Healthcare-associated infections acquired in intensive care units

Reporting on data retrieved from TESSy* on 22 May 2017

Suggested citation: European Centre for Disease Prevention and Control. Annual Epidemiological Report 2016 – Healthcare-associated infections acquired in intensive care units. [Internet]. Stockholm: ECDC; 2016 [cited YYYY Month DD]. https://ecdc.europa.eu/en/publications-data/healthcare-associated-infections-acquired-intensive-care-units-annual

Key facts

- In 2014, 6 995 (8%) of patients staying in an intensive care unit (ICU) for more than two days presented with at least one ICU-acquired healthcare-associated infection (HAI) under surveillance.
- Of all patients staying in an ICU for more than two days, 6% presented with pneumonia, 4% with bloodstream infection (BSI) and 3% with urinary tract infection (UTI).
- 98% of pneumonia episodes were associated with intubation, 48% of BSI episodes were catheter-related, and 98% of UTI episodes were associated with presence of a urinary catheter.
- The most frequently isolated microorganism was *Pseudomonas aeruginosa* in ICU-acquired pneumonia episodes, coagulase-negative *Staphylococcus* spp. in ICU-acquired bloodstream infections and *Escherichia coli* in ICU-acquired urinary tract infections.
- 25% of *Staphylococcus aureus* isolates were oxacillin-resistant (MRSA). Resistance to third-generation cephalosporins was reported in 17% of *E. coli* isolates, 44% of *Klebsiella* spp. isolates and 44% of *Enterobacter* spp. isolates. Carbapenem resistance was reported in 8% of *Klebsiella* spp. isolates, in 28% of *P. aeruginosa* isolates and in 64% of *Acinetobacter baumannii* isolates.

Methods

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A patient-based ('standard') protocol and a unit-based ('light') protocol are used for the EU level surveillance of healthcare-associated infections (HAIs) acquired in intensive care units (ICUs). The patient-based protocol is used to collect data for all patients, regardless of infection, including information on risk factors allowing risk-adjusted inter-hospital comparisons. With the unit-based protocol, denominator data, i.e. patient-days, are collected at ICU level while patient data are recorded only for patients with HAIs.

Inclusion criteria, risk factors and case definitions of ICU-acquired HAIs are described in detail in the protocol [1]. Infections occurring after 48 hours in the ICU are considered as ICU-acquired in both protocols. With admission day being counted as day 1, infections with onset from day 3 onwards should therefore be reported. One record per HAI is collected, together with antimicrobial resistance markers for isolated microorganisms. ICUs with fewer than 20 patients in the surveillance database were excluded from unit-based analyses.

The minimal requirement for surveillance of ICU-acquired HAIs is to include BSI and pneumonia. Collection of data on urinary tract infections (UTIs) and central venous catheter (CVC)-related infections is optional.

A case of pneumonia is defined in accordance with clinical criteria (X-ray, fever >38 °C, leucocytosis >12 000 white blood cells (WBC)/mm3, purulent sputum) and further sub-categorised in five categories according to the level of microbiological confirmation: PN1, minimally contaminated lower respiratory tract sample with quantitative culture (104 colony-forming units (CFU)/ml for bronchoalveolar lavage, 103 CFU/ml for protected brush samples or distal protected aspirate); PN2, non-protected sample (endotracheal aspirate, ETA) with quantitative culture (106 CFU/ml); PN3, alternative microbiological criteria (e.g. positive blood culture); PN4, sputum bacteriology or non-quantitative ETA; and PN5, no microbiological documentation, clinical signs and symptoms only.

A BSI is defined as a positive blood culture of a recognised pathogen or the combination of clinical symptoms (fever > 38 °C, chills, hypotension) and two positive blood cultures of a common skin contaminant from two separate blood samples drawn within 48 hours.

A UTI is defined as either (a) a microbiologically confirmed symptomatic UTI (UTI-A) whereby the presence of at least one sign or symptom coincides with a positive urine culture (defined as ≥105 microorganisms per ml of urine, with no more than two species of microorganisms), or (b) a non-microbiologically-confirmed symptomatic UTI (UTI-B), whereby the presence of at least two signs or symptoms coincide with other criteria, e.g. a positive dipstick for leukocyte esterase and/or nitrate (see protocol for details of case definitions).

Number of HAIs, percentage of HAIs associated with the presence of a relevant device, the incidence density of HAIs per 1 000 patient-days and the incidence density of HAIs adjusted per 1 000 days of device use were estimated. The ten most frequently isolated pathogens for each type of HAI and antimicrobial resistance percentages for *Staphylococcus aureus, Enterococcus* spp., *Enterobacteriaceae, Pseudomonas aeruginosa* and *Acinetobacter baumannii* are presented.

In 2014, 15 countries reported data from 1 019 hospitals and 1 290 ICUs (Figure 1): Belgium, the Czech Republic, Estonia, France, Germany, Hungary, Italy, Lithuania, Luxembourg, Malta, Portugal, Romania, Slovakia, Spain and the United Kingdom (UK–Scotland). The median size of the participating ICUs was eight beds ranging from 1 to 43 beds. Five countries (the Czech Republic, Germany, Hungary, Malta and Romania) only provided unit-based data, and one country (Belgium) provided both patient-based and unit-based data. The remaining nine countries only provided patient-based data.

As in previous years, Germany did not provide selective denominator data for patients staying in an ICU for more than two days. Therefore, data from Germany were only included in the descriptive analysis of ICU-acquired HAIs and excluded from the calculation of HAI rates.

Figure 1. Participation in surveillance of healthcare-associated infections in intensive care units, EU/EEA, 2014

Source: ECDC, HAI-Net patient-based and unit-based data, 2014

Epidemiology

Of 87 337 patients staying in an ICU for more than two days (patient-based data), 6 995 patients (8.0%) presented with at least one HAI.

ICU-acquired pneumonia

Of the 4 809 cases of pneumonia reported, 97.5% were associated with intubation. Among patients staying in an ICU for more than two days, 5.5% were affected by at least one episode of pneumonia.

The incidence of pneumonia was six episodes per 1 000 patient-days.

The mean incidence density per ICU was 3.86 pneumonia episodes per 1 000 patient-days (ICU IQR:0.9–5.0), ranging from 2.0 in ICUs with less than 30% intubated patients to 3.6 in ICUs with 30–59% intubated patients, and 6.4 in ICUs with 60% or more intubated patients.

In patient-based surveillance, the mean device-adjusted rate was 10.0 intubation-associated pneumonia episodes per 1 000 intubation-days and varied between 2.8 in UK–Scotland and 15.8 per 1 000 intubation-days in Italy and Belgium (Table 1).

Table 1. ICU-acquired intubation-associated pneumonia rates by country, EU/EEA, 2014

Country	Number of ICUs	Number of patients	Average length of ICU stay (days)	Intubation use (days per 100 patient-days)	Intubation-associated pneumonia rate (episodes per 1 000 intubation-days)			
					Country mean	25th percentile	Median	75th percentile
Belgium	7	1 151	7.9	38.0	15.8	11.1	12.8	20.7
Estonia	8	1 559	10.2	62.1	8.3	2.5	6.6	9.7
France	212	34 226	11.8	54.8	14.3	7.5	13.2	19.6
Italy	20	1 197	10.1	59.3	15.8	8.1	14.7	20.2
Lithuania	24	2204	8.9	48.7	11.8	0	10.1	18.3
Luxembourg	8	2 749	9.6	32.8	3.3	1.8	2.8	4.2
Portugal	31	4 778	11.7	68.2	9.4	4.4	7.1	11.7
Slovakia	7	370	11.5	60.4	14.6	5.2	9.6	24.9
Spain	184	31 484	8.1	41.3	6.3	1.1	5.2	8.8
United Kingdom	23	7 041	7.7	60.4	2.8	0.9	1.8	4.9

Source: ECDC, HAI-Net patient-based data 2014. United Kingdom: data from UK–Scotland only.
Percentiles: distribution of incidence per ICU

The most frequently isolated microorganisms in ICU-acquired pneumonia episodes were *Pseudomonas aeruginosa* followed by *Staphylococcus aureus*, *Klebsiella* spp. and *Escherichia coli* (Table 2).

Table 2. Number of isolates and percentages of the ten most frequently isolated microorganisms in ICU-acquired pneumonia episodes, by country, EU/EEA, 2014

Microorganism	Belgium (n=60)	Estonia (n=63)	France (n= 3 039)	Germany (n= 4 906)	Hungary (n=40)	Italy (n=97)	Lithuania (n=103)	Luxembourg (n=18)	Portugal (n=252)	Romania (n=233)	Slovakia (n=28)	Spain (n=532)	United Kingdom (n=67)	Total (n=9 434)
Pseudomonas aeruginosa	23.3	15.9	31	23.7	41.2	15.5	27.8	29.4	30.5	25	7.5	13.5	27.5	18.8
Staphylococcus aureus	6.7	17.5	17.5	18.3	14.4	17.5	16.7	19.4	8.6	4.2	25.4	17.3	12.5	17.6
Klebsiella spp.	16.7	22.2	12.8	10.2	20.6	34	22.2	15.1	12.9	45.8	11.9	15.9	10	14.1
Escherichia coli	20	15.9	7.7	13.3	6.2	9.7	0	7.5	1.3	8.3	16.4	14.6	15	13.4
Enterobacter spp.	11.7	9.5	8.3	11.6	7.2	6.8	5.6	7.5	36.5	4.2	6	8.1	15	9.2
Candida spp.	0	7.9	1.5	3.2	0	4.9	5.6	2	3	8.3	13.4	12.7	2.5	8.2
Serratia spp.	5	1.6	5.5	4.9	1	0	22.2	5.2	1.3	4.2	3	5.7	5	5.3
Stenotrophomonas maltophilia	6.7	6.3	5.6	5.2	7.2	1	0	3.6	0.4	0	6	4.7	12.5	4.9
Haemophilus spp.	10	3.2	5.6	6.8	0	3.9	0	9.9	0	0	9	2.6	0	4.4
Enterococcus spp.	0	0	4.5	2.9	2.1	6.8	0	0.4	5.6	0	1.5	5	0	4

n = number of isolates
Source: ECDC, HAI-Net patient-based and unit-based data, 2014. United Kingdom: data from UK–Scotland only

ICU-acquired bloodstream infections (BSIs)

A total of 3 072 cases of ICU-acquired BSIs were reported. On average, ICU-acquired BSIs occurred in 3.5% of patients staying in an ICU for more than two days. The mean incidence density per ICU was 1.7 BSI episodes per 1 000 patient-days (ICU IQR: 0.4-3.0).

BSIs were catheter-related in 48.3% of cases, secondary to another infection in 32.6% of cases, and of unknown origin in 19.1% of cases. When the BSI was secondary to another infection, the primary infection site was pulmonary in 47.5%, gastrointestinal (17.2%), the urinary tract (18.6%), a surgical site (2.7%), skin and soft tissues (5.2%), and another body site in the remaining 8.5% episodes.

In patient-based surveillance, the central vascular catheter (CVC) utilisation rate was on average 70.5 CVC-days per 100 patient days; it was the lowest (57.0) in Slovakia and the highest (83.0) in Estonia. The mean device-adjusted rate in patients staying in an ICU for more than two days was 2.4 CVC-associated BSI episodes (ICU IQR: 1.3–3.0).

The most frequently isolated microorganisms in ICU-acquired BSI episodes were coagulase-negative staphylococci followed by *Enterococcus* spp., *Staphylococcus aureus* and *Klebsiella* spp.

Table 3. Number of isolates and percentages of the ten most frequently isolated microorganisms in ICU-acquired bloodstream infection (BSI) episodes by country, EU/EEA, 2014

Microorganism	Belgium (n=27)	Czech Republic (n=95)	Estonia (n=77)	France (n=1 300)	Germany (n=2 188)	Hungary (n=17)	Italy (n=85)	Lithuania (n=45)	Luxembourg (n=18)	Malta (n=22)	Portugal (n=207)	Romania (n=49)	Slovakia (n=15)	Spain (n=890)	United Kingdom (n=65)	Total (n=5 588)
Coagulase-negative staphylococci	18.5	36.4	32.5	20.2	27.5	29.4	38.8	43.9	22.2	0	13.5	6.1	26.7	27.6	20	25.3
Enterococcus spp.	14.8	15.6	18.2	12.4	17.7	0	7.1	5.3	27.8	4.5	11.6	16.3	0	15.1	13.8	15
Staphylococcus aureus	22.2	15.6	3.9	11.9	16.5	5.9	1.2	8.8	5.6	0	15	0	6.7	2.7	18.5	12.1
Klebsiella spp.	3.7	24.7	7.8	11.8	8.1	5.9	14.1	8.8	5.6	36.4	15	22.4	33.3	10.3	10.8	10.3
Escherichia coli	18.5	7.8	3.9	10.8	9.7	5.9	2.4	3.5	5.6	9.1	7.7	0	6.7	7.6	9.2	9.2
Candida spp.	7.4	7.8	18.2	9.2	8	0	9.4	5.3	5.6	9.1	4.8	4.1	6.7	8.4	12.3	8.4
Pseudomonas aeruginosa	3.7	10.4	3.9	9.8	4.4	29.4	8.2	3.5	5.6	18.2	11.1	8.2	13.3	13.7	4.6	8
Enterobacter spp.	0	0	9.1	10.4	4.9	17.6	3.5	3.5	11.1	13.6	8.7	0	0	6	6.2	6.7
Acinetobacter spp.	0	1.3	1.3	1.3	0.8	5.9	14.1	15.8	5.6	9.1	7.2	40.8	6.7	5.4	4.6	2.5
Serratia spp.	11.1	3.9	1.3	2	2.3	0	1.2	1.8	5.6	0	5.3	2	0	3.1	0	2.5

n = number of isolates
Source: ECDC, HAI-Net patient-based and unit-based data 2014. United Kingdom: data from UK-Scotland only.
Coagulase-negative staphylococci: includes unspecified Staphylococcus *spp.*

ICU-acquired urinary tract infections

A total of 1 178 cases of ICU-acquired UTIs were reported. On average, ICU-acquired UTIs occurred in 2.6% of patients staying in an ICU for more than two days, with 98.4% of UTI episodes being associated with the use of a urinary catheter. The mean incidence density per ICU was 1.1 UTI episodes per 1 000 patient-days (ICU IQR: 0–2.13).

On average, urinary catheters were used in 78% of the patient-days. The mean device-adjusted rate in patients staying in an ICU for more than two days was 3.8 catheter-associated UTI episodes per 1 000 catheter-days (ICU IQR: 0.2–5.2).

The most frequently isolated microorganisms in ICU-acquired UTI episodes were *Escherichia coli* followed by *Enterococcus* spp., *Pseudomonas aeruginosa* and *Klebsiella* spp.

Table 4. Percentages of the ten most frequently isolated microorganisms in ICU-acquired urinary tract infection (UTI) episodes, by country, EU/EEA, 2014

Microorganism	Estonia (n=42)	Germany (n=1 961)	Hungary (n=28)	Italy (n=42)	Lithuania (n=79)	Luxembourg (n=49)	Portugal (n=82)	Romania (n=146)	Slovakia (n=23)	Spain (n=721)	Total (n=3 173)
Escherichia coli	28.6	33	10.7	16.7	24.1	28.6	32.9	3.4	4.3	29.7	31.4
Enterococcus spp.	33.3	20.9	21.4	14.3	16.5	32.7	8.5	9.6	4.3	18.3	19.9
Pseudomonas aeruginosa	2.4	11.8	17.9	14.3	5.1	14.3	14.6	11.6	21.7	16.1	12.7
Klebsiella spp.	11.9	10.5	7.1	21.4	21.5	10.2	17.1	12.3	52.2	12.3	11.9
Candida spp.	11.9	8.4	28.6	9.5	6.3	4.1	8.5	3.4	8.7	11.9	9.2
Proteus spp.	0	6.8	0	4.8	10.1	4.1	6.1	2.7	8.7	4.2	6.1
Enterobacter spp.	9.5	5	3.6	2.4	1.3	4.1	1.2	0	0	3.5	4.4
Acinetobacter spp.	0	1.6	0	2.4	0	2	1.2	0	0	1.7	1.6
Citrobacter spp.	0	0.3	7.1	14.3	12.7	0	9.8	51.4	0	1.7	1.4
Coagulase-negative staphylococci	2.4	1.7	3.6	0	2.5	0	0	5.5	0	0.7	1.4

n = number of isolates
Source: ECDC, HAI-Net ICU 2014

Antimicrobial resistance

The reported percentages of antimicrobial-resistant isolates in selected bacteria associated with ICU-acquired HAIs were: oxacillin resistance in *S. aureus* (MRSA) in 25.3% of *S. aureus* isolates (n=912); vancomycin resistance in 2.4% of *Enterococcus* spp. isolates (n=637); ceftazidime resistance in 24.2% of *P. aeruginosa* isolates (n=1 548); and resistance to third-generation cephalosporins in 17.3% of *E. coli* isolates (n=1 364), 43.7% of *Klebsiella* spp. isolates (n=1 303) and 43.5% of *Enterobacter* spp. isolates (n=835). Carbapenem resistance was reported in 7.7% of *Klebsiella* spp. isolates (n=871), 0.9% of *E. coli* isolates (n=899), 1.5% of

Enterobacter spp. isolates (n=648), 27.7% of *P. aeruginosa* isolates (n=1 491) and 63.5% of *Acinetobacter baumannii* (n=244) isolates.

Discussion

Fifteen countries submitted data on ICU-acquired infections in 2014. The number of included ICU patients increased compared with the last report, which was based on 2012 data [2]. In 2014, the expansion of the surveillance network continued with one additional country (Hungary), which reported surveillance data on ICU-acquired infections.

HAI surveillance at the local and national levels is an essential component of HAI prevention and control. Participating ICUs benefit from a standardised tool which enables them to compare their own performance to that of other ICUs. In addition, participation in the European surveillance network encourages compliance with existing guidelines and helps to correct or improve specific practices as well as evaluate new preventive practices. Participation in the European network may also produce additional benefits at the local level, allowing comparisons with a wide range of ICUs nationally and at the European level. Nevertheless, inter-country differences in surveillance methods persist, and there is an ongoing effort to further harmonise the methodology for surveillance of HAIs in ICUs in Europe.

Device-adjusted HAI rates of ICU-acquired pneumonia, bloodstream infections and UTIs remained stable in 2014 compared with 2012 [2]. However, there is substantial variability in HAI rates across the EU/EEA. Part of this variability can be attributed to variation in diagnostic practices. Characteristics of the participating ICUs and patient population, such as clinical severity and infection control practices may also affect the reported incidence of HAIs. A comparison of infection control practices is not possible with the currently available data. Quality indicators for infection control and antimicrobial stewardship will allow a more comprehensive assessment of the observed variability. Moreover, metrics for HAI outcomes are necessary for a better estimation of the burden of HAIs in ICUs.

The distribution of pathogens associated with HAIs in 2014 remained virtually unchanged compared with 2012. The relative contribution of gram-negative bacteria as a cause of HAIs in ICUs continues to vary geographically, with higher proportions of HAIs caused by *Klebsiella* spp. and *Acinetobacter* spp. in some countries. This report confirms the importance of antimicrobial resistance in gram-negative bacteria in European ICUs in 2014, with resistance percentages being comparable to the report for 2012 for both gram-positive and gram-negative bacteria. The high percentages of resistance to carbapenems of *P. aeruginosa*, *A. baumannii* and *K. pneumoniae* reflect the challenges of treatment of ICU patients, a highly vulnerable patient population.

Public health conclusions

ICUs are the hospital wards with the highest prevalence of HAIs [3]. The majority of HAIs in ICUs are associated with the use of invasive devices (e.g. endotracheal tubes, vascular and urinary catheters), and a significant proportion of these HAIs is considered preventable. Moreover, the burden of antimicrobial resistance is high in ICUs, due to the severity of the clinical condition of the patients, the frequent use of antibiotics and varying infection control practices.

Strengthening infection control measures and implementing antimicrobial stewardship constitute essential measures to prevent HAIs and the spread of antimicrobial resistance in ICUs. Further understanding of the variation in incidence and of the burden of HAIs in ICUs will be facilitated through the use of quality indicators and information on outcome. These are included in the new ECDC protocol for surveillance of HAIs in ICUs and are expected to increase the utility of the surveillance data.

References

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Annex

Table. Healthcare-associated infections acquired in intensive care units, surveillance systems overview, 2014

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* The European Surveillance System (TESSy) is a system for the collection, analysis and dissemination of data on communicable diseases. EU Member States and EEA countries contribute to the system by uploading their infectious disease surveillance data at regular intervals.