 0 | 301 |
| Norway | 30 (88.2) | 2 (5.9) | 1 (2.9) | 1 (2.9) | 0 | 0 | 34 |
| Poland | 4 (36.4) | 1 (9.1) | 5 (45.5) | 0 | 1 (9.1) | 0 | 11 |
| Portugal | 85 (88.5) | 8 (8.3) | 2 (2.1) | 1 (1.0) | 0 | 0 | 96 |
| Romania | 0 | 0 | 2 (66.7) | 0 | 1 (33.3) | 0 | 3 |
| Sweden | 64 (44.1) | 12 (8.3) | 37 (25.5) | 24 (16.6) | 8 (5.5) | 0 | 145 |
| Slovakia | 0 | 1 (50.0) | 1 (50.0) | 0 | 0 | 0 | 2 |
| Slovenia | 59 (90.8) | 0 | 3 (4.6) | 1 (1.5) | 2 (3.1) | 0 | 65 |
| Spain | 1 179 (95.8) | 22 (1.8) | 26 (2.1) | 0 | 4 (0.3) | 0 | 1 231 |
| UK | 303 (81.0) | 67 (17.9) | 2 (0.5) | 0 | 2 (0.5) | 0 | 374 |
| **Total** | **4 592 (81.7)** | **522 (9.3)** | **303 (5.4)** | **132 (2.3)** | **69 (1.2)** | **3 (0.1)** | **5 621** |

[a] *Complete data from Cyprus and the Czech Republic were supplied only after the reporting deadline and therefore could not be taken into account.*

[b] *One case with laboratory method coded as 'Other' (and with an epidemiologic link) not shown.*

Of 5 185 confirmed and probable cases for which the causative species was indicated, 5 177 (99.8%) were reportedly due to *Legionella pneumophila* and 4 648 (89.8%) to *L. pneumophila* serogroup 1 (Table 8). For 4 900 confirmed cases, the corresponding figures were 4 896 (99.9%) and 4 620 (94.3%), respectively. Of 445 culture-confirmed cases that were not additionally confirmed by urinary antigen testing, 441 (99.1%) were due to

*L. pneumophila* and 390 (87.6%) to serogroup 1 (Table 8). For 33 culture-confirmed cases, the *Legionella* species and serogroup were missing or reported as unknown.

The sequence type was only reported for 44 cases, 40 of which were from one country. The distribution in Europe, therefore, could not be analysed.

**Table 8 Reported cases of Legionnaires' disease and *Legionella* isolates by species and serogroup, EU/EEA, 2009[a]**

| Species and serogroup | All cases | | Confirmed cases | | Culture-confirmed cases[b] | |
|---|---|---|---|---|---|---|
| | n | %[c] | n | %[c] | n | %[c] |
| *L. pneumophila* | 5 177 | 99.8 | 4 896 | 99.9 | 444 | 98.4 |
| Serogroups | | | | | | |
| 1 | 4 648 | 89.8 | 4 620 | 94.3 | 390 | 87.8 |
| 2 | 7 | 0.1 | 4 | 0.1 | 3 | 0.7 |
| 3 | 29 | 0.6 | 17 | 0.3 | 16 | 3.6 |
| 4 | 1 | 0 | 1 | 0 | 1 | 0.2 |
| 5 | 5 | 0.1 | 3 | 0.1 | 3 | 0.7 |
| 6 | 10 | 0.2 | 7 | 0.1 | 7 | 1.6 |
| 7 | 9 | 0.2 | 1 | 0 | 1 | 0.2 |
| 8 | 4 | 0.1 | 2 | 0 | 2 | 0.5 |
| 9 | 1 | 0.0 | – | – | – | – |
| 10 | 7 | 0.1 | 7 | 0.1 | 7 | 1.6 |
| 14 | 1 | 0 | – | – | – | – |
| Mixed | 23 | 0.4 | 7 | 0.1 | 1 | 0.2 |
| Unknown | 432 | 8.3 | 227 | 4.6 | 13 | 2.9 |
| *L. bozemanii* | 1 | 0 | 1 | 0 | 1 | 0.2 |
| *L. longbeachae* | 4 | 0.1 | 2 | 0 | 2 | 0.4 |
| *L. maceachernii* | 1 | 0 | – | – | – | – |
| *L. micdadei* | 2 | 0 | 1 | 0 | 1 | 0.2 |
| **Total** | **5 185** | **100.0** | **4 900** | **100.0** | **448** | **100.0** |

[a] *Does not include 11 German cases with pathogen coded as 'Other' meaning 'Legionella other than L. pneumophila serogroup1'.*
[b] *Does not include 50 cases confirmed by culture and urinary antigen test and reported as L. pneumophila serogroup 1 to exclude cases possibly assumed by default to belong to this serogroup.*
[c] *Percentage of the column total.*

## 3.1.7 Environmental investigation

The environmental follow-up status was known for 2 207 cases, 371 (16.8%) of which had prompted an investigation of the implicated site(s). Of 1 847 domestic cases with known follow-up status, 326 (17.7%) had been followed by an environmental investigation. Domestic confirmed cases were no more likely to lead to an environmental investigation than were probable cases (OR=1.0; 95% CI=0.6–2.0). However, domestic fatal cases were more likely to prompt an investigation than non-fatal cases (OR=1.6; 95% CI=1.05–2.5).

Fourteen countries reported a known environmental follow-up status for more than half of their domestic cases (Table 9). In four of these countries, however, an investigation was carried out in less than 10% of cases. Three countries accounting for 59.9% of all domestic cases reported the environmental follow-up status as unknown for all or nearly all of the implicated sites.

For 324 of 326 domestic environmental investigations, findings were reported. *Legionella* was found in 125 investigations (38.6%) and not found in 188 investigations (58.0%) while results were unknown in 11 instances (3.4%). In countries with eight or more reported domestic environmental investigations, the percentage of *Legionella* detections ranged from 17.4% to 100% (Table 10).

Of 120 investigations with positive findings, 77 (64.2%) retrieved *Legionella* from the water system without further specification, 26 (21.7%) from the hot water system, 4 (3.3%) from a whirlpool, 3 (2.5%) from the cold water system, 1 (0.8%) from a cooling tower and 9 (7.5%) from other sampling sites.

Matching clinical and environmental *Legionella* isolates were found in 28 domestic cases from five countries and thus in 73.7% of 38 cases where both isolates were available.

**Table 9 Environmental follow-up status of reported domestic cases of Legionnaires' disease by reporting country, EU/EEA, 2009**

| Country* | Investigation | | No investigation | | Status unknown | | Total |
|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n |
| Austria | 62 | 77.5 | 16 | 20.0 | 2 | 2.5 | 80 |
| Belgium | 23 | 76.7 | 1 | 3.3 | 6 | 20.0 | 30 |
| Denmark | 15 | 20.5 | 0 | 0 | 58 | 79.5 | 73 |
| Estonia | 2 | 50.0 | 2 | 50.0 | 0 | 0 | 4 |
| France | 0 | 0 | 0 | 0 | 1 138 | 100.0 | 1 138 |
| Germany | 0 | 0 | 0 | 0 | 192 | 100.0 | 192 |
| Greece | 1 | 7.7 | 10 | 76.9 | 2 | 15.4 | 13 |
| Hungary | 1 | 1.6 | 25 | 98.4 | 0 | 0 | 26 |
| Iceland | 2 | 28.6 | 5 | 71.4 | 0 | 0 | 7 |
| Ireland | 1 | 33.3 | 0 | 0 | 2 | 66.7 | 3 |
| Italy | 56 | 4.8 | 1 120 | 95.2 | 0 | 0 | 1 176 |
| Malta | 2 | 66.7 | 1 | 33.3 | 0 | 0 | 3 |
| Netherlands | 37 | 26.4 | 98 | 70.0 | 5 | 3.6 | 140 |
| Poland | 1 | 50.0 | 1 | 50.0 | 0 | 0 | 2 |
| Portugal | 8 | 15.4 | 44 | 84.6 | 0 | 0 | 52 |
| Slovakia | 1 | 50.0 | 1 | 50.0 | 0 | 0 | 2 |
| Slovenia | 0 | 0 | 65 | 100.0 | 0 | 0 | 65 |
| Spain | 18 | 1.5 | 0 | 0 | 1 168 | 98.5 | 1 186 |
| UK | 96 | 41.9 | 132 | 57.6 | 1 | 0.4 | 229 |
| **Total** | **326** | **7.4** | **1 521** | **34.4** | **2 574** | **58.2** | **4 421** |

** Excludes countries with setting of infection reported as unknown for all cases. Complete data from Cyprus and the Czech Republic were supplied only after the reporting deadline and therefore could not be taken into account.*

**Table 10 *Legionella* findings of domestic environmental investigations by reporting country, EU/EEA, 2009**

| Country* | Detection | | No detection | | Result unknown | | Total |
|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n |
| Austria | 24 | 38.7 | 35 | 56.5 | 3 | 4.8 | 62 |
| Belgium | 4 | 17.4 | 15 | 65.2 | 4 | 17.4 | 23 |
| Denmark | 13 | 86.7 | 2 | 13.3 | 0 | 0 | 15 |
| Estonia | 1 | 50.0 | 1 | 50.0 | 0 | 0 | 2 |
| Greece | 0 | 0 | 0 | 0.0 | 1 | 100.0 | 1 |
| Hungary | 1 | 100.0 | 0 | 0 | 0 | 0 | 1 |
| Iceland | 0 | 0 | 1 | 50.0 | 1 | 50.0 | 2 |
| Ireland | 0 | 0 | 1 | 33.3 | 2 | 66.7 | 3 |
| Italy | 29 | 51.8 | 27 | 48.2 | 0 | 0.0 | 56 |
| Malta | 1 | 50.0 | 0 | 0 | 1 | 50.0 | 2 |
| Netherlands | 11 | 29.7 | 26 | 70.3 | 0 | 0 | 37 |
| Poland | 1 | 100.0 | 0 | 0 | 0 | 0 | 1 |
| Portugal | 8 | 100.0 | 0 | 0 | 0 | 0 | 8 |
| Slovakia | 1 | 100.0 | 0 | 0 | 0 | 0 | 1 |
| Spain | 11 | 61.1 | 6 | 33.3 | 1 | 5.6 | 18 |
| UK | 20 | 20.8 | 75 | 78.1 | 1 | 1.0 | 96 |
| **Total** | **125** | **38.6** | **188** | **58.0** | **11** | **3.4** | **324** |

** Excludes countries with setting of infection reported as unknown for all cases. Complete data from Cyprus and the Czech Republic were supplied only after the reporting deadline and therefore could not be taken into account.*

# 3.2 Deaths

## 3.2.1 Case-fatality ratio, case classification and mortality notification rate

A known clinical outcome was reported for 3 729 (67.6%) of all reported cases of Legionnaires' disease. Of these cases, 404 (10.8%) died: 386 (11.4%) of 3 387 confirmed cases and 18 (5.3%) of 342 probable cases. Fatal cases were more than twice as likely to meet the definition of a confirmed case (OR=2.3; 95% CI=1.4–4.0) and more than five times as likely to have been confirmed by culture (OR=5.5; 95% CI=3.2–9.9). The mortality rate in 2009 was 0.8 per million population and has been stable since 2005.

## 3.2.2 Time and place

The distribution of deaths by month of disease onset revealed a trend towards higher case-fatality ratios in the colder months of the year (Figure 4). Fatal cases were more likely to occur with a disease onset in January, February and October to December than with an onset from March to September (OR=1.7; 95% CI=1.3–2.3).

The overall case-fatality ratio in countries with less than 25% unknown outcomes was 9.1%, ranging from zero to 60%, and from 3.1 to 17.1% when only taking countries with more than 10 reported cases into account (Table 11). A fatal case was 40% more likely to have been reported by a country with more than 25% unknown outcomes than by a country with a more complete follow-up (OR=1.4; 95% CI=1.1–1.7).

## 3.2.3 Age and gender

In males, 273 (10.1%) of 2 695 cases with a known outcome were reported to have died, in females 130 (12.6%) of 1 028 cases (Table 12). Case fatality showed an increase with age, reaching 25.8% in those 80 years and older. The only age groups in which males had a slightly higher case fatality than females were those from 50 to 69 years. Overall, females were 30% more likely to have died from Legionnaires' disease than males (OR=1.3; 95% CI=1.01–1.6), and compared to cases below 40 years of age, the likelihood of a fatal outcome was twice as high (OR=2.1; 95% CI=1.0–4.3) in cases aged 40 to 59, five times as high (OR=5.0; 95% CI=2.4–10.4) in cases aged 60 to 79, and 13 times as high (OR=12.8; 95% CI=6.0–27.3) in cases aged 80 years and older. The trend towards an increase of case-fatality with age was observed in all countries, most evidently in those with more than 10 reported deaths (Annex, Table 1).

**Figure 4 Reported deaths from Legionnaires' disease and case-fatality ratio (CFR) by month of onset, EU/EEA, 2009**

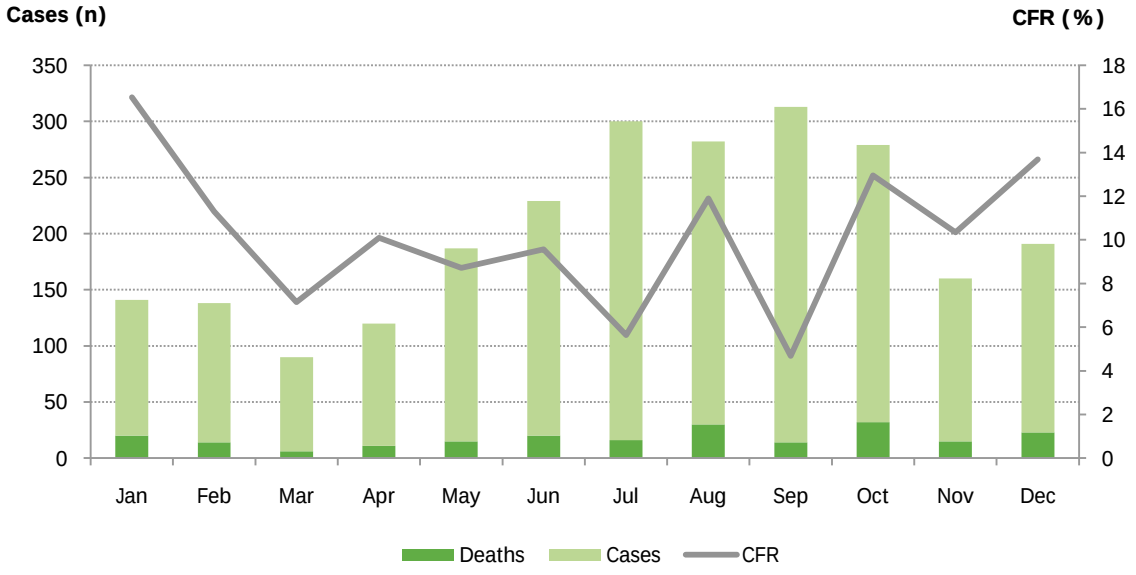


**Table 11 Reported outcomes of Legionnaires' disease and case fatality by reporting country, EU/EEA, 2009**

| Country[a] | Survival n (%) | Death n (%) | Unknown n (%) | Total n | Case-fatality[b] % |
|---|---|---|---|---|---|
| Austria | 84 (91.3) | 8 (8.7) | 0 (0) | 92 | 8.7 |
| Belgium | 39 (48.8) | 4 (5) | 37 (46.3) | 80 | n.a.[c] |
| Bulgaria | 0 (0) | 0 (0) | 4 (100) | 4 | n.a. |
| Denmark | 102 (82.9) | 21 (17.1) | 0 (0) | 123 | 17.1 |
| Estonia | 6 (100) | 0 (0) | 0 (0) | 6 | 0 |
| Finland | 21 (95.5) | 1 (4.5) | 0 (0) | 22 | 4.5 |
| France | 966 (80.1) | 125 (10.4) | 115 (9.5) | 1 206 | 11.5 |
| Germany | 467 (93) | 35 (7) | 0 (0) | 502 | 7.0 |
| Greece | 14 (93.3) | 1 (6.7) | 0 (0) | 15 | 6.7 |
| Hungary | 59 (90.8) | 5 (7.7) | 1 (1.5) | 65 | 7.8 |
| Iceland | 6 (85.7) | 1 (14.3) | 0 (0) | 7 | 14.3 |
| Ireland | 4 (57.1) | 2[d] (0) | 1 (42.9) | 7 | 0 |
| Italy | 421 (35.2) | 66 (5.5) | 710 (59.3) | 1 197 | n.a. |
| Latvia | 3 (100) | 0 (0) | 0 (0) | 3 | 0 |
| Luxembourg | 2 (40) | 3 (60) | 0 (0) | 5 | 60.0 |
| Malta | 4 (100) | 0 (0) | 0 (0) | 4 | 0 |
| Netherlands | 234 (93.2) | 17 (6.8) | 0 (0) | 251 | 6.8 |
| Norway | 29 (85.3) | 1 (2.9) | 4 (11.8) | 34 | 3.3 |
| Poland | 10 (100) | 0 (0) | 0 (0) | 10 | 0 |
| Portugal | 37 (38.5) | 4 (4.2) | 55 (57.3) | 96 | n.a. |
| Romania | 3 (100) | 0 (0) | 0 (0) | 3 | 0 |
| Slovakia | 1 (50) | 1 (50) | 0 (0) | 2 | 50.0 |
| Slovenia | 63 (96.9) | 2 (3.1) | 0 (0) | 65 | 3.1 |
| Spain | 730 (59.3) | 61 (5) | 440 (35.7) | 1 231 | n.a. |
| Sweden | 0 (0) | 0 (0) | 114 (100.0) | 114 | n.a. |
| UK | 20 (5.3) | 48 (12.8) | 306 (81.8) | 374 | n.a. |
| **Total[e]** | **2074 (85.9)** | **221 (9.2)** | **118 (5.0)** | **2 422** | **9.1** |

*[a] Complete data from Cyprus and the Czech Republic were supplied only after the reporting deadline and therefore could not be taken into account.*
*[b] Denominator: known outcomes (survivals and deaths).*
*[c] Not applicable where > 25% of outcomes unknown.*
*[d] Not directly due to Legionnaires' disease, therefore not taken into account.*
*[e] Includes only countries where < 25% of outcomes unknown.*

**Table 12 Reported case-fatality (CFR) of Legionnaires' disease by gender and age group, EU/EEA, 2009**

| Age (y) | Male | | | Female | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | Deaths n | Total n | CFR % | Deaths n | Total n | CFR % | Deaths n | Total n | CFR % |
| 0–19 | 0 | 12 | 0 | 0 | 7 | 0 | 0 | 19 | 0 |
| 20–29 | 1 | 46 | 2.2 | 0 | 16 | 0 | 1 | 62 | 1.6 |
| 30–39 | 5 | 177 | 2.8 | 2 | 44 | 4.5 | 7 | 221 | 3.2 |
| 40–49 | 22 | 450 | 4.9 | 7 | 129 | 5.4 | 29 | 579 | 5.0 |
| 50–59 | 36 | 629 | 5.7 | 9 | 189 | 4.8 | 45 | 818 | 5.5 |
| 60–69 | 58 | 573 | 10.1 | 20 | 223 | 9.0 | 78 | 796 | 9.8 |
| 70–79 | 67 | 463 | 14.5 | 31 | 203 | 15.3 | 98 | 666 | 14.7 |
| 80+ | 84 | 345 | 24.3 | 61 | 217 | 28.1 | 145 | 562 | 25.8 |
| **Total** | **273** | **2 695** | **10.1** | **130** | **1 028** | **12.6** | **403** | **3 723** | **10.8** |

## 3.2.4 Setting

Case-fatality of Legionnaires' disease was highest among cases acquired in healthcare facilities (mainly hospitals and nursing homes), followed in decreasing order by community-acquired and travel-associated cases (Table 13). Compared with community-acquired cases, travel-associated cases were 30% less likely to have died (OR=0.7; 95% CI=0.5–0.97), whereas fatal outcomes among healthcare-associated cases were more than four times as likely (OR=4.2; 95% CI=3.1–5.5).

**Table 13 Reported case-fatality of Legionnaires' disease, by setting, EU/EEA, 2009**

| Setting | Total reported n | Case-fatality | |
|---|---|---|---|
| | | n | % |
| Healthcare | 312 | 97 | 31.1 |
| Community | 2 288 | 223 | 9.7 |
| Domestic travel | 352 | 30 | 8.5 |
| Travel abroad | 379 | 22 | 5.8 |
| Other | 38 | 4 | 10.5 |
| **Total** | **3 369** | **376** | **11.2** |

## 3.2.5 Laboratory data

Of 404 fatal cases of Legionnaires' disease, 95 (23.5%) were confirmed by culture as compared to 319 (9.6%) of 3 325 cases who survived (OR=2.9; 95% CI=2.2–3.8). Of species and serogroups accounting for more than five cases of Legionnaires' disease, *L. pneumophila* serogroups 6 and 10 showed the highest case-fatality ratios, regardless of whether the analysis was done on the entire dataset or restricted to confirmed or culture-confirmed cases (Table 14). Among culture-confirmed cases, these two serogroups had a 14-fold higher likelihood of being associated with death than all other *L. pneumophila* serogroups together (OR=14.3; 95% CI=4.3–54.5).

**Table 14 Reported case-fatality (CFR) of Legionnaires' disease by *Legionella* species and serogroup, EU/EEA, 2009[a]**

| Species and serogroup | All cases | | | Confirmed cases | | | Culture-confirmed cases[b] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Deaths n | Total n | CFR % | Deaths n | Total n | CFR % | Deaths n | Total n | CFR % |
| *L. pneumophila* | 385 | 3 525 | 10.9 | 370 | 3 270 | 11.3 | 80 | 353 | 22.7 |
| Serogroups | | | | | | | | | |
| 1 | 335 | 3 019 | 11.1 | 334 | 2 994 | 11.2 | 63 | 299 | 21.1 |
| 2 | 0 | 7 | 0 | 0 | 4 | 0 | 0 | 3 | 0 |
| 3 | 5 | 29 | 17.2 | 5 | 17 | 29.4 | 4 | 16 | 25.0 |
| 4 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 5 | 1 | 4 | 25.0 | 1 | 3 | 33.3 | 1 | 3 | 33.3 |
| 6 | 6 | 10 | 60.0 | 5 | 7 | 71.4 | 5 | 7 | 71.4 |
| 7 | 0 | 9 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 8 | 1 | 4 | 25.0 | 1 | 2 | 50.0 | 1 | 2 | 50.0 |
| 9 | 0 | 1 | 0 | | | | | | |
| 10 | 4 | 7 | 57.1 | 4 | 7 | 57.1 | 4 | 7 | 57.1 |
| 14 | 0 | 1 | 0 | | | | | | |
| Mixed | 4 | 22 | 18.2 | 1 | 7 | 14.3 | 1 | 1 | 100.0 |
| Unknown | 29 | 411 | 7.1 | 19 | 227 | 8.4 | 1 | 13 | 7.7 |
| *L. bozemanii* | 1 | 1 | 100.0 | 1 | 1 | 100.0 | 1 | 1 | 100.0 |
| *L. longbeachae* | 0 | 4 | 0 | 0 | 2 | 0 | 0 | 2 | 0 |
| *L. maceachernii* | 0 | 1 | 0 | | | | | | |
| *L. micdadei* | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| Unknown species | 17 | 185 | 9.2 | 15 | 104 | 14.4 | 6 | 16 | 37.5 |
| **Total** | **403** | **3 718** | **10.8** | **386** | **3 387** | **11.4** | **87** | **373** | **23.3** |

[a] *Does not include 11 German cases with pathogen coded as 'Other' meaning 'Legionella other than L. pneumophila serogroup1'.*
[b] *Does not include 40 cases confirmed by culture and urinary antigen test and reported as L. pneumophila serogroup 1 to exclude cases possibly assumed by default to belong to this serogroup.*

### 3.2.6 Cluster status

Cluster status was reported for 2 373 cases with known outcome. Death occurred in 13 (7.9%) of 164 clustered cases and 240 (10.9%) of 2 209 sporadic cases, the two groups not differing significantly from each other (OR=0.7; 95% CI=0.4–1.3).

### 3.2.7 Diagnostic delay

The median diagnostic delay, i.e. the delay between date of onset and date of diagnosis was six days (0–255 days) with 73% of cases diagnosed within the first week of illness and 93% of cases diagnosed within the first two weeks. Of 193 cases diagnosed within the first two days after onset of disease, 37 (19.2%) died compared with 105 (9.4%) of 1 120 cases who were diagnosed with a delay greater than two days (OR=2.3; 95% CI=1.5–3.5).

### 3.2.8 Adjusted predictors of fatal outcome in confirmed cases

In decreasing order of magnitude of association, causative *Legionella* species and serogroup, patient age, setting of infection, season of disease onset and country-specific completeness of outcome reporting were found to be independent predictors of fatal outcome in confirmed cases of Legionnaires' disease reported in 2009 (Table 15). Gender was not independently associated with fatal outcome. The season of onset modified the effect of the infection setting on disease outcome in community-acquired and travel-associated cases, but not in healthcare-associated cases. The goodness-of-fit of the underlying logistic regression model was fair with an area under the receiver-operating curve of 0.74.

**Table 15 Adjusted predictors of fatal outcome of Legionnaires' disease, EU/EEA, 2009**

| Risk factor | Odds ratio | 95% confidence interval | Cases exposed (%) |
|---|---|---|---|
| **Legionella species and serogroup** | | | |
| *L. pneumophila* serogroups 6 and 10 versus all other species and serogroups | 16.5 | 4.2–65.1 | 0.4 |
| **Age** | | | |
| 40–59 years versus ≤ 39 years | 2.3 | 1.0–5.3 | 37.6 |
| 60–79 years versus ≤ 39 years | 4.5 | 2.0–10.4 | 39.7 |
| ≥ 80 years versus ≤ 39 years | 10.2 | 4.4–23.7 | 15.6 |
| **Setting of infection by season of onset** | | | |
| ***Spring/summer[a]:*** Travel versus community | 0.6 | 0.4–0.99 | 15.7 |
| Healthcare versus community | 3.9 | 2.6–5.8 | 5.4 |
| ***Autumn/winter[b]:*** Travel versus community | 1.4 | 0.8–2.2 | 5.9 |
| Healthcare versus community | 2.6 | 1.7–4.1 | 3.9 |
| **Season of onset by setting of infection** ***Autumn/winter versus spring/summer*** | | | |
| Community | 1.4 | 1.02–1.8 | 28.0 |
| Travel | 2.9 | 1.6–5.3 | 5.9 |
| Healthcare | 0.9 | 0.5–1.5 | 3.9 |
| **Country-specific outcome reporting** | | | |
| Incomplete[c] versus complete | 1.4 | 1.1–1.8 | 41.0 |

[a] *March to September.*
[b] *January, February, October to December.*
[c] *≥ 25% of outcomes coded as 'Unknown'.*

## 3.3 Clusters

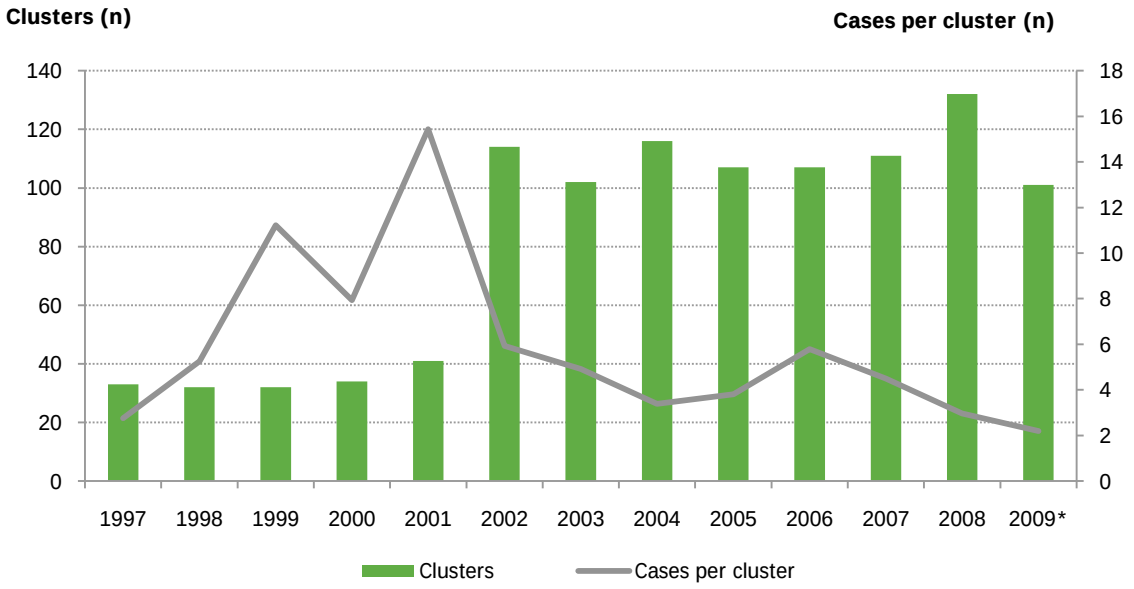
### 3.3.1 Frequency, size, classification and outcome

In 2009, 101 clusters of Legionnaires' disease were reported, 23.5% less than 2008 and 10.6% less than the average annual number of clusters reported from 2002 to 2008 (Figure 5). Correcting for Italian clusters that were not reported in 2009 but in previous years, the decline between 2008 and 2009 amounted to 17.9%. The 101 clusters involved 254 cases, representing 6.5% of 3 879 cases with known cluster status. On average, there were two cases to each cluster, continuing a trend in cluster size that had been decreasing since a peak in 2001, interrupted only by a smaller peak from 2005 to 2007 (Figure 5).

Of 3 581 confirmed and 298 probable cases with known cluster status, 239 (6.7%) and 15 (5.0%), respectively, formed part of a cluster. Confirmed cases were no more likely to cluster than probable cases (OR=1.3; 95% CI=0.8–2.5).

Thirteen (7.9%) of 164 fatal cases and 240 (10.9%) of 2 209 non-fatal cases with known cluster status had formed part of a cluster (OR=0.7; 95% CI=0.4–1.3). Case-fatality did not differ between clustered and sporadic cases of Legionnaires' disease (see Section 3.2.6).

**Figure 5 Reported clusters of Legionnaires' disease and average number of cases per cluster by year of reporting, EU/EEA, 1997–2009**




** Does not include Italian clusters as they were not reported.*

## 3.3.2 Time and place

The proportion of clustered cases by month of onset peaked at between 8% and 10% in January, May and September (Figure 6). Unlike the pattern observed for fatal cases, clustered cases were not associated with any particular season ($OR_{March\ to\ September}$=1.1; 95% CI=0.8–1.5).

The overall proportion of clustered cases in countries with less than 25% unknown cluster statuses was 6.0%, ranging from 2.2% to 30.0%, and from 2.2% to 15.9% when only taking countries with more than 10 reported cases into account (Table 16). A clustered case was eight times more likely to have been reported by a country with more than 25% unknown cluster statuses than by a country with more complete cluster status information (OR=7.9; 95% CI=4.7–13.0).

## 3.3.3 Age and gender

Clustering of reported cases of Legionnaires' disease was known to have occurred in 179 (6.4%) of 2 807 male cases and 73 (6.9%) of 1 062 female cases (Table 17). There was no significant difference between the genders (OR=1.1; 95% CI=0.8–1.4). Clustering appeared to increase with age before dropping off among cases aged 80 years and older. Incompatible with this trend, a relatively high proportion among those aged 20 to 29 was due to three female cases who carried undue numerical weight because of the small gender and age group-specific denominator. Overall, statistically, only the age group from 60 to 79 differed significantly from the others in increasing the likelihood of clustering by 50% (OR=1.5; 95% CI=1.1–1.9). The trend towards increasing clustering with age was also observed in Member States with higher numbers of reported cases (Annex, Table 2).

**Figure 6 Reported clustering of Legionnaires' disease by month of onset, EU/EEA, 2009**


**Table 16 Reported clustering of Legionnaires' disease by reporting country, EU/EEA, 2009**

| Country[a] | Clusters n | Clustered n (%) | Sporadic n (%) | Unknown n (%) | Total n | Cluster ratio[b] % |
|---|---|---|---|---|---|---|
| Austria | 1 | 2 (2.2) | 90 (97.8) | 0 (0) | 92 | 2.2 |
| Belgium | 1 | 1 (1.3) | 53 (66.3) | 26 (32.5) | 80 | n.a.[c] |
| Bulgaria | 0 | 0 (0) | 4 (100.0) | 0 (0) | 4 | 0 |
| Denmark | 9 | 10 (8.1) | 111 (90.2) | 2 (1.6) | 123 | 8.3 |
| Estonia | 0 | 0 (0) | 6 (100.0) | 0 (0) | 6 | 0 |
| Finland | 0 | 0 (0) | 0 (0) | 22 (100.0) | 22 | n.a. |
| France | 0 | 0 (0) | 0 (0) | 1 206 (100.0) | 1 206 | n.a. |
| Germany | 10 | 13 (2.6) | 489 (97.4) | 0 (0) | 502 | 2.6 |
| Greece | 0 | 0 (0) | 15 (100.0) | 0 (0) | 15 | 0 |
| Hungary | 0 | 0 (0) | 65 (100.0) | 0 (0) | 65 | 0 |
| Iceland | 0 | 0 (0) | 7 (100.0) | 0 (0) | 7 | 0 |
| Ireland | 0 | 0 (0) | 7 (100.0) | 0 (0) | 7 | 0 |
| Italy | Unknown | 28 (2.3) | 1 169 (97.7) | 0 (0) | 1 197 | 2.3 |
| Latvia | 0 | 0 (0) | 3 (100.0) | 0 (0) | 3 | 0 |
| Luxembourg | 0 | 0 (0) | 4 (80.0) | 1 (20.0) | 5 | 0 |
| Malta | 0 | 0 (0) | 4 (100.0) | 0 (0) | 4 | 0 |
| Netherlands | 23 | 26 (10.4) | 0 (0) | 225 (89.6) | 251 | n.a. |
| Norway | 1 | 4 (11.8) | 30 (88.2) | 0 (0) | 34 | 11.8 |
| Poland | 1 | 3 (30.0) | 7 (70.0) | 0 (0) | 10 | 30.0 |
| Portugal | 1 | 8 (8.3) | 88 (91.7) | 0 (0) | 96 | 8.3 |
| Romania | 0 | 0 (0) | 3 (100.0) | 0 (0) | 3 | 0 |
| Slovakia | 0 | 0 (0) | 1 (50.0) | 1 (50.0) | 2 | n.a. |
| Slovenia | 0 | 0 (0) | 65 (100.0) | 0 (0) | 65 | 0 |
| Spain | 21 | 101 (8.2) | 1 098 (89.2) | 32 (2.6) | 1231 | 8.4 |
| Sweden | 0 | 0 (0) | 0 (0) | 114 (100) | 114 | n.a. |
| UK | 33 | 58 (15.5) | 306 (81.8) | 10 (2.7) | 374 | 15.9 |
| **Total[d]** | **101** | **227 (5.9)** | **3 571 (92.9)** | **45 (1.2)** | **3843** | **6.0** |

*[a] Complete data from Cyprus and the Czech Republic were supplied only after the reporting deadline and therefore could not be taken into account.*
*[b] Denominator: known outcomes (clustered and sporadic cases).*
*[c] Not applicable where > 25% of cluster statuses unknown.*
*[d] Includes only countries where < 25% of cluster statuses unknown.*

**Table 17 Reported clustering of Legionnaires' disease by gender and age group, EU/EEA, 2009**

| Age (y) | Male | | | Female | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | Clustered n | Total n | Clustered % | Clustered n | Total n | Clustered % | Clustered n | Total n | Clustered % |
| 0–19 | 0 | 12 | 0 | 0 | 6 | 0 | 0 | 18 | 0 |
| 20–29 | 1 | 40 | 2.5 | 3 | 16 | 18.8 | 4 | 56 | 7.1 |
| 30–39 | 7 | 183 | 3.8 | 2 | 39 | 5.1 | 9 | 223 | 4.0 |
| 40–49 | 33 | 478 | 6.9 | 8 | 129 | 6.2 | 42 | 608 | 6.9 |
| 50–59 | 45 | 653 | 6.9 | 11 | 196 | 5.6 | 56 | 849 | 6.6 |
| 60–69 | 37 | 631 | 5.9 | 24 | 209 | 11.5 | 61 | 840 | 7.3 |
| 70–79 | 48 | 491 | 9.8 | 17 | 245 | 6.9 | 65 | 737 | 8.8 |
| 80+ | 8 | 319 | 2.5 | 8 | 222 | 3.6 | 16 | 541 | 3.0 |
| **Total** | **179** | **2 807** | **6.4** | **73** | **1 062** | **6.9** | **253** | **3 872** | **6.5** |

## 3.3.4 Setting

The proportion of clustered cases was highest among those who presumably contracted Legionnaires' disease while travelling abroad, followed by domestic travellers, healthcare-associated and community-acquired cases (Table 18). Compared with non-travel-associated cases, cases in domestic travellers were three times more likely to form part of a cluster (OR=3.1; 95% CI=2.2–4.5) while this likelihood was fivefold in cases who had travelled abroad (OR=5.0; 95% CI=3.6–6.9). The average cluster size was biggest in clusters of community-acquired and domestic travel-related cases with five and four cases per cluster, respectively.

**Table 18 Reported clustering of Legionnaires' disease, by setting, EU/EEA, 2009**

| Setting | Total cases reported n | Clusters n | Clustered cases | | Cases per cluster n |
|---|---|---|---|---|---|
| | | | n | % | |
| Travel abroad* | 367 | 51 | 69 | 18.8 | 1 |
| Domestic travel | 376 | 12 | 48 | 12.8 | 4 |
| Healthcare | 271 | 7 | 13 | 4.8 | 2 |
| Community | 2 438 | 24 | 108 | 4.4 | 5 |
| Other | 44 | 2 | 9 | 20.5 | 5 |
| **Total** | **3 496** | **96** | **247** | **7.1** | **3** |

** Data quality, especially of cluster size compromised by a) clusters spanning up to two years and therefore not reported entirely in 2009; and b) poor reporting of cluster status and/or cluster identifiers by a number of countries that cannot easily link their cluster data to the cases involved.*

## 3.3.5 Laboratory data

Of 254 clustered cases of Legionnaires' disease, 31 (12.2%) were confirmed by culture as compared to 208 (5.7%) of 3 625 sporadic cases (OR=2.3; 95% CI=1.5–3.4). Since all clustered cases with a known culture result were due to *L. pneumophila* serogroup 1, the association of pathogen and case clustering could not be estimated (Annex, Table 3).

## 3.3.6 Environmental investigation

An environmental investigation ensued in 81 (64.3%) of 126 clustered cases and 248 (13.2%) of 1 872 sporadic cases of Legionnaires' disease. The likelihood of an environmental investigation was 12 times higher in clustered cases (OR=11.8; 95% CI=7.9–17.8).

*Legionella* was found in 43 (54.4%) of 79 environmental investigations following clustered cases and in 74 (32.2%) of 230 investigations following sporadic cases. Positive findings were more than twice as likely if the environmental investigation was prompted by a clustered case (OR=2.5; 95% CI=1.4–4.4).

Matching clinical and environmental *Legionella* isolates were found in 8 (66.7%) of 12 clustered cases and 18 (90%) of 20 sporadic cases where both isolates were available. The difference was not significant (OR=0.2; 95% CI=0.02–2.0).

## 3.3.7 Adjusted predictors of clustering in confirmed cases

In decreasing order of magnitude of association, country-specific completeness of cluster status reporting, setting of infection and patient age were found to be independent predictors of clustering in confirmed cases of Legionnaires' disease reported in 2009 (Table 19). Gender was not independently associated with clustering. Causative *Legionella* species and serogroup could not be controlled for since all clustered confirmed cases with available information had been due to *L. pneumophila* serogroup 1 (or unknown serogroup). The goodness-of-fit of the underlying logistic regression model was poor with an area under the receiver-operating curve of 0.68.

**Table 19 Adjusted predictors for case clustering of Legionnaires' disease, EU/EEA, 2009**

| Risk factor | Odds ratio | 95% confidence interval | Cases exposed (%) |
|---|---|---|---|
| **Country-specific reporting of cluster status** | | | |
| Incomplete[a] versus complete | 6.6 | 3.7–12.0 | 29.2 |
| **Setting of infection** | | | |
| Travel versus non-travel-related | 3.3 | 2.5–4.3 | 21.8 |
| **Age** | | | |
| 60–79 years versus others | 1.5 | 1.1–2.0 | 40.5 |

[a] *≥ 25% of cluster statuses coded as 'Unknown'.*

# 4 Discussion

Legionnaires' disease remains severely underascertained in Europe. In the EU, Iceland and Norway, approximately 130 000 people died from pneumonia in 2008 [12]. Based on this mortality, and assuming a case-fatality of 10% [2], an estimated 1 300 000 persons suffer from pneumonia every year. Assuming further that 4% of these cases are due to *Legionella* [2,3], there could possibly be up to 52 000 cases of Legionnaires' disease annually, almost 10 times the 5 518 cases notified in Europe in 2009.

A mixture of underdiagnosis and underreporting, the underascertainment appears to be pan-European with even the highest country-specific notification rate, 32 per million population in Slovenia, remaining considerably below the estimated European incidence rate of 103 per million. Compared with long-time Member States, notification rates were significantly lower in the less affluent, predominantly central and eastern European countries joining the EU/EEA after 2000. This suggests that in addition to the omnipresent limited clinical awareness, a lack of resources, especially in terms of laboratory capacity, may contribute to the underascertainment of Legionnaires' disease in some of the newer Member States.

The observed frequency peak of Legionnaires' disease in late summer is in line with common microbiological knowledge of *Legionellae* growing best at temperatures between 20°C and 42°C [13]. It is also consistent with published findings of a statistical association between warm and humid weather and Legionnaires' disease [14,15].

The increasing incidence of Legionnaires' disease with age and its predilection for males seen in 2009 have been described previously [16]. Interestingly, country-specific age trends differed among the countries accounting for the highest numbers of reported cases. While age distributions in Denmark, the Netherlands, Sweden and the United Kingdom peaked between 60 and 69 years, they showed a more continuous increase towards the oldest age group in France, Italy and Spain. This difference could be due to underdiagnosis of elderly cases in countries with lower notification rates.

Overall, 68% of Legionnaires' disease cases were reported to have been community-acquired and 22% to have been travel-associated. The country-specific distribution of cases related to foreign and domestic travel appeared to mostly reflect European tourist flows with higher proportions of foreign travel in central, north-western and northern Europe and higher proportions of domestic travel in southern Europe. The reported virtual absence of nosocomial cases of Legionnaires' disease even in some countries with sizeable overall numbers of reported cases is probably rather suggestive of underascertainment than of superior hospital maintenance.

As observed in previous years [16], over 80% of cases were confirmed by urinary antigen detection. The countries joining the EU/EEA after 2000, however, were eight times more likely than older Member States to have verified the majority of their cases by single high antibody titre. Although the current EU case definition for Legionnaires' disease accepts cases confirmed by single high titres as probable, they should be treated with sound caution given the relatively high background prevalence of such titres in some countries [17] and the known serological cross-reactivity of *Legionella* with other bacteria [18]. Culture accounted only for 9% of reported laboratory tests overall with countries joining the EU/EEA after 2000 being 16 times more likely than older Member States not to have confirmed any cases by culture at all. Even among cluster cases, only 12% were culture-confirmed. Epidemiologically, this gives rise to concern as most outbreak investigations fall short of identifying the source in the absence of a clinical *Legionella* isolate that can be matched to an environmental isolate.

Among confirmed cases of Legionnaires' disease, 94% were reported to have been caused by *L. pneumophila* serogroup 1. This includes all cases confirmed by urinary antigen test. Some countries are known to interpret each positive urinary antigen test result as indicative of *L. pneumophila* serogroup 1 although two common test kits have been reported to detect non-serogroup 1 *L. pneumophila* with a sensitivity of 29% and 51%, respectively [19]. Limiting the denominator to culture-confirmed cases decreased the proportion attributable to *L. pneumophila* serogroup 1 to a probably more realistic 87%.

*L. pneumophila* sequence types were only reported for 44 cases from three countries. This is in stark contrast with the 521 entries from 14 EU/EEA countries listed in the EWGLI Sequence-Based Typing (SBT) Database for 2009. Although listings in the SBT database are by microbiological isolation date, and isolation and case reporting may have not always occurred in the same year, most missing sequence types are probably due to difficulties in linking them to case data at national level.

Relatively few cases, 17% of those with available information, had prompted an environmental investigation, the likelihood being 1.6 times higher in fatal compared with non-fatal cases, and 12 times higher in clustered compared with sporadic cases. The dependence of environmental investigations on a high index of suspicion was further evidenced by the fact that matching clinical and environmental isolates were reported for 77% of cases where both were available. Less restrictive initiation of such investigations might have reduced this overall success rate. Country-specific environmental *Legionella* detection ratios varied substantially but are difficult to interpret without taking into account laboratories' performance in external quality assurance (EQA) schemes.

The reported case-fatality of 11% was well within the expected range. The higher likelihood of fatal cases to fulfil the definition of a confirmed case and especially to have been confirmed by culture can probably be explained by intensified diagnostic efforts in more severe cases of Legionnaires' disease. Unlike previous studies that found diagnostic delay to be associated with higher risk of fatal outcome [20,21], diagnosis within the first two days after onset of symptoms increased the likelihood of death twofold, possibly acting as a proxy for greater disease severity in this dataset. Of the predictors for fatal outcome identified in this analysis by logistic regression, only higher age [20], laboratory confirmation of *L. pneumophila* serogroup 6 as the causative agent [22] and hospital-acquired infection [22] were described before.

*L. pneumophila* serogroup 10 has previously not received much attention [22,23], let alone as a risk factor for fatal outcome of Legionnaires' disease. In a recent study of the distribution of *L. pneumophila* in England and Wales, Harrison et al. found 2 (1.2%) of 167 clinical and 27 (9.8%) of 276 environmental isolates to belong to serogroup 10 suggesting that this serogroup might not cause Legionnaires' disease as easily as serogroups/subgroups (such as serogroup 1, subgroup Allentown) that accounted for a very low proportion of environmental isolates, yet were overrepresented among clinical isolates [24]. Of the seven culture-confirmed cases reported to ELDSNet for 2009 as having been caused by *L. pneumophila* serogroup 10, five were presumably community-acquired, one was associated with foreign travel, and one setting was reported as unknown. Four (57%) of these patients died. Underlying conditions of cases of Legionnaires' disease are not reported at European level but are less likely to massively confound the association of serogroup 10 and fatal outcome, given that none of the seven cases was reported as nosocomial. Numbers are rather small, however, and underlying conditions might still provide a plausible explanation for at least some of these cases that not only contracted a clinically very uncommon *L. pneumophila* serogroup but succumbed to it. The analysis of a larger historical ELDSNet dataset will have to show if the association holds and remains largely restricted to non-nosocomial cases.

Neither the effect of travel history on clinical outcome of Legionnaires' disease nor its modification by the season of onset found in the 2009 European data have been documented before. Both travel-associated and community-acquired cases faced a significantly higher mortality risk if their disease onset was in autumn and winter compared to spring and summer with the effect being more pronounced in travel-associated cases. In healthcare-associated cases, no such seasonal difference was observed. During the colder months of the year, however, travel-associated cases were not more at risk of dying than community-acquired cases. Bearing in mind that overall, fewer cases occurred in autumn and winter, their higher case fatality seems to suggest confounding by underlying conditions, the distribution of which likely varies between settings and seasons.

Finally, cases were 40% more likely to have died if they were reported by countries with at least 25% unknown clinical outcomes, suggesting a reporting bias in favour of deaths in these countries. Controlling for this confounder in the multivariable logistic regression model enabled the inclusion of cases from such countries and thus a better precision of estimates.

Unlike risk factors for fatal outcome of Legionnaires' disease, independent predictors of clustering are not well studied. In the 2009 European surveillance data, the strongest predictor of clustering was the country of reporting. Cases reported by countries with at least 25% unknown cluster statuses were seven times more likely to have formed part of a cluster than cases from countries with more complete reporting. This reporting bias in favour of cluster cases was much stronger than the bias in favour of fatal cases.

Travel-associated cases were three times more likely to cluster than non-travel-associated cases. This may have been partly due to the reporting bias within a surveillance network that has had its focus on travel-associated Legionnaires' disease clusters from its very beginning. One explanation could also lie in travel habits: many people travel with family or friends, many also buy holiday packages from tour operators contracting selected hotels. Both patterns increase the number of persons potentially exposed to a common source of *Legionella* infection. Another possible explanation could be that Europeans tend to spend their holidays in warmer climates that favour the growth of *Legionella* and where those maintaining the water systems may not always be aware of the additional challenge.

The mildly elevated risk of clustering for cases between 60 and 79 years of age is not surprising. These age groups tend to combine a higher prevalence of underlying conditions predisposing them to Legionnaires' disease with a level of activity that increases their likelihood of becoming exposed to environmental sources of *Legionella*.

Finally, although the association of *Legionella* species and serogroup with case clustering could not be formally established, the fact that almost all confirmed cluster cases were caused by *L. pneumophila* serogroup 1 indicates the propensity of this species and serogroup to produce clusters. This is in line with many published major outbreak investigations [7–9].

This data analysis has two important limitations. Firstly, it is based on data from passive surveillance systems with rather incomplete reporting on some variables in a number of countries. This is especially true for clinical outcome and cluster status that were reported as unknown for approximately 30% of cases of Legionnaires' disease in 2009. Whether or not an environmental investigation was carried out was reported as unknown for 60% of the cases.

Clinical outcome data are frequently missing because outcome tends to be unknown at the time of reporting and is rarely updated later on. The reason for missing cluster and environmental investigation status is mostly that countries collect this information separately and not case-based, rendering data linkage with cases difficult or even impossible. The lack of data resulted in the necessity to merge variable categories for meaningful analysis and interpretation, but it was not always possible to avoid a lack of precision of estimates, and some associations may have been overlooked. Secondly, ELDSNet does not currently collect data on risk factors such as underlying conditions or smoking status although they are crucial in understanding and explaining the epidemiology of Legionnaires' disease, especially its more severe outcomes [20,22]. Both multivariable logistic regression models employed in this data analysis suffered from suboptimal goodness-of-fit and would have very likely benefitted from inclusion of these confounders.

# 5 Conclusions for European Legionnaires' disease surveillance

Given that this was the first disaggregate collection of annual Legionnaires' disease surveillance data in the EU/EEA and that Member States had relatively little time for preparation, this surveillance report is a remarkable success for the network. It describes the epidemiology of Legionnaires' disease in Europe in 2009 and generates several new hypotheses as to possible risk factors for fatal outcome and clustering. However, there is room for improvement.

In terms of epidemiologic surveillance, Member States are well advised to think about ways to either integrate cluster and environmental investigation status in their case databases or use record linkage methods to provide more complete information. Countries should also explore the possibility of encouraging relevant updates from their local and regional levels of public health administration for more complete reporting of clinical outcome. Finally, as this report has shown, analysis of Legionnaires' disease surveillance data beyond mere description of distributions will remain preliminary as long as well-documented confounders are not taken into account. ELDSNet should therefore consider identifying EU/EEA Member States that are already collecting underlying conditions and smoking status as part of their routine Legionnaires' disease surveillance and discuss the best way for them to report these important data to the European level. In order not to unnecessarily inflate the metadataset, the network might consider the possibility of dropping importation status and travel country instead. The former duplicates the foreign travel information already contained in the setting variable, the latter adds little to the information on travel destination collected much more rigorously through the ELDSNet surveillance of travel-associated Legionnaires' disease.

Laboratory surveillance in some countries could be sharpened by promoting the replacement of single high titres by more specific diagnostic methods. Experts should make sure not to automatically equate each positive urinary antigen test with the presence of *L. pneumophila* serogroup 1. In cluster situations, culture should once again become the diagnostic method of choice to enable molecular matching of clinical and environmental isolates, thus properly confirming or refuting an outbreak and its source. Finally, what was said above on the necessity to consider record linkage techniques for better integration of epidemiologic and environmental data, also applies to sequence-based typing results. If reported more widely, they could add an exciting new molecular layer to the descriptive and analytical epidemiology of Legionnaires' disease.

None of these improvements should be sought for their own sake. The aim must be to provide better information for public health action. Clearly, European retrospective passive Legionnaires' disease surveillance in annual intervals cannot be primarily geared towards fast-paced outbreak detection and control. Instead, an important strategic goal to consider could be to gradually but steadily increase the ascertainment of cases of Legionnaires' disease, agreeing within ELDSNet on a notification rate (e.g. 100 cases per million population) as the target for Europe and monitoring the progress every year. Some building blocks towards this goal have already been put into place with ECDC funding, including the standardisation of diagnostic and typing methods through laboratory capacity mapping, EQA schemes and training.

Annual network meetings and European reports such as this one provide additional opportunity for benchmarking of country practices through exchange of state-of-the art surveillance methods and results. One building block just taking shape is disaggregate reporting of Legionnaires' disease from the national to the European level. Many of the proposed changes to this system are meant to strengthen aspects of Legionnaires' disease surveillance outputs (e.g. case-fatality, clustering) that might help to attract clinicians' attention and raise their awareness.

As a final building block, however, in the absence of any alternative players taking the initiative, ELDSNet and each network member may need to disseminate these and other potentially interesting findings more effectively to the regional and local public health levels as well as to clinicians through both scientific and popular media channels in their countries. The practical goal would be that each European case of Legionnaires' disease is diagnosed and adequately treated as quickly as possible before being reported to the national and European level. Eventually, ELDSNet should not merely be about counting cases and deaths, but about helping to reduce morbidity and mortality of Legionnaires' disease in Europe.

# References


[1] Edelstein PH, Cianciotto NP. Legionella. In: Mandell GL, Bennett JE and Dolin R (Eds). Mandell, Douglas and Bennett's principles and practice of infectious disease. 6th edition. Philadelphia, 2005.

[2] File TM. Community-acquired pneumonia. Lancet 2003;362(9400):1991-2001.

[3] Marrie TJ, MacDonald S, Clarke K, Haldane D. Nosocomial legionnaires' disease: lessons from a four-year prospective study. Am J Infect Control 1991;19(2):79-85.

[4] Dominguez A, Alvarez J, Sabria M, Carmona G, Torner N, Oviedo M, et al. Factors influencing the case-fatality rate of Legionnaires' disease. Int J Tuberc Lung Dis. 2009 Mar;13(3):407-12.

[5] Campese C, Bitar D, Jarraud S, Maine C, Forey F, Etienne J, et al. Progress in the surveillance and control of Legionella infection in France, 1998-2008. Int J Infect Dis 2011;15(1):e30-7.

[6] Fraser DW, Tsai TR, Orenstein W, Parkin WE, Beecham HJ, et al. Legionnaires' disease: description of an epidemic of pneumonia. N Engl J Med 1977;297(22):1189-97.

[7] Den Boer JW, Yzerman EP, Schellekens J, Lettinga KD, Boshuizen HC, Van Steenbergen JE, et al. A large outbreak of Legionnaires' disease at a flower show, the Netherlands, 1999. Emerg Infect Dis 2002;8(1):37-43.

[8] García-Fulgueiras A, Navarro C, Fenoll D, García J, González-Diego P, Jiménez-Buñuales T, et al.. Legionnaires' disease outbreak in Murcia, Spain. Emerg Infect Dis 2003;9(8):915-21.

[9] Telford D, Partridge S, Cumming I, Smith A, Calvert N. The legionnaires' outbreak in Barrow-in-Furness, summer 2002. J Epidemiol Community Health 2006; 60(6): 464–466.

[10] Commission Decision of 19 March 2002 laying down case definitions for reporting communicable diseases to the Community network under Decision No 2119/98/EC of the European Parliament and of the Council. Official Journal of the European Communities 2002; L86 (45): 44-62.

[11] Commission Decision of 28 April 2008 amending Decision 2002/253/EC laying down case definitions for reporting communicable diseases to the Community network under Decision No 2119/98/EC of the European Parliament and of the Council. Official Journal of the European Communities 2008; L159 (51):46-90.

[12] Eurostat. Causes of death – absolute number (annual data). Available from: http://epp.eurostat.ec.europa.eu/portal/page/portal/health/public_health/data_public_health/database.

[13] Diederen BM. Legionella spp. and Legionnaires' disease. J Infect 2008;56(1):1-12.

[14] Karagiannis I, Brandsema P, van der Sande M. Warm, wet weather associated with increased Legionnaires' disease incidence in The Netherlands. Epidemiol Infect 2009;137(2):181-7.

[15] Ricketts KD, Charlett A, Gelb D, Lane C, Lee JV, Joseph CA. Weather patterns and Legionnaires' disease: a meteorological study. Epidemiol Infect 2009;137(7):1003-12.

[16] Joseph CA, Ricketts KD; European Working Group for Legionella Infections. Legionnaires disease in Europe 2007-2008. Euro Surveill 2010;15(8):19493.

[17] Rudbeck M, Mølbak K, Uldum S. High prevalence of antibodies to Legionella spp. in Danish blood donors. A study in areas with high and average incidence of Legionnaires' disease. Epidemiol Infect 2008;136(2):257-62.

[18] Fields BS, Benson RF, Besser RE. Legionella and legionnaires' disease: 25 years of investigation. Clin Microbiol Rev 2002;15:506-26.17.

[19] Olsen CW, Elverdal P, Jørgensen CS, Uldum SA. Comparison of the sensitivity of the Legionella urinary antigen EIA kits from Binax and Biotest with urine from patients with infections caused by less common serogroups and subgroups of Legionella. Eur J Clin Microbiol Infect Dis 2009;28(7):817-20.

[20] Jespersen S, Søgaard OS, Schønheyder HC, Fine MJ, Ostergaard L. Clinical features and predictors of mortality in admitted patients with community- and hospital-acquired legionellosis: a Danish historical cohort study. BMC Infect Dis 2010;10:124.

[21] Heath CH, Grove DI, Looke DF. Delay in appropriate therapy of Legionella pneumonia associated with increased mortality. Eur J Clin Microbiol Infect Dis 1996;15(4):286-90.

[22] Marston BJ, Lipman HB, Breiman RF. Surveillance for Legionnaires' disease. Risk factors for morbidity and mortality. Arch Intern Med 1994;154(21):2417-22.

[23] Bernander S, Jacobson K, Lundholm M. A hospital-associated outbreak of Legionnaires' disease caused by *Legionella pneumophila* serogroups 4 and 10 with a common genetic fingerprinting pattern. APMIS 2004;112(3):210-7.

[24] Lück PC, Schneider T, Wagner J, Walther I, Reif U, Weber S, et al. Community-acquired Legionnaires' disease caused by *Legionella pneumophila* serogroup 10 linked to the private home. J Med Microbiol 2008;57(Pt 2):240-3.

[25] Harrison TG, Afshar B, Doshi N, Fry NK, Lee JV. Distribution of *Legionella pneumophila* serogroups, monoclonal antibody subgroups and DNA sequence types in recent clinical and environmental isolates from England and Wales (2000-2008). Eur J Clin Microbiol Infect Dis 2009;28(7):781-91.

# Annex

**Figure A Proportion of reported cases of Legionnaires' disease by laboratory method of diagnosis and year of reporting, EU/EEA, 2005–2009 (more than one method per case possible)**

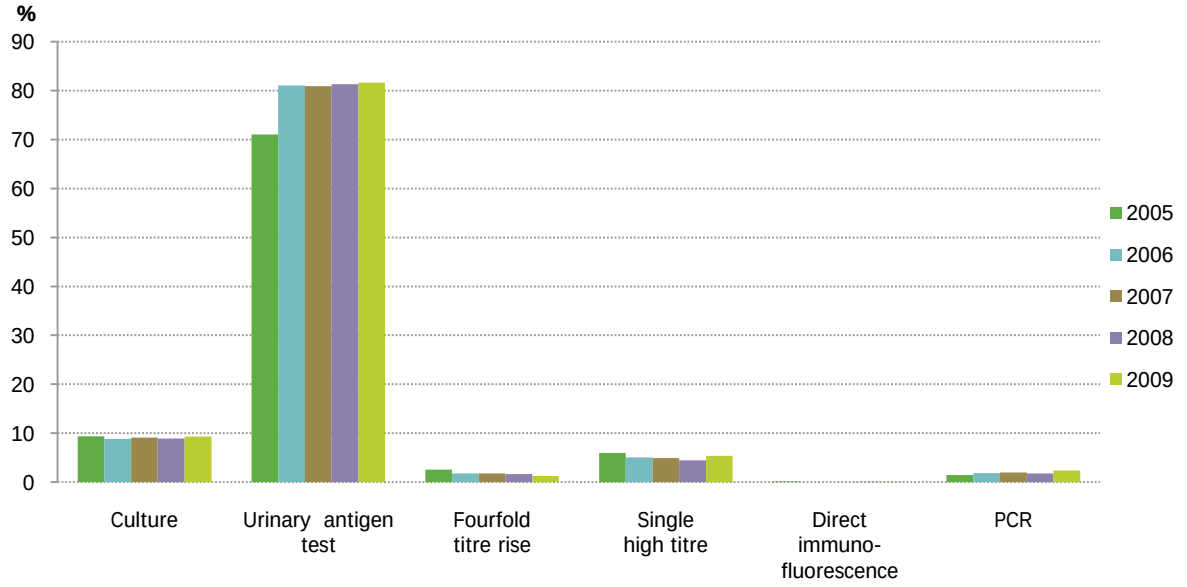



**Table A Reported case-fatality of Legionnaires' disease by country and age group, EU/EEA, 2009**

| Country[a] | Age (y) | | | | | | | | All[b] |
|---|---|---|---|---|---|---|---|---|---|
| | 0–19 n (%) | 20–29 n (%) | 30–39 n (%) | 40–49 n (%) | 50–59 n (%) | 60–69 n (%) | 70–79 n (%) | 80+ n (%) | n (%) |
| Austria | –[c] | 0/3 (0) | 0/7 (0) | 0/21 (0) | 3/18 (16.7) | 0/21 (0) | 1/14 (7.1) | 4/8 (50.0) | 8/92 (8.7) |
| Denmark | – | 0/1 (0) | 0/4 (0) | 1/13 (7.7) | 1/20 (5.0) | 6/49 (12.2) | 3/18 (16.7) | 10/18 (55.6) | 21/123 (17.1) |
| Estonia | – | – | – | 0/1 (0) | 0/1 (0) | 0/2 (0) | 0/2 (0) | – | 0/6 (0) |
| Finland | 0/1 (0) | 0/3 (0) | 0/2 (0) | 0/1 (0) | 0/8 (0) | 1/4 (25.0) | 0/1 (0) | 0/2 (0) | 1/22 (4.5) |
| France | 0/1 (0) | 0/20 (0) | 2/70 (2.9) | 10/158 (6.3) | 12/223 (5.4) | 18/216 (8.3) | 28/188 (14.9) | 55/215 (25.6) | 125/1091 (11.5) |
| Germany | 0/8 (0) | 0/8 (0) | 2/20 (10.0) | 2/97 (2.1) | 6/127 (4.7) | 3/96 (3.1) | 15/91 (16.5) | 7/55 (12.7) | 35/502 (7.0) |
| Greece | – | – | 0/3 (0) | 0/4 (0) | 0/3 (0) | 0/2 (0) | 1/3 (33.3) | – | 1/15 (6.7) |
| Hungary | 0/3 (0) | 0/4 (0) | 0/10 (0) | 1/11 (9.1) | 0/19 (0) | 3/10 (30.0) | 1/5 (20.0) | 0/2 (0) | 5/64 (7.8) |
| Iceland | 0/1 (0) | – | – | – | – | 0/1 (0) | 0/2 (0) | 1/3 (33.3) | 1/7 (14.3) |
| Latvia | – | 0/1 (0) | – | 0/1 (0) | – | 0/1 (0) | – | – | 0/3 (0) |
| Luxembourg | – | – | – | – | 1/2 (50.0) | 0/1 (0) | – | 2/2 (100.0) | 3/5 (60.0) |
| Malta | – | – | – | 0/2 (0) | – | 0/2 (0) | – | – | 0/4 (0) |
| Netherlands | 0/1 (0) | 0/3 (0) | 0/9 (0) | 1/29 (3.4) | 0/65 (0) | 6/80 (7.5) | 5/42 (11.9) | 5/22 (22.7) | 17/251 (6.8) |
| Norway | – | 0/1 (0) | 0/1 (0) | 0/5 (0) | 0/6 (0) | 0/10 (0) | 1/6 (16.7) | 0/1 (0) | 1/30 (3.3) |
| Poland | – | 0/1 (0) | – | 0/1 (0) | 0/4 (0) | 0/4 (0) | – | – | 0/10 (0) |
| Romania | – | – | 0/3 (0) | – | – | – | – | – | 0/3 (0) |
| Slovakia | – | – | – | – | – | 1/1 (100.0) | – | 0/1 (0) | 1/2 (50.0) |
| Slovenia | – | 0/3 (0) | 0/9 (0) | 0/11 (0) | 0/16 (0) | 1/9 (11.1) | 0/12 (0) | 1/5 (20.0) | 2/65 (3.1) |

[a] *Excludes countries where > 25% of outcomes are unknown (Belgium, Bulgaria, Ireland, Italy, Portugal, Spain, Sweden and the UK).*
[b] *Only cases with known outcome.*
[c] *No cases reported.*

**Table B Reported clustering of Legionnaires' disease by country and age group, EU/EEA, 2009**

| Country[a] | Age (y) | | | | | | | | All[b] n (%) |
|---|---|---|---|---|---|---|---|---|---|
| | 0–19 n (%) | 20–29 n (%) | 30–39 n (%) | 40–49 n (%) | 50–59 n (%) | 60–69 n (%) | 70–79 n (%) | 80+ n (%) | |
| Austria | –[c] | 0/3 (0) | 0/7 (0) | 1/21 (4.8) | 0/18 (0) | 0/21 (0) | 1/14 (7.1) | 0/8 (0) | 2/92 (2.2) |
| Bulgaria | – | – | 0/1 (0) | – | 0/2 (0) | – | – | 0/1 (0) | 0/4 (0) |
| Germany | 0/8 (0) | 0/8 (0) | 1/20 (5.0) | 1/97 (1.0) | 3/127 (2.4) | 6/96 (6.3) | 2/91 (2.2) | 0/55 (0) | 13/502 (2.6) |
| Denmark | – | 0/1 (0) | 1/4 (25.0) | 1/13 (7.7) | 5/20 (25.0) | 1/48 (2.1) | 2/17 (11.8) | 0/18 (0) | 10/121 (8.3) |
| Estonia | – | – | – | 0/1 (0) | 0/1 (0) | 0/2 (0) | 0/2 (0) | – | 0/6 (0) |
| Spain | – | – | 0/3 (0) | 0/4 (0) | 0/3 (0) | 0/2 (0) | 0/3 (0) | – | 0/15 (0) |
| UK | 0/3 (0) | 0/4 (0) | 0/10 (0) | 0/12 (0) | 0/19 (0) | 0/10 (0) | 0/5 (0) | 0/2 (0) | 0/65 (0) |
| Greece | – | – | – | – | 0/2 (0) | 0/3 (0) | 0/1 (0) | 0/1 (0) | 0/7 (0) |
| Hungary | 0/1 (0) | – | – | – | – | 0/1 (0) | 0/2 (0) | 0/3 (0) | 0/7 (0) |
| Ireland | 0/2 (0) | 0/19 (0) | 2/65 (3.1) | 2/148 (1.4) | 3/229 (1.3) | 6/248 (2.4) | 8/261 (3.1) | 7/223 (3.1) | 28/1195 (2.3) |
| Iceland | – | – | – | – | 0/1 (0) | 0/1 (0) | – | 0/2 (0) | 0/4 (0) |
| Italy | – | 0/1 (0) | – | 0/1 (0) | – | 0/1 (0) | – | – | 0/3 (0) |
| Luxembourg | – | – | – | 0/2 (0) | – | 0/2 (0) | – | – | 0/4 (0) |
| Latvia | – | 1/1 (100.0) | 0/1 (0) | 2/6 (33.3) | 0/7 (0) | 1/10 (10.0) | 0/8 (0) | 0/1 (0) | 4/34 (11.8) |
| Malta | – | 0/1 (0) | – | 0/1 (0) | 2/4 (50.0) | 1/4 (25.0) | – | – | 3/10 (30.0) |
| Norway | – | 0/2 (0) | 1/13 (7.7) | 3/18 (16.7) | 2/27 (7.4) | 1/15 (6.7) | 1/13 (7.7) | 0/7 (0) | 8/95 (8.4) |
| Poland | – | – | 0/3 (0) | – | – | – | – | – | 0/3 |
| Portugal | – | 0/3 (0) | 0/9 (0) | 0/11 (0) | 0/16 (0) | 0/9 (0) | 0/12 (0) | 0/5 (0) | 0/65 |
| Romania | 0/3 (0) | 0/8 (0) | 4/73 (5.5) | 17/205 (8.3) | 20/255 (7.8) | 22/241 (9.1) | 30/230 (1.3) | 8/182 (4.4) | 101/1197 (8.4) |
| Slovenia | 0/1 (0) | 1/3 (33.3) | 0/11 (0) | 9/53 (17.0) | 14/98 (14.3) | 14/107 (13.1) | 20/65 (30.8) | 0/26 (0) | 58/364 (15.9) |

*[a] Excludes countries where > 25% of cluster statuses are unknown (Belgium, Finland, France, the Netherlands, Slovakia and Sweden)*
*[b] Only cases with known cluster status.*
*[c] No cases reported.*

**Table C Reported clustering of Legionnaires' disease by *Legionella* species and serogroup, EU/EEA, 2009[a]**

| Species and serogroup | All cases | | | Confirmed cases | | | Culture-confimed cases[b] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Clustered n | Total n | Clustered % | Clustered n | Total n | Clustered % | Clustered n | Total n | Clustered % |
| *L. pneumophila* | 240 | 3 672 | 6.5 | 233 | 3 462 | 6.7 | 28 | 211 | 13.3 |
| Serogroups | | | | | | | | | |
| 1 | 227 | 3 231 | 7.0 | 227 | 3 211 | 7.1 | 28 | 173 | 16.2 |
| 2 | 0 | 2 | 0 | 0 | 1 | 0 | – | – | – |
| 3 | 0 | 24 | 0 | 0 | 13 | 0 | 0 | 13 | 0 |
| 5 | 0 | 3 | 0 | 0 | 3 | 0 | 0 | 3 | 0 |
| 6 | 0 | 8 | 0 | 0 | 5 | 0 | 0 | 5 | 0 |
| 7 | 0 | 7 | 0 | – | – | – | – | – | – |
| 8 | 0 | 2 | 0 | – | – | – | – | – | – |
| 9 | 0 | 1 | 0 | – | – | – | – | – | – |
| 10 | 0 | 6 | 0 | 0 | 6 | 0 | 0 | 6 | 0 |
| 14 | 0 | 1 | 0 | – | – | – | – | – | – |
| Mixed | 0 | 22 | 0 | 0 | 6 | 0 | – | – | – |
| Unknown | 13 | 365 | 3.6 | 6 | 217 | 2.8 | 0 | 11 | 0 |
| *L. longbeachae* | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 2 | 0 |
| *L. micdadei* | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| Unknown species | 14 | 188 | 7.4 | 6 | 104 | 5.8 | 0 | 18 | 0 |
| **Total** | **254** | **3875** | **6.6** | **239** | **3 578** | **6.7** | **28** | **233** | **12.0** |

*[a] Does not include 11 German cases with pathogen coded as 'Other' meaning 'Legionella other than L. pneumophila serogroup1'.*
*[b] Does not include six cases confirmed by culture and urinary antigen test and reported as L. pneumophila serogroup 1 to exclude cases possibly assumed by default to belong to this serogroup.*