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SURVEILLANCE REPORT

Point prevalence survey of healthcare-associated infections and antimicrobial use in European acute care hospitals

2016–2017

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This report of the European Centre for Disease Prevention and Control (ECDC) was coordinated by Carl Suetens.

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Abbreviations

AHR	Alcohol-based handrub
AMC	Antimicrobial consumption
AM	Antimicrobial agent
ARPAC project	Antimicrobial Resistance: Prevention and Control. 'Development of strategies for control and prevention of antibiotic resistance in European hospitals' project
AST	Antimicrobial susceptibility testing
ATC	Anatomical therapeutic chemical
AU	Antimicrobial use
BSI	Bloodstream infection
CDI	*Clostridioides difficile* infection
CEO	Chief Executive Officer
CI	Confidence interval
CRI	Catheter-related infection
CVC	Central vascular catheter
CVS	Cardio-vascular system
DDD	Defined daily dose
EARS-Net	European Antimicrobial Resistance Surveillance Network (ECDC)
ECDC	European Centre for Disease Prevention and Control
EEA	European Economic Area
ESAC	European Surveillance of Antimicrobial Consumption project
ESAC-Net	European Surveillance of Antimicrobial Consumption Network (ECDC)
EU	European Union
FTE	Full-time equivalent
HAI	Healthcare-associated infection
HAI-Net	Healthcare-Associated Infections Surveillance Network (ECDC)
HCW	Healthcare worker
HELICS project	Hospitals in Europe Link for Infection Control through Surveillance project
ICU	Intensive care unit
IPC	Infection prevention and control
IPCD	Infection prevention and control doctor
IPCN	Infection prevention and control nurse
IPSE project	Improving Patient Safety in Europe project
IQR	Inter-quartile range
LOS	Length of stay
LTCF	Long-term care facility
LRTI	Lower respiratory tract infection
Med	Median
MRSA	Meticillin-resistant *Staphylococcus aureus*
NHSN	National Healthcare Safety Network (CDC)
NS	Non-susceptible
OR	Odds ratio
PCR	Polymerase chain reaction
PPS	Point prevalence survey
PVC	Peripheral vascular catheter
R	Resistant
ROC	Receiver operating characteristic
S	Susceptible
SAUR	Standardised antimicrobial use ratio
SIR	Standardised infection ratio
TRICE project	Training in Infection Control in Europe project (ECDC)
UTI	Urinary tract infection
VRE	Vancomycin-resistant *Enterococcus* spp.
WHO	World Health Organization

Summary

Participation

In 2016–2017, 28 EU/EEA Member States and one EU candidate country (Serbia) participated in the second EU-wide, ECDC-coordinated point prevalence survey (PPS) of healthcare-associated infections (HAIs) and antimicrobial use in acute care hospitals.

Data from a total of 1 734 hospitals were submitted to ECDC. Of these, 325 737 patients from 1 274 hospitals were included in the final European sample for analysis. Data from a single ward were collected on a single day. The total time frame for data collection for all wards of a single hospital was 11 days on average (median eight days). Aggregated results were only reported for the EU/EEA, corresponding to 310 755 patients from 1 209 hospitals. Surveys in the four administrations of the United Kingdom[i] (England, Northern Ireland, Scotland and Wales) were organised independently and results are reported separately. Extended summaries of the results of the 2016-2017 ECDC PPS were published in Eurosurveillance on the European Antibiotic Awareness Day in November 2018 [1,2].

Healthcare-associated infections

The prevalence of patients with at least one HAI in the EU/EEA sample was 5.9% (country range: 2.9–10.0%). When extrapolated to the average daily number of occupied beds per country, the weighted HAI prevalence was 5.5% (cumulative 95% confidence interval [CI]: 4.5–6.6%). Correcting for results of national validation studies, the adjusted prevalence of patients with at least one HAI was estimated at 6.5% (95% confidence interval: 5.4–7.8%). After adjustment for non-participating EU/EEA countries (Denmark and Sweden), this corresponded to an estimated total of 98 166 (95% CI: 81 022–117 484) patients with at least one HAI on any given day, 3.8 million (95% CI: 3.1–4.5 million) patients with at least one HAI and 4.5 million (95% CI: 2.6-7.6 million) HAIs (infection episodes) per year in the period 2016 to 2017 in acute care hospitals in the EU/EEA.

Of a total of 19 624 reported HAIs, the most frequently reported types of HAI were respiratory tract infections (pneumonia 21.4% and lower respiratory tract infections 4.3%), urinary tract infections (18.9%), surgical site infections (18.4%), bloodstream infections (10.8%) and gastro-intestinal infections (8.9%), with *C. difficile* infections accounting for 54.6% of the latter and 4.9% of all HAIs. Twenty-three percent of HAIs (n=4 451) were present on admission. One third of HAIs on admission were surgical site infections.

The prevalence of patients with at least one HAI varied between 4.5% in primary care hospitals to 7.2% in tertiary care hospitals. It was the highest in intensive care patients with 19.2% compared with 5.2% for all other specialties combined.

A total of 13 083 microorganisms were reported in 10 338 (52.7%) HAIs. The microorganisms most frequently isolated were, in decreasing order, *Escherichia coli* (16.1%), *Staphylococcus aureus* (11.6%), *Klebsiella* spp. (10.4%), *Enterococcus* spp. (9.8%), *Pseudomonas aeruginosa* (8.0%), *Clostridioides difficile* (7.4%), coagulase-negative staphylococci (7.1%), *Candida* spp. (5.2%), *Enterobacter* spp. (4.4%), *Proteus* spp. (3.6%) and *Acinetobacter* spp. (3.2%). The PPS protocol required the reporting of antimicrobial susceptibility testing (AST) data only on specific bug-drug combinations. Selected AST data were available on the day of the survey for 88.9% of microorganisms selected for AST reporting in the PPS protocol. Methicillin resistance was reported in 30.9% of *S. aureus* isolates with known AST results. Vancomycin resistance was reported in 10.8% of isolated enterococci. Third-generation cephalosporin resistance was reported in 33.3% of all Enterobacterales and was the highest in *K. pneumoniae* with 60.3%. Carbapenem resistance was reported in 30.2% of *P. aeruginosa* isolates and 77.0% of *Acinetobacter baumannii* isolates. The combined index of these first-level antimicrobial resistance (AMR) markers (composite index of AMR) showed that in microbiologically documented HAIs, 31.6% of microorganisms were resistant to antimicrobials (mean of countries: 30.8%). The second-level AMR markers showed that carbapenem resistance was reported in 6.2% of all included Enterobacterales (mean of countries: 5.9%) and was the highest (20.4%) in *K. pneumoniae*.

[i]Please note that the data collection was undertaken in 2019, from EU/EEA Member States. This explains the inclusion of UK data in this report.

Antimicrobial use

The prevalence of patients receiving at least one antimicrobial in the EU/EEA and the UK sample was 32.9% (country range 16.0–55.6%). The survey detected 139 740 antimicrobials that were used in 102 089 patients: 70.6% of the patients received one antimicrobial, 23.6% received two and 5.8% received three or more antimicrobials. The overall prevalence of antimicrobial use extrapolated to the total number of occupied beds in the European sample was 30.5% (range: 15.9%-55.6%, cumulative 95% CI: 27.7-33.5). Correcting for results of national validation studies, the adjusted prevalence of patients receiving at least one antimicrobial was estimated at 31.4% (95% CI: 27.7-33.5%). After adjustment for non-participating EU/EEA countries (Denmark and Sweden), this corresponded to an estimated total of 472 525 (95% CI: 416 771-531 520) patients receiving at least one antimicrobial on any given day in the EU/EEA and the UK.

Antimicrobials were administered parenterally in 72.8% of the agents, and the reason for antimicrobial use was documented in the patient's medical record for 80.3% of the agents.

The prevalence of antimicrobial use was the lowest in psychiatric patients (2.5%) and the highest among intensive care patients (55.9%). Antimicrobials were most frequently prescribed for treatment of an infection (70.6%): community-acquired infection (49.5%), hospital-acquired infection (19.3%) and infection acquired in a long-term care facility (1.9%). Surgical prophylaxis was the indication for 14.2% of the prescriptions and was prolonged for more than one day in 7.7% (or 54.3% of surgical prophylaxis). Medical prophylaxis was the indication for 10.8% of prescriptions.

Out of a total of 233 different antimicrobials reported at the fifth ATC level, 20 (8.6%) accounted for 75% of the total antimicrobial use in European acute care hospitals. The most frequently prescribed antibiotic, amoxicillin with enzyme inhibitor (J01CR02), accounted for 11.1% of all antimicrobial agents.

Information about change of antimicrobials during the treatment of an infection was reported for 76.4% of the prescriptions. Most prescriptions (78.8%, country range: 61.5–93.6%) were not changed from the initiation of treatment to survey date. Escalation, de-escalation and switch from intravenous to oral use were reported for 10.9%, 3.9%, and 4.3% antimicrobial prescriptions, respectively. The change was due to adverse effects for 0.4% and to other reasons for 1.8% prescriptions.

At country level, a lower prevalence of antimicrobial use and a higher percentage of antimicrobials changed during treatment were associated with a lower composite index of AMR.

Structure and process indicators of infection prevention and control and antimicrobial stewardship

A major change in the protocol of the second PPS compared to the first PPS in 2011-2012 was the inclusion of additional structure and process indicators for infection prevention and control (IPC) and of antimicrobial stewardship at hospital and ward level.

Overall, 78.7% and 77.4% of EU/EEA and the UK hospitals, respectively, reported having an annual IPC plan and an annual IPC report that was approved by the hospital CEO or a senior executive officer. The median number of IPC nurse full-time equivalent (FTE) per 250 beds was 1.04 (inter-quartile range [IQR]: 0.58–1.56), with 14.8%, mostly small, hospitals from 18 countries not having an IPC nurse. Higher IPC nurse staffing levels were significantly associated with a lower composite index of AMR, with the lowest AMR levels for hospitals with two or more FTE IPC nurses per 250 beds (corresponding to one IPC nurse per 100 occupied beds). The median number of IPC doctor FTE per 250 beds was 0.28 (IQR: 0.04–0.64), with 24.0% hospitals from 26 countries not reporting any IPC doctor worktime.

There was wide variability of microbiological test access and use across EU/EEA and the UK countries. Full availability of microbiological laboratory test access during weekend days was reported by 47% of hospitals, ranging from 0% hospitals in Latvia to 100% hospitals in UK-Northern Ireland. Concerning test use, the median number of blood cultures per 1 000 patient-days was 22.8 (IQR: 6.6–49.5) and varied between less than 10 in Lithuania, Hungary, Serbia, Romania, Latvia and Slovakia and more than 50 in UK-Northern Ireland, Belgium, Norway and Finland. The median number of stool tests for CDI per 1 000 patient-days was 3.4 (IQR: 1.3–7.7) and varied between less than two in Lithuania, Latvia, Bulgaria, Estonia, Hungary, France and Slovakia, more than eight in Cyprus, Finland, Ireland, Belgium and more than 10 in the four UK administrations. The latter two indicators of microbiological test use were strongly correlated with each other and with the HAI prevalence. The blood culture use rate explained almost half of the inter-country variation of the HAI prevalence, and this was independent of patient case mix or type of hospitals. Countries using more microbiology found more HAIs.

Participation in HAI surveillance networks (according to ECDC's Healthcare-Associated Infections Surveillance Network [HAI-Net] surveillance targets) was reported by 45% of hospitals for surveillance of surgical site infections (SSI), 34% of hospitals for surveillance of HAIs in intensive care units (ICU) and 46% of hospitals for surveillance of *C. difficile* infections (CDI). Countries in which hospitals reported participation in HAI surveillance networks did not always report data to ECDC. Participation in AMR surveillance networks according to the European Antimicrobial Resistance Surveillance Network (EARS-Net) was reported by 54% hospitals and participation in a network for hospital-based surveillance of antimicrobial consumption was reported by 49% hospitals.

Seven elements of multimodal prevention strategies were collected by the PPS protocol: guidelines, care bundles, training, checklists, audits of prevention practices, surveillance and feedback. Guidelines were the most frequently reported element, both in the ICU and at the hospital-wide level. Checklists and audits were the least frequently reported elements. Prevention of bloodstream infections (healthcare-associated and/or device-associated) was the most targeted type of HAI for prevention strategies, both in the ICU and at the hospital-wide level. There was little hospital-wide activity in pneumonia prevention, despite (yet probably contributing to) the fact that non-ventilator-associated healthcare-associated pneumonia (non-VAP HAP) accounted for 64.0% of HAP and 13.7% of all HAIs.

Furthermore, two indicators measured monitoring and/or audit of hand hygiene practices. The median alcohol-based handrub (AHR) consumption (mostly reported for the year preceding the PPS) was 20.3 litres per 1000 patient-days (IQR: 11.6-34.6), and ranged from 6.4 L/1 000 patient-days in Latvia to 58.7 L/1 000 patient-days in Norway. The median was the lowest in psychiatry wards (4.0 L/1 000 patient-days) and the highest in intensive care units (59.1 L/1 000 patient-days). The second indicator was the number of observed hand hygiene opportunities in the previous year. The median was 3.0 observed opportunities per 1 000 patient-days (IQR: 0-22.4), with 29.2% hospitals not reporting any opportunity observations and 4.4% hospitals reporting more than 100 opportunities per 1 000 patient-days, mainly in Bulgaria (41.7%) and Cyprus (87.5%).

The workload of healthcare workers (HCW) was evaluated by staffing levels of registered nurses and nursing assistants and by bed occupancy. When combining the full-time equivalent (FTEs) of registered nurses and nursing assistants, the median was 108.4 FTE nurses per 100 hospital beds (IQR: 72.9-181.0), ranging from 43.7 in Hungary to 270.6 in UK-England. In intensive care units, the median was 284.3 nurses per 100 ICU beds (IQR: 200.0-405.9) and ranged from 137.0 in Slovakia to more than 500 in Ireland and UK-Scotland. The median bed occupancy measured at midnight on the day of the PPS was 78.1% (IQR: 67.6-86.2) and the median bed occupancy in the previous year calculated from hospital denominator data was 72.5% (IQR: 63.8-80.9). At hospital level, alcohol-based handrub consumption was negatively associated with bed occupancy in the previous year (regression coefficient -0.22, $p<0.001$) and positively associated with nursing staffing levels per 100 beds (regression coefficient 0.07, $p<0.001$).

The hospital environment was evaluated by the availibility of alcohol-based hand rub (AHR) dispensers at the point of care, the number of single rooms and the number of airborne infection isolation rooms. The median percentage of beds with AHR dispenser at the point of care was 52.8% (IQR: 8.6-94.6) and varied between less than 10% in Austria, Hungary, Latvia, Romania and Serbia and more than 90% in Belgium, Ireland, Malta and Spain. Higher availibility of AHR dispensers was significantly associated with a higher consumption of AHR and a lower composite index of AMR at country level. The median percentage of single-room beds was 10.6% (IQR: 4.6-25.8) ranging from less than 5% in Greece, Hungary, Poland, Slovenia and Serbia to more than 50% in France. A higher percentage of single-room beds was also associated with a lower composite index af AMR at country level. The median number of airborne infection isolation rooms was 7.9 per 1 000 hospital beds, and varied between less than one per 1 000 in Croatia and Hungary to 20 per 1 000 hospital beds or more in Estonia, Finland and the Netherlands.

Antimicrobial stewardship consultant FTE was collected separately from IPC doctor FTE. The median was 0.08 FTE per 250 beds (country range: 0–0.60), with 46.7% hospitals not reporting any antimicrobial stewardship consultant worktime. The FTE antimicrobial stewardship consultant was the only indicator measured at hospital or ward level which was significantly associated with indicators measured at antimicrobial use level (e.g. percentage of changed antimicrobials) and with the composite index of AMR, when analysed as a dichotomous variable at hospital level (presence of any FTE antimicrobial stewardship yes/no). At country level, none of the antimicrobial stewardship indicators measured at hospital or ward level (FTE antimicrobial stewardship, presence of post-prescription review procedure, multimodal strategy for antimicrobial use) were significantly associated with indicators measured at antimicrobial use level (e.g. change of antimicrobials during treatment, prolonged surgical prophylaxis, use of broad-spectrum antimicrobials etc.) or with the composite index of AMR. However, indicators measured at hospital/ward level were inter-correlated.

Validation

A total of 28 EU/EEA countries (counting UK administrations separately) and Serbia performed a national validation survey during the PPS in 2016-2017, including a total of 241 validated hospitals and 12 477 validated patient files. On average, 2.3% (country range: 0.3–5.6%) patients who were reported as not having an HAI by the primary PPS data collectors were found to have an HAI by the national validation teams (false negatives). One in five (mean: 20.3%, country range: 0–46.2%) patients reported as having an HAI did not have an HAI according to the national validation team (false positives). This resulted in a mean sensitivity for detecting and reporting a patient with at least one HAI of 69.4% (country range: 40.1–94.4%) and a mean specificity of 98.8% (country range: 96.1-100%). At country level, the HAI prevalence in the primary PPS was significantly associated with the specificity (Spearman's rho -0.62, $p<0.001$), but not with the sensitivity. The mean sensitivity for detecting and reporting a patient receiving at least one antimicrobial was 93.8% (country range: 81.8–100%) and the mean specificity was 98.8% (country range: 96.1–100%), with an average of 3.2% false negatives and 4.4% false positives.

In addition to national validation, an external validation team visited hospitals in 25 countries during their respective national validation studies (as commissioned by the Framework contract ECDC/2016/013). The main findings of these visits included difficulties to evaluate potential HAIs due to a frequent lack of laboratory data (particularly microbiology data) in combination with poorly written patient charts and lack of or illegible notes. Similarly, the quality of patient files complicated the assessment of antimicrobial use variables such as the indication, the reason for change and the start date of the prescribed antimicrobials. As for the structure and process indicators, the external validation teams found most discordant values for the reporting of multimodal strategy elements, mostly over-reporting by the primary PPS data collectors, which may explain some inconsistent results found for `yes/no' variables in the data analysis, in comparison with the numeric indicators.

Thirdly, national validation teams were asked by ECDC to complete a set of 10 case vignettes (randomly selected from a total of 60) prior to the national validation studies. The overall kappa for the presence of an HAI was 0.72 when comparing validators with the gold standard answer proposed by the authors of the case vignettes. Omitting difficult cases, the kappa was 0.86.

Discussion

The 2016-2017 ECDC PPS was the largest European PPS of HAIs and antimicrobial use in acute care hospitals to-date despite the non-participation of two EU/EEA countries (Denmark and Sweden). As it was paralleled by an unprecedented validation effort and because of the better representativeness of the PPS sample as a whole, it allowed for calculation of the most robust estimates of the annual number of HAIs at EU/EEA level to-date.

Results confirmed that HAIs, and AMR in bacteria responsible for HAIs, represent a significant public health challenge for the EU/EEA, with a total estimated number of 3.8 million patients acquiring at least one HAI per year in 2016-2017 in EU/EEA acute care hospitals. Overall results for the EU/EEA for HAIs and antimicrobial use were similar to the first ECDC PPS in 2011-2012, even though at individual country level important differences were observed. Further analysis should be performed to assess changes between the two surveys considering differences in patient case mix.

Despite the validation studies and advanced risk adjustment, the 2016-2017 ECDC PPS did not allow for improvement of the comparability of HAI prevalence between countries. However, with important implications for all stakeholders, it identified key reasons why HAI prevalence cannot be compared between EU/EEA Member States. The most important reason was (and is) the wide variability of microbiological testing use rates across countries – possibly also reflecting diagnostic testing barriers and opportunities as a whole – which explained almost half of the variation of the HAI prevalence between countries. Indeed, when test results are missing, some HAIs will frequently not match case definitions and consequently, will not be reported. This problem was also confirmed by the findings of some of the national validation teams and of the external validation team. Therefore, urgent attention should be given at national and European level to harmonised diagnostic stewardship, in particular for optimal use of microbiology testing for infectious disease management. Secondly, as expected, validation surveys showed wide variability in sensitivity and specificity of reporting HAIs by hospital PPS staff across countries, obviously influencing the reported HAI prevalence. However, because of limited validation sample sizes in two thirds of the countries, validation results could only be used to correct HAI prevalence at EU/EEA level, not at country level. Improving the performance of the hospital PPS staff in terms of validity requires further training in the PPS methodology, in particular of HAI case definitions. For future comparison of HAI prevalence between countries, a standardised indicator of HAI prevalence, adjusting for the frequency of diagnostic testing, results from nationally representative validation studies and differences in patient case mix should be considered.

The composite index of AMR in HAIs at country level appeared to be a more robust indicator than the HAI prevalence, as shown by 1) an excellent correlation between data from the ECDC PPS and EARS-Net surveillance of antimicrobial resistance, 2) a lesser dependence on the frequency of microbiological testing and 3) consistent correlations with the prevalence of antimicrobial use, other indicators of rational antimicrobial use measured at antimicrobial level (e.g. the percentage of antimicrobials changed during treatment), staffing levels of infection prevention and control nurses, alcohol-based handrub consumption (or the percentage of beds with AHR dispensers) and isolation capacity as measured by the percentage of single-room beds.

Antimicrobial use data collected in the PPS showed good validity and identified several areas for targeted improvement of antimicrobial use in several European countries including: reducing the use of broad-spectrum antimicrobials, adherence to

single-dose surgical prophylaxis, reducing medical prophylaxis, targeting change from parenteral to oral administration of antibiotics, and improving the documentation of the reason for antimicrobial prescribing in the patient's records.

The 2016-2017 PPS also provided a detailed picture of the organisation and performance of infection prevention and control and antimicrobial stewardship in European acute care hospitals, showing large variability in the implementation of the core components of IPC and antimicrobial stewardship programmes, with 7-to-54-fold differences between countries with the lowest and the highest mean values: microbiological testing (blood cultures 39×, stool testing 54×), IPC staffing levels (nurses 9×, doctors 23×), staffing levels for antimicrobial stewardship consultants (37×), staffing levels of nurses and nursing assistants (7×), alcohol-based handrub consumption (7×), percentage of beds with AHR dispensers (13×) and percentage of beds in single rooms (24×). Structure and process indicators were often inter-correlated, showing that hospitals and countries investing in one area often perform better in the other. Further adjustments to the structure and process indicators developed for the ECDC PPS are needed, replacing or complementing indicators measuring the simple presence of structures or practices (`yes/no/unknown' indicators) by more objective and informative numeric indicators wherever possible.

Continued prevention of HAIs and antimicrobial resistance in European acute care hospitals requires the continued implementation of existing recommendations and guidelines. Specific major recommendations from the findings of the 2016-2017 ECDC PPS are formulated, as follows:

- an urgent need to harmonise diagnostic stewardship and improve access to microbiological diagnostic testing in EU/EEA hospitals;
- increasing IPC nurse staffing levels to (ideally) one IPC nurse per 100 occupied beds;
- installing AHR dispensers at the point of care;
- ensuring adequate nursing staffing levels in accordance with workload to improve hand hygiene compliance;
- increasing the percentage of single rooms to improve isolation capacity;
- increasing post-prescription review of antimicrobial treatment, de-escalating when possible;
- ensuring training, dedicated skilled personnel and time for antimicrobial stewardship consultancy.

Background and objectives

In 2008, ECDC estimated that approximately 4.1 million patients acquire a healthcare-associated infection (HAI) each year in European acute care hospitals and that 37 000 of these patients die as a direct consequence of their infection [1]. This estimate was based on a review of 30 national or multicentre point prevalence surveys (PPSs) of HAIs in 19 countries that was conducted between 1996 and 2007, and showed an average HAI prevalence of 7.1%. However, major methodological differences between the surveys made cross-country comparison impossible [4] and emphasised the need for a standardised methodology to estimate and monitor the complete HAI disease burden in Europe.

ECDC subsequently developed a protocol for PPSs of HAIs and antimicrobial use in acute care hospitals through seven expert meetings organised from 2009 to 2011. More than 100 experts and representatives from all EU Member States, two EEA countries, four EU enlargement countries, international partners (the European Society of Intensive Care Medicine, WHO Regional Office for Europe, the United States Centers for Disease Control and Prevention (CDC)), ESAC and ECDC contributed to the development of the protocol. It was agreed that national PPSs should be conducted at least once every five years. The first ECDC PPS was conducted in 2011–2012 (version 4.2 and 4.3 of the protocol, see [5]) and estimated the number of patients acquiring an HAI each year in EU/EEA acute care hospitals in 2011–2012 at 3.2 million [6]. A study using the data of the 2011-2012 PPS estimated the number of deaths attributable to six main types of HAIs (healthcare-associated pneumonia, urinary tract infection, surgical site infection, *Clostridioides difficile* infection, neonatal sepsis and primary bloodstream infection) at 91 000 deaths per year in 2011-2012 [7].

For the second EU-wide point prevalence survey in 2016–2017, the protocol was adapted during six meetings organised at ECDC from 2013 to 2015. The new protocol further supported the implementation of Council Recommendation 2009/C 151/01 [8] by including more structure and process indicators for the prevention of HAIs and antimicrobial resistance (AMR) in acute care hospitals, based on a systematic review of such indicators performed upon ECDC's request [9]. Indicators for antimicrobial stewardship were added as well, based on a consensus process carried out by a working group of the Transatlantic Taskforce on Antimicrobial Resistance (TATFAR) [10].

The objectives of the second ECDC PPS of HAIs and antimicrobial use in acute care hospitals were:

- to estimate the total burden (prevalence) of HAIs and antimicrobial use in acute care hospitals in the EU;
- to describe HAIs (sites, microorganisms including markers of antimicrobial resistance) and antimicrobials prescribed (compounds, indications)
  - by type of patients, specialties or healthcare facilities; and
  - by EU country, adjusted or stratified;
- to describe key structures and processes for the prevention of HAIs and antimicrobial resistance at the hospital and ward level in EU hospitals;
- to disseminate results to policy makers and practitioners at local, regional, national and EU levels in order to:
  - raise awareness;
  - train and reinforce surveillance structures and skills;
  - identify common EU problems and set up priorities accordingly; and
  - evaluate the effect of strategies and to inform future local/regional/national policies (repeated PPS);
- to provide a standardised tool for hospitals to identify targets for quality improvement.

Methodology

Participation

National PPS contact points in EU Member States, Iceland, Norway and EU candidate and potential candidate countries were invited to organise a PPS in their countries based on the ECDC PPS protocol during one of four suggested periods. The four periods (April to June or September to November of 2016 or 2017) were selected to fall outside the winter period (higher antimicrobial use) and summer holidays (lower staffing). National contact points for the ECDC PPS were nominated operational contact points for the HAI-Net PPS and/or the nominated national focal points for HAIs. Countries were asked to confirm participation in one of the above-mentioned periods. EU Member States declining participation (Denmark and Sweden) were repeatedly contacted by ECDC, offering customised participation options agreed with the HAI-Net Disease Network Coordination Committee (DNCC), but without success. For Norway, the HAI-Net DNCC accepted the Norwegian proposal to participate using the national PPS protocol, while optionally adding elements of the ECDC PPS protocol (see below). EU candidate and potential candidate countries were invited in the framework of the Instrument for Pre-Accession Assistance (IPA) - 4 project funded by the European Commission. Representatives of the seven IPA-4 countries (Albania, Bosnia and Herzegovina, Kosovo, Montenegro, Serbia, North Macedonia and Turkey) were invited to (and attended) three ECDC PPS protocol meetings in 2015 (February, October) and 2016 (May). In addition, a special TESSy training was organised for data managers of these countries in May 2016 in Belgrade, Serbia as well as a PPS training (including PPS software training) for the designated PPS contact points of these countries in October 2016 in Porec, Croatia. Despite these efforts, only one country (Serbia) participated in the ECDC PPS in 2017.

Data for the United Kingdom were collected independently by the four UK administrations. For this reason, and on the request of the overall surveillance coordination of the United Kingdom, data are reported separately for UK-England, UK-Northern Ireland, UK-Scotland and UK-Wales in this report. The total of different PPS data sources was therefore 32. For simplicity, the term 'country' is used for the four UK administrations throughout the report.

Protocol

The final ECDC PPS protocol used for the second EU-wide PPS (version 5.1) was distributed to Member States on 15 January 2016. It was also available for staff members of the national PPS coordinating centres on a protected website (ECDC's HAI-Net Extranet), together with training material, software and a questions and answers section. A minor update of the protocol (version 5.2) was published together with the updated HelicsWin.Net software on 5 May 2016. Finally, the edited version 5.3 was published on ECDC's website in October 2016 [11]. We refer to the latter document for methodological details.

As in 2011-2012, the protocol offered two options for data collection of denominators: a patient-based data collection (referred to as the standard option) and a less labour-intensive unit-based data collection (light option). According to the standard option, demographic and risk factor data had to be collected for every inpatient, also for those without an HAI or not receiving any antimicrobial. According to the light protocol option, denominator data were to be aggregated at the ward level and, within each ward, for each patient/consultant specialty (specialty of the main disease of the patient or of the consulting physician in charge of the patients, depending on what was the usual practice for this variable at the hospital or country level). Both protocol versions used the same inclusion criteria, assumed the same case finding process and were used to collect exactly the same information on HAI, antimicrobial use and structure and process indicators at hospital and ward level. Results for both protocol options are therefore reported combined, except for the analysis of patient risk factors which was only possible for data collected using the patient-based protocol.

Sampling of hospitals

Countries were recommended to draw a representative sample of acute care hospitals applying systematic random sampling to the national list of hospitals, ranked according to hospital type and size. In the absence of a European definition of an acute care hospital, national definitions were allowed. The required sample size per country was calculated for an estimated HAI prevalence of 6% with a precision of +/-1%. This resulted in a sample size of 8 000 to 22 000 patients in 25 to 60 hospitals, depending on the average hospital size in the country and the estimated design effect resulting from clustering of HAIs within hospitals (see protocol). Countries with fewer than 25 hospitals were recommended to include all hospitals. Countries had the possibility to submit more than the recommended number of hospitals to ECDC, but were then asked to indicate for each hospital whether it belonged to the representative national sample or not. Submission of more hospitals was preferred by several countries because ECDC offered complete national data analysis and individual hospital feedback reports to the national PPS coordinators.

For the European analysis in this report, however, hospitals not belonging to the national representative sample were excluded to avoid over-representation of countries (Hungary, Italy, Poland, Portugal, Spain and UK-England).

The sample representativeness was evaluated and categorised in four levels (optimal, good, poor and very poor) depending on compliance with the recommended sampling methodology, as follows:

Optimal:

- systematic random sample of 25–60 hospitals (depending on hospital size in the country) and inclusion of at least 75% of these hospitals;
- inclusion of ≥75% of all acute care hospitals or occupied acute care hospital beds in the country, and recommended sample size achieved.

Good:

- selection of at least 25 hospitals or at least 75% of the recommended number of hospitals and/or patients using another sampling methodology (e.g. voluntary participation);
- recommended sample size not achieved, but inclusion of ≥75% of all acute care hospitals or occupied acute care hospital beds in the country.

Poor:

- between five and 25 hospitals included in countries with more than 25 acute care hospitals and required sample size not achieved;
- less than five hospitals included in countries with more than five acute care hospitals but inclusion of 50–75% of all acute care hospitals or occupied acute care hospital beds in the country.

Very poor:

- inclusion of less than five hospitals and less than 50% of all acute care hospitals and less than 50% of all occupied acute care hospital beds.

Within a participating hospital, all eligible patients had to be included. Sampling of patients was not included as a methodological option because this would have increased the required number of hospitals and would have affected the usefulness of the data at the hospital level.

Inclusion criteria

All acute care hospitals were eligible for inclusion. An acute care hospital was defined in accordance with national definitions. There was no minimal size of hospitals. All wards in acute care facilities were included, except for accident and emergency departments. However, unlike in the first ECDC PPS in 2011-2012, long-term-care wards located in acute care hospitals were included in 2016-2017.

All patients admitted to the ward before 8:00 am on the day of the survey and not discharged from the ward at the time of the survey were included. Neonates on maternity and paediatric wards were included if born before/at 8 am. Day cases were excluded, i.e.

- patients undergoing same-day treatment or surgery;
- patients seen at outpatient department;
- patients in the emergency room;
- dialysis patients (outpatients).

Data levels and definitions

Data were collected at national, hospital, ward and patient level (for the latter, including infection and antimicrobial use data, if any) on standardised data collection forms (questionnaires).

Hospital data

The hospital questionnaire was used to collect data on the type and size (number of beds) of the hospital, hospital ownership, hospital statistics (number of patient-days and discharges in the preceding year) as well as structure and process indicators for infection prevention and control and antimicrobial stewardship (see below).

Four hospital type categories (primary, secondary, tertiary and specialised) were defined as follows:

1. Primary

- Often referred to as 'district hospital' or 'first-level referral'.
- Few specialties (mainly internal medicine, obstetrics–gynaecology, paediatrics, general surgery or only general practice).
- Limited laboratory services are available for general, but not for specialised pathological analysis.
- Often corresponds to general hospital without teaching function.

2. Secondary

- Often referred to as 'provincial hospital'.
- Hospital is highly differentiated by function with five to ten clinical specialties, such as haematology, oncology, nephrology, ICU.
- Takes some referrals from other (primary) hospitals.
- Often corresponds to general hospital with teaching function.

3. Tertiary

- Often referred to as 'central', 'regional' or 'tertiary-level' hospital.
- Highly specialised staff and technical equipment (ICU, haematology, transplantation, cardio-thoracic surgery, neurosurgery).
- Clinical services are highly differentiated by function.
- Specialised imaging units.
- Provides regional services and regularly takes referrals from other (primary and secondary) hospitals.
- Often a university hospital or associated with a university.

4. Specialised hospital

- Single clinical specialty, possibly with sub-specialties.
- Highly specialised staff and technical equipment.

Hospital ownership was defined as follows:

- Public: Hospitals that are owned or controlled by a government unit or a public corporation (where control is defined as the ability to determine the general corporate policy).
- Private, not-for-profit: Hospitals that are legal or social entities created for the purpose of producing goods and services, whose status does not permit them to be a source of income, profit, or other financial gain for the unit(s) that establish, control or finance them.
- Private, for-profit: Hospitals that are legal entities set up for the purpose of producing goods and services and are capable of generating a profit or other financial gain for their owners.
- Other or unknown: Hospital ownership cannot be categorised as one of one of the above, or hospital ownership is unknown.

Ward data

Data collected at the ward level included the ward code, main ward specialty, ward survey date and aggregated denominators (number of eligible patients present on the ward) for the total ward and for each consultant/patient specialty. Unlike the first ECDC PPS, only broad specialty categories were used to describe ward specialty in the 2016-2017 PPS: surgery, medicine, intensive care, paediatrics, neonatology, gynaecology/obstetrics, geriatrics, psychiatry, rehabilitation, long-term care, mixed specialties and other specialties. The main ward specialty was defined as the specialty of at least 80% of the patients on the ward. If fewer than 80% of patients belonged to the same specialty, the ward specialty had to be reported as 'mixed'. Collection of aggregated denominator data was only required for hospitals using the light protocol option. Some of the structure and process indicator data were preferentially collected at ward level (see below). However, countries and/or hospitals could also choose to collect these indicators at hospital-level.

Patient data

In the standard protocol option, patient data were collected for all patients with or without HAI or antimicrobials. Collected variables were age, gender, date of hospital admission, consultant/patient specialty, surgery since admission, the McCabe severity of underlying illness score [12], presence of invasive devices and code of the current ward. If ward-level data were not collected in the standard option, then the ward specialty and ward survey date needed to be collected at patient level as well.

Patient data in the light protocol were collected only for patients with an HAI and/or receiving antimicrobials and were limited to the consultant/patient specialty, age, gender and date of admission.

HAI data

Healthcare-associated infection (HAI) data included the type of HAI corresponding to one of the HAI case definitions, the origin of HAI (current hospital, other hospital or other/unknown), association of the HAI with the current ward, the date of onset if the HAI was not present on admission, the presence of invasive devices in the 48 hours before onset of the HAI (for pneumonia, urinary tract infections and bloodstream infections), isolated microorganisms and selected antimicrobial resistance data.

European HAI case definitions were used that had been previously developed by HELICS or other European projects [13-16]. Otherwise, case definitions from the National Healthcare Safety Network (NHSN, formerly NNIS) at the United States Centers for Disease Control and Prevention (CDC) were used [17]. The HAI case definitions for surgical site infection (SSI), pneumonia (PN), *Clostridioides difficile* infection (GI-CDI) and clinical sepsis in children and adults (SYS-CSEP) underwent minor changes compared to the 2011-2012 ECDC PPS (details see protocol [11]). The updated case definitions were also published as Commission Implementing Decision under the EU legislation on communicable diseases [18].

For the purposes of the ECDC PPS protocol, an infection was defined as active on the day of the survey when:

1. signs and symptoms were present on the date of the survey;
OR
2. signs and symptoms were no longer present, but the patient was still receiving treatment for that infection on the date of the survey. In this case, the symptoms and signs occurring from the start of treatment until the date of the survey were checked to ascertain that the infection matched one of the type-specific HAI case definitions.

An active infection was defined as healthcare-associated (associated with acute care hospital stay only, for the purpose of this protocol) when:

1. the onset of the signs and symptoms was on Day 3 of the current admission or later (with Day 1 being the day of admission);
OR
2. the signs and symptoms were present on admission or became apparent before Day 3, but the patient had been discharged from an acute care hospital less than two days before admission;
OR
3. the signs and symptoms of an active surgical site infection were present on admission or started before Day 3, and the surgical site infection occurred within 30 days of a surgical intervention (or in the case of surgery involving an implant, a deep or organ/space surgical site infection that developed within 90 days of the intervention);
OR
4. the signs and symptoms of a *C. difficile* infection were present on admission or started before Day 3, with the patient having been discharged from an acute care hospital less than 28 days before the current admission.

In the HAI section, data on microorganisms and the respective resistant phenotype were collected. Only results that were already available at the time of the survey were included.

Antimicrobial use data

Data on antimicrobial use included the antimicrobial agent, the route of administration, the indication for antimicrobial use, the site of diagnosis for treatment intention of an infection (e.g. respiratory tract), the start date of the treatment and of the current antimicrobial, whether there had been a change in prescribed antimicrobials during the treatment course (and, if so, why, e.g. de-escalation) and whether the reason for prescribing the antimicrobial agent was documented in the patient's charts or not. For data on treatment intention, the aim was to record what the physicians or other prescribers thought they were treating. To do so, it was recommended to check all patient records and to request additional information from doctors, nurses or pharmacists if needed. The appropriateness of prescriptions was not to be discussed and suspected or confirmed infections for which a treatment was prescribed did not need to match any case definition.

The Anatomical Therapeutic Chemical (ATC) classification system of the World Health Organization Collaborating Centre for Drug Statistics Methodology was used to classify antimicrobial agents [19]. Antimicrobial agents for systemic use within the following ATC groups were included: intestinal anti-infectives (A07AA), dermatological antifungals for systemic use (D01BA), antibacterials for systemic use (J01), antimycotics for systemic use (J02), antimycobacterials used as second-line treatment of e.g. MRSA infections or for treatment of mycobacterial infections other than tuberculosis (MOTT) (within ATC group J04) and nitroimidazole-derived antiprotozoals (P01AB) were included. Antiviral agents and antimicrobials for the treatment of tuberculosis were not included.

National data

The national questionnaire was used to collect data on the method used for sampling hospitals, the number of acute care hospitals (both the total number for the country and the number included in the PPS), the previous year's aggregated hospital statistics for all acute care hospitals in the country (total number of beds, discharges and patient-days), for all beds and for acute care beds only. When national denominator data were missing, available data from Eurostat were used [20]. When Eurostat data were missing or incomplete, data from the 2011-2012 ECDC PPS were used.

An additional national questionnaire was sent to collect data on the coordination of the national PPS, the training provided to participating hospitals and the software tools used. Responses to this additional national questionnaire were received from all 32 countries.

Structure and process indicators

Infection prevention and control indicators

The main change to the protocol for the second ECDC PPS in 2016-2017 was the inclusion of additional structure and process indicators for the prevention of HAIs and antimicrobial resistance (AMR). Indicators were developed by ECDC and European country experts during seven teleconferences and five meetings from 2013 to 2015, based on ten key components for hospital IPC programmes proposed by Zingg et al. [9], who performed a systematic review as part of the ECDC contract ECDC/10/026 'Systematic review and evidence-based guidance on organisation of hospital infection control programmes' (SIGHT project, 2010). In 2016, after an update of the systematic review, and including only studies using a quantitative methodology (excluding qualitative research), WHO proposed eight core components in its `Guidelines on core components of infection prevention and control programmes at the national and acute health care facility level' [21]. As the WHO core components were similar to the SIGHT key components, the indicators developed for the second ECDC PPS could be mapped to the WHO core components and were reported accordingly in the current report (Table 1). It should be noted that the ECDC PPS indicators developed in 2013-2015 are different from the variables/indicators published by WHO in 2018 in the self-assessment tool `Infection prevention and control assessment framework at the facility level' (IPCAF, [22]). For the ECDC protocol, numeric indicators were preferred over categorical `yes/no' indicators when possible, as numeric indicators provide more detailed information to show differences between hospitals and countries, and between repeated measurements over time.

Table 1. ECDC PPS indicators of infection prevention and control at hospital level by WHO core components of IPC programmes at acute healthcare facility level

WHO Core Component		Description[1]	ECDC PPS hospital indicators
1	Infection prevention and control programmes	An effective infection control programme in an acute care hospital must include at least: one full-time specifically trained IC-nurse ≤ 250 beds; a dedicated physician trained infection control; microbiological support; data management support	- FTE IPC nurses and doctors - Approved IPC plan and report - Number of blood culture sets, stool tests for CDI - Microbiology services during weekends
2	IPC guidelines	Evidence-based guidelines combined with education and training of relevant health care workers and monitoring of adherence with guideline	Presence of guidelines, audit and checklist for prevention of PN, BSI, UTI, SSI and for antimicrobial stewardship (as part of multimodal strategy, in ICU and hospital-wide)
3	IPC education and training	IPC education and training involves frontline staff, and is team- and task-oriented	Presence of training in prevention of PN, BSI, UTI, SSI and antimicrobial stewardship (as part of multimodal strategy, ICU and hospital-wide)
4	Surveillance	Participating in prospective surveillance and offering active feedback, preferably as part of a network	- Participation in networks for the surveillance of HAIs in the ICU, surveillance of SSIs, CDIs, AMR and AMC - Surveillance as part of multimodal strategy
5	Multimodal strategies	Implementing infection control programmes follow a multimodal strategy including tools such as bundles and checklists developed by multidisciplinary teams and taking into account local conditions	Presence of guidelines, bundle, training, checklist, audit, surveillance and feedback for prevention of PN, BSI, UTI, SSI and for antimicrobial stewardship
6	Monitoring/audit of IPC practices and feedback	Organising audits as a standardized (scored) and systematic review of practice with timely feedback	- Number of hand hygiene observations - Alcohol-based handrub consumption - Audit and feedback as part of multimodal strategy
7	Workload, staffing and bed occupancy	To make sure that the ward occupancy does not exceed the capacity for which it is designed and staffed; staffing and workload of frontline health-care workers must be adapted to acuity of care; and the number of pool/agency nurses and physicians minimised	- Bed occupancy at midnight - FTE registered nurses, hospital-wide and ICU - FTE nursing assistants, hospital-wide and ICU
8	Built environment, materials and equipment for IPC at the facility level	Sufficient availability of and easy access to material and equipment and optimized ergonomics; adequate number of single rooms (preferably with private toilet facilities) and/or rooms suitable for patient cohorting for the isolation of suspected /infected patients, including those with TB and multidrug-resistant organisms, to prevent transmission to other patients, staff and visitors	- Alcohol-based handrub dispensers at point of care; carriage of AHR bottles by health-care workers - Number of single rooms - Number of single rooms with toilet and shower - Number of airborne infection isolation rooms

[1]*Adapted from reference [21]; IPC: Infection Prevention and Control; IC: Infection Control; ICU: Intensive Care Unit; FTE: full-time equivalent; CDI:* C. difficile *infection; BSI: bloodstream infection; PN: pneumonia; SSI: surgical site infection; UTI: urinary tract infection; AMR: antimicrobial resistance; AMC: antimicrobial consumption.*

Antimicrobial stewardship indicators

Indicators of antimicrobial stewardship were based on a consensus process carried out by a working group of the Transatlantic Taskforce on Antimicrobial Resistance (TATFAR) [10]. Indicators for which data were collected at hospital or ward level included the number of full-time equivalent antimicrobial stewardship consultants and the presence of a formal procedure to review the appropriateness of an antimicrobial within 72 hours (three calendar days) from the initial order (post-prescription review), participation in a national or regional hospital antimicrobial consumption surveillance network and the presence of a multimodal strategy for antimicrobial stewardship at hospital-wide and ICU level. Indicators measured at the patient-antimicrobial level included prolonged surgical prophylaxis and change of prescribed antimicrobial(s) during treatment.

Hospital- and ward-level indicator data collection

For some of the indicators, data was recommended to be collected at ward level, as the information is more readily available at ward level rather than at the hospital-wide level. These indicators were alcohol-based handrub consumption, number of hand hygiene opportunities observed during the last year, number of alcohol-based handrub dispensers at the point of care, number of healthcare workers carrying alcohol-based handrub bottles, number of single rooms, number of single rooms with toilet and shower, number of beds occupied at midnight and presence of a formal procedure for post-prescription review of antimicrobials.

However, countries or hospitals also had the option to collect these indicators at the hospital-wide level (form H3 in the protocol [11]). When information was collected both at ward and at hospital level, information collected at ward level was prioritised over information collected at the hospital-wide level in the current report.

Data collection and processing

The protocol recommended that all data from any given ward should be collected on a single day. The total time frame for data collection for all wards of a single hospital was recommended not to exceed three weeks.

Data on wards, patients, HAIs and antimicrobial use were retrieved from patient charts in the hospital wards and/or other sources of information available in the hospital (e.g. hospital information system, laboratory database) using standardised data collection forms.

The number and type of healthcare workers involved in the data collection were not assessed. However, they were previously assessed during the pilot PPS study carried out before the first ECDC PPS in 2011-2012. Healthcare workers involved in PPS data collection were – in decreasing order of frequency – infection prevention and control staff, ward nurses and physicians, infectious disease physicians, medical specialist trainees, microbiologists, pharmacists and other hospital staff [23]. In some countries, national or regional PPS coordination staff also participated in the data collection process.

To facilitate data entry at hospital level, ECDC developed and provided an updated version of the standalone software HelicsWin.Net which allowed hospitals to enter and validate their PPS data, and to export them in different formats, including the format required to upload data in ECDC's TESSy system [24]. Hospitals using HelicsWin.Net were asked to send the export files to the national PPS coordination centre. Export files did not contain any personal identifiers. Hospital data files were uploaded in TESSy by the national centre. National data were collected by the national coordinators and submitted separately to TESSy.

The ECDC software HelicsWin.Net was used by 19 (59.3%) countries (Belgium, Bulgaria, Croatia, Cyprus, Czechia, Estonia, Finland, Greece, Iceland, Italy, Latvia, Luxembourg, Malta, Norway, Poland, Portugal, Romania, Serbia, Slovakia). Eleven (34.4%) countries (Austria, France, Germany, Hungary, Ireland, the Netherlands, Norway, Spain, UK-England, UK-Northern Ireland, UK-Wales) used a national web-based system, one country (UK-Scotland) used a system based on optical character recognition (OCR), and two countries (Lithuania, Slovenia) used a national standalone application. Norway used a national web-based system for the national PPS data and HelicsWin.Net for the indicator data. Regardless of the data entry tool applied, national data had to be submitted in TESSy format.

In 21 (65.6%) countries, all data were entered by the hospital staff. In seven countries (Estonia, Latvia, Lithuania, Norway, Romania, Serbia and Slovakia), data were entered both at the hospital level and at the regional or national level. Finally, in four countries (Finland, Malta, Slovenia and UK-Scotland), all data were entered at the level of the national or regional PPS coordination centres.

Data quality reports were available in TESSy after upload. In addition, detailed reports by hospital were produced by ECDC using Stata v14.1 (StataCorp. 2015. *Stata Statistical Software: Release 14*. College Station, TX: StataCorp LP) and Excel v2013 (Microsoft. Microsoft Excel 2013, Redmond, Washington) and sent to the national PPS coordinators within two weeks after data submission (except for a longer delay for the first countries submitting data), together with the national results. These Excel reports were produced for all submitted data, even for hospitals that did not belong to the national representative sample. Unmodified or modified ECDC reports were sent back to participating hospitals by 68% of the countries, while 32% sent a nationally produced hospital feedback.

Preliminary European results were presented to national PPS coordination staff at a meeting organised at ECDC in March 2018 and during the Joint annual meeting of the Antimicrobial Resistance and Healthcare-Associated Infections (ARHAI) Networks organised in Copenhagen, Denmark, June 2018. When needed, countries re-uploaded corrected data in TESSy, e.g. because of errors detected in the feedback reports provided by ECDC or because the comparative analysis of country results presented at the ARHAI meeting revealed errors that were not detected before.

National PPS protocols and tools

Most (75%) countries used an unmodified version of the ECDC PPS protocol version 5.2 or version 5.3. The collection of structure and process indicators at ward level was optional and could be replaced by aggregated collection of `ward' indicators at hospital level (form H3 in the protocol). Finland, France, Greece, Hungary, the Netherlands, Norway and Spain only used the H3 form and did not collect indicators at ward level. Czechia did not collect ward-level indicators at all, neither at ward nor at hospital level.

Norway used a national protocol with aggregated denominator data, using the same case definitions as in the ECDC protocols, but only including the most frequent types of HAI (respiratory tract, urinary tract, surgical site, bloodstream infections). In addition, HAI data were collected in an aggregated manner, which had a large impact on available HAI data: HAI codes were only detailed at group level (e.g. respiratory infections, not differentiating between pneumonia or lower respiratory tract infections); the date of HAI onset, presence of HAI on admission, association of the HAI with the current ward, microorganisms and AST data were not collected.

The origin of BSI only specified primary BSI versus secondary BSI, without further details. Types of HAI for which data collection was not mandatory in the Norwegian protocol were still collected by 19 of the 43 participating Norwegian hospitals. For the remaining 24 hospitals, missing types of HAI were imputed based on the relative frequency of these types of HAI in the

19 Norwegian hospitals that did collect the data. After conversion of the Norwegian aggregated HAI data to case-based data in TESSy format, 36 HAIs out of a total of 495 HAIs were imputed at case level (i.e. patient level). As antimicrobial use data in the Norwegian protocol were case-based, patients receiving antimicrobials for `treatment of hospital infection' with a diagnosis site which was compatible with the HAI that had to be imputed, were prioritised. Imputation further took into account the specialty (e.g. gynaecology and obstetrics for reproductive tract infections), age and gender of the patient and the size of the ward/hospital. Most other HAI records were also matched to patients receiving antimicrobial use based on the indication and the site of diagnosis. Antimicrobial use data in the Norwegian protocol included all variables of the ECDC PPS protocol except the start date and data about change of the prescription. Structure and process indicators at hospital level were added optionally in the Norwegian protocol and data were collected by 24 hospitals, as per ECDC PPS protocol. Ward-level data were not included.

France, the Netherlands and Spain used an adapted version of the (previous) national PPS protocol.

In France, the national protocol covered not only acute care hospitals, but also rehabilitation, long-term care and home care. Nevertheless, the hospital sample submitted to ECDC only included acute care hospitals. France also included HAIs with examination results available after the survey. In the French protocol, antimicrobial susceptibility data were collected according to the PPS-1 method, i.e. non-susceptibility was recorded without differentiating between intermediate and resistant. The national protocol in France also did not include all structure and process indicators of the ECDC PPS protocol.

Greece used the first ECDC PPS protocol (version 4.2) as a main protocol. Data on antimicrobial stewardship indicators were collected separately after the PPS. Other indicators and new variables of the second PPS were only collected by hospitals participating in the national validation study, but they were not submitted as part of the final national database.

Germany also included HAIs on admission imported from long-term care facilities. In Hungary, the ECDC PPS protocol was adapted by excluding the light option and ward-level indicators, and by allowing the collection of any type of antimicrobial resistance for any microorganism. Nevertheless, antimicrobial resistance data as per the original ECDC PPS protocol were submitted to TESSy.

In the Netherlands, the compatibility of the national protocol improved considerably compared to the first ECDC PPS. Antimicrobial susceptibility data and data on HAIs present on admission were collected for the second ECDC PPS. Structure and process indicators were optional and were only collected by a small number of hospitals.

Spain also adapted the national protocol, keeping additional variables (not submitted to ECDC) such as infection data on community-acquired infections. However, there were no discrepancies in the Spanish protocol for the variables included in the ECDC protocol.

Other minor differences in national protocols were the following:

- Lithuania: non-inclusion of bed occupancy at midnight; access to microbiology during weekends: no differentiation between clinical and screening tests;
- UK-England: non-inclusion of multimodal strategies in intensive care units;
- UK-Scotland: non-inclusion of antimicrobial resistance data;
- UK-Wales: non-inclusion of the indicators hand hygiene opportunities, AHR dispensers at the point of care and healthcare workers carrying AHR bottles.

Training

Training of hospital staff in the methodology of the ECDC PPS was considered a priority throughout the development of the protocol and the preparation of the EU-wide PPS. The training curriculum for a one-day course for participating hospitals developed in 2010 [25] was adapted to the new protocol and discussed during a train-the-trainer workshop organised at ECDC in October 2015 with national PPS coordination staff in order to optimise consistency of national training courses across Europe. Training materials (presentation slides and case studies) were made available in English on the ECDC HAI-Net Extranet (a password-protected communication platform for national PPS coordinating teams) and on the ECDC Virtual Academy (EVA) platform after external review [26]. In addition, a list with frequently asked questions (FAQ) and ECDC answers was kept updated on the ECDC HAI-Net Extranet and distributed by email by ECDC. The last update of the FAQ list (before the last PPS wave of September-November 2017) contained 87 questions.

All countries organised at least one training course for participating hospital staff. On average, five courses were organised per country (median three courses) with a mean duration of 6.7 hours (median six hours) per course. The mean number of hospital staff trained during the PPS courses was 175 participants per country (median 94, range 20–850) from on average 70 hospitals (median 42, range 2–500). The total number of hospital staff trained in the participating countries by the national PPS coordinating teams for the purpose of the 2016-2017 ECDC PPS was estimated at 5 584 people.

Validation of PPS data

National validation studies

Validation of PPS data was done by national validation teams visiting a subset of participating hospitals and re-examining a sample of patient files included in the national (primary) PPS according to an ECDC PPS validation protocol [27]. The protocol was slightly adapted from the validation protocol used in 2012 [6], which was itself based on the findings of a pilot validation project carried out in 2011 [28]. The main objective of the validation PPS was to estimate the sensitivity and specificity of the primary PPS at EU/EEA level, based on the number of false-negative and false-positive patients with an HAI or antimicrobial use. Validation teams consisted of members of the national PPS coordination centre, possibly complemented by additional experts trained by the coordination centre for this purpose, and applied the ECDC PPS protocol, with special emphasis on HAI case definitions, as precisely as possible (gold standard).

All PPS coordinating centres were invited to perform national validation of the primary PPS data against a modest financial support (10 000 EUR per country) provided by ECDC to support the organisation of the national validation studies. The minimal requirement for the sample size was set to re-examining the files of 250 patients in five hospitals per country. The objective was to obtain a representative validation sample at EU/EEA level, in order to assess the percentage false positives and false negatives and to correct the estimated prevalence at EU/EEA level. The recommended sample size for national representativeness of the validation sample was 750 patients in 25 hospitals, to detect a sensitivity of 80% with a precision of 10%, assuming HAI prevalence of 7%. All countries participating in the PPS except Cyprus, Norway and Slovenia performed a validation study. Slovakia and Serbia performed a validation study without support contract. Portugal performed the largest validation study with re-examination of 2 172 patient files in 26 hospitals.

The recommended validation method was:

- validation on the same day of primary PPS, so that the availability of data was as similar as possible between the primary PPS and the validation PPS;
- blinded, meaning no communication between the primary PPS staff and the national validation team regarding individual patient results, so that validation teams were not influenced by the judgement of the primary team and that primary PPS results would not be 'corrected' according to the findings of the validation team;
- prioritise high-prevalence wards to increase the precision of the estimates (higher number of expected HAIs).

It was recommended to include all patients present on the wards that were selected for the validation. This exhaustive inclusion of all patients on a selected ward was mandatory for countries performing the primary PPS using the light option of the protocol because matching patients at individual level was not possible with aggregated denominator data.

Validation data were entered separately in HelicsWin.Net which included specific fields for this purpose or in a national software according to the PPS validation metadata. Primary data of the validated hospitals needed to be submitted together with the validation datasets.

Validation data were matched to the primary PPS data using the 'primary PPS patient counter', which was collected by the national validation teams for the validated wards. False positive and false negative patients were identified by cross-analysing primary data with validation data. To estimate the sensitivity and specificity of the national PPS, the percentage and 95% confidence intervals of false positives and false negatives of the validation sample were applied to the total national PPS population.

External (international) validation

All members of national validation teams received a test with 10 case vignettes to assess the sensitivity and specificity of the national validation team members prior to performing national validation. The case vignettes were randomly selected from a total of 60 prepared by ECDC during the first quarter of 2016 [29]. Tests were sent to the validation teams by email and answers were collected by ECDC on a uniform Excel sheet. After receiving the complete set of tests, ECDC sent individual results back to the national validation team members within one day and two weeks.

In addition, ECDC put out a call for tender (Publication Reference: OJ/27/10/2015-PROC/2015/028) for external validation to be undertaken during the national validation studies. The aims of this were to:

- Assess adherence of the national validation teams to the gold standard, i.e. the ECDC protocol;
- Validate data on IPC structure and process indicators;
- Explore how the ECDC PPS relates to the hospital IPC strategy through in-depth interviews with the hospital management (Chief Executive Officer) and the IPC team in one hospital per country.

An external validation team (usually composed of two experts) was asked to organise one visit per participating country during the national validation study. The team applied a mixed methods evaluation research involving three components and approaches to address each of the three aims:

- External validation of the national validators within member states;
- Interviews with the national validation team about the validation process;

- An external validation review of 10 cases (five with HAI, if available on the day of validation);
- Review of IPC indicators with local (the hospital that was site visited in each country) IPC team – external validation of the primary PPS data;
- Interview with CEO, the chief medical officer (CMO), and nurse director (ND) of the hospital that was site visited to explore how the ECDC PPS relates to the hospital IPC strategy.

The external validation visits were performed by a team led by Walter Zingg (Framework contract ECDC/2016/013 with Imperial London, United Kingdom, coordinated by Alison Holmes) and Jacqui Reilly (Glasgow Caledonian University, United Kingdom), involving seven other experts with national PPS experience (see acknowledgements). External validators worked in pairs during the country visits, even though on seven occasions the validation was undertaken by a single validator because a date on which all involved parties were available could not be agreed on. To ensure homogeneity of the `external gold standard', a technical workshop for the external validators was organised in September 2016, which included training on validation methods, qualitative research and interview techniques, as well as a discussion of key frequently asked questions. Interview guides for the interviews with the national validation team and the hospital management were provided, as well as a template for the validation of indicators with the IPC staff. External validators also took the ECDC case vignette test prior to the meeting and discussed `controversial' case vignettes for which the proposed standard answers were not straightforward.

Data analysis

Data were processed and analysed by ECDC using Stata version 14 (StataCorp. 2015. *Stata Statistical Software: Release 14*. College Station, TX: StataCorp LP.) and R, version 3.4.0 (R Foundation for Statistical Computing, Vienna, Austria).

Recoding of variables

Because of differences in interpretation leading to inconsistent reporting between hospitals and/or countries, the following variables were recoded before analysis:

- The specialty of the main disease of the patient or of the consulting physician in charge of the patient (patient/consultant specialty) was recoded to the corresponding ICU specialty if the patient was in an ICU but had a patient/consultant specialty that was not an ICU specialty. For example, a patient in a mixed ICU ward with a patient/consultant specialty 'general surgery' (PPS protocol code: SURGEN) was attributed a patient/consultant specialty 'surgical ICU' (PPS protocol code: ICUSUR).
- Negative microorganism codes for reported *C. difficile* infections were replaced by the microorganism *C. difficile* in the analysis. This resulted in the addition of 104 of 1027 (10.1%) *C. difficile* microorganism records in 18 of 31 countries which reported *C. difficile* infections (Austria 7 records added of a total of 28 *C. difficile* microorganism records, Belgium 2/30, Croatia 2/28, Czechia 1/85, Finland 14/44, Germany 12/41, Greece 6/26, Hungary 9/87, Ireland 2/30, Italy 3/55, Lithuania 7/16, Poland 10/103, Romania 5/80, Slovakia 1/57, Spain 1/35, UK-England 8/48, UK-Northern Ireland 2/15, UK-Wales 12/27).
- The presence of the HAI on admission was recoded from 'unknown' to 'no' if the date of onset was given and the day of onset of the HAI was on Day 3 or later (n=72 HAIs in eight countries).

Calculation of indicators

The prevalence of HAIs was reported as the percentage of patients with at least one HAI over the total number of patients. The HAI prevalence was never reported as the ratio of HAIs (× 100) over the number of patients (which is, historically, often done in HAI prevalence surveys) because this indicator is not a true percentage as the numerator is not part of the denominator.

For types of HAI and microorganisms, relative frequencies were reported using the total number of HAIs or microorganisms as the denominator.

Antimicrobial resistance data were collected for selected bug–drug combinations only (see ECDC PPS protocol). Contrary to the PPS-1, antimicrobial susceptibility data were collected as susceptible (S), intermediate (I), resistant (R) or unknown (U), and were reported as the percentage of resistant bacteria (PPS-1: non-susceptible (intermediate or resistant) bacteria) over the total number of isolates for which antimicrobial susceptibility testing results were available at the time of survey. Resistance for *Enterococcus* spp. was also reported for motile enterococci (enterococci other than *E. faecium* and *E. faecalis*). In the analysis by country, countries for which fewer than 10 isolates were reported were excluded, as per the standard EARS-Net analysis [30]. Antimicrobial resistance in HAI was also evaluated using two indicators: a composite index of AMR and the percentage of carbapenem-resistant Enterobacterales. The composite index of AMR was calculated as the percentage of resistant isolates for the 'first level' AMR markers in the PPS protocols divided by the sum of the isolates for which results from antimicrobial susceptibility testing (AST) were reported. These first level markers were *Staphylococcus aureus* resistant to meticillin (MRSA), *Enterococcus faecium* and *Enterococcus faecalis* resistant to vancomycin, Enterobacterales resistant to third-generation cephalosporins, and *Pseudomonas aeruginosa* and *Acinetobacter baumannii* resistant to carbapenems. Selected Enterobacterales were *Escherichia coli*, *Klebsiella* spp., *Enterobacter* spp., *Proteus* spp., *Citrobacter* spp., *Serratia* spp. and *Morganella* spp.

The prevalence of antimicrobial use was reported as the percentage of patients receiving at least one antimicrobial agent. For antimicrobial agents, relative frequencies among the total number of antimicrobials are given in this report. The relative

frequency at the fifth ATC level was reported as the Drug Utilization 75% (DU75%), describing 75% of the antimicrobial use in participating hospitals [31].

The distribution of antimicrobial groups and agents followed the WHO/ATC classification (2018) except for further classification of quinolone antibacterials (ATC group J01M) into three generations based on their chemical structure and antimicrobial activity as described by the ESAC project and used by the European Surveillance of Antimicrobial Consumption Network, ESAC-Net [32, 33].

The proportion of the broad-spectrum antibacterials, among all antibacterials for systemic use (ATC J01), was calculated as proposed in the ECDC, European Food Safety Authority (EFSA) and European Medicines Agency (EMA) 'Joint Scientific Opinion on a list of outcome indicators for surveillance of AMR and antimicrobial consumption in humans and food producing animals' [34]. The following antimicrobial groups and agents were included under broad-spectrum antimicrobials: piperacillin and beta-lactamase inhibitor (ATC J01CR05), third- and fourth-generation cephalosporins (J01DD and J01DE), monobactams (J01DF), carbapenems(J01DH), fluoroquinolones (J01MA), glycopeptides (J01XA), polymyxins (J01XB), daptomycin (J01XX09) and oxazolidinones: linezolid (J01XX08) and tedizolid (J01XX11).

In addition to the relative use of antimicrobial groups and agents, the prevalence of antimicrobial use among the total number of hospitalised patients was also reported for carbapenems (ATC groups J01DH), for glycopeptide antibacterials (ATC group J01XA), for parenteral polymyxins (ATC group J01XB) and/or tigecycline (J01AA12) as an indicator of empirical or documented therapy of carbapenem-resistant gram-negative bacteria [35], for use of oral metronidazole (P01AB01) and/or oral vancomycin (A07AA09) as an indicator of the oral treatment of *C. difficile* infections, and for the use of antimycotics (ATC group J02 and nystatin).

Dichotomous variables from the hospital and ward indicator questionnaires could have three values: yes, no and unknown. In several countries or hospitals however, only `yes' and `unknown' answers were reported. In terms of data entering, software such as HelicsWin.Net would require active entering of the value `no', while no action would export the value as `unknown'. In several countries it was obvious that hospitals only actively reported `yes' when the answer to the question (e.g. presence of a guideline) was `yes', while `no' answers were not reported but left `unknown'. Therefore, `unknown' answers belonging to same group of questions were considered as `no' if the hospital replied `yes' or `no' at least once to the group of questions. This was applied to following groups of questions:

- Multimodal strategy for HAI prevention at hospital level (28 variables);
- Multimodal strategy for HAI prevention at ICU level (21 variables);
- Participation in HAI/AMR surveillance networks (five variables).

The number of FTE IPCN was reported per 250 beds in line with the standard derived from the SENIC study [36]. Based on data from the ECDC Training in Infection Control in Europe (TRICE) project, infection prevention and control doctors represent a more heterogeneous group of professionals in Europe, with a predominantly medical microbiology background, but also commonly a public health or epidemiological medical background, sometimes with other medical backgrounds or other professionals such as pharmacists, with a special training in infection prevention and control/hospital hygiene [37]. Given the heterogeneity of this group, a straightforward FTE standard is not available in literature. For this reason and to facilitate comparison with the FTE for IPCN, the FTE of IPCD, as well as the FTE antimicrobial stewardship consultant, were also expressed per 250 hospital beds. As per the 2016-2017 ECDC PPS protocol, the FTE antimicrobial stewardship needed to be deducted from the FTE IPCD by the reporting hospital if antimicrobial stewardship was otherwise counted as part of the job description of the IPC doctor.

Alcohol-based handrub consumption was reported as the number of litres per 1 000 patient-days. Single beds were reported as the percentage of single-room beds among the total number of beds, which was preferred as a proxy indicator for isolation capacity rather than the percentage of single-bed rooms among the total number of rooms, because of large variations in the number of beds per room between countries.

Statistical analysis

Univariate analyses

Relationships between two dichotomous variables were examined using the Chi-squared test and crude odds ratios with 95% confidence intervals. Categorical variables were examined using logistic regression and the analysis of continuous variables was done using linear regression and/or quantile regression, as appropriate. The correlation between two continuous variables was examined using the Pearson and/or Spearman correlation coefficients (rho).

Risk adjustment of HAI and antimicrobial use prevalence

Multiple logistic regression models were developed on a systematic sample of two thirds of the data and validated on the other third. One model was developed for the prediction of the presence of any HAI, and another model for receiving at least one antimicrobial agent on the day of the survey. For the prediction of HAIs, risk factors for an HAI with onset during the current hospital stay were considered before onset of the HAI: length of stay until the day of onset of the HAI, presence of invasive devices before HAI onset (by using the variable presence of invasive device before HAI in the infection data), and McCabe score estimated without the influence of the infection, if any (as defined in the ECDC PPS protocol). The presence of a central or peripheral vascular catheter was excluded from both models because of the correlation with the parenteral administration of antimicrobials. After each model, risk scores were developed by multiplying and rounding each regression coefficient by a factor of 10, and goodness-of-fit and discriminatory accuracy of the model were assessed using the risk scores. Goodness-of-fit was

assessed on eight smaller random sub-samples of the data using the Hosmer–Lemeshow Chi-squared test. The discriminatory accuracy of the multiple logistic regression models was assessed using receiver operating characteristic (ROC) analysis. Random effect logistic regression analysis models (including country-level random effects) were performed to examine the effect on regression coefficients. For light protocol data with aggregated denominator data by patient/consultant specialty, logistic regression for grouped data was used to construct a risk model for HAIs and antimicrobial use, including patient/consultant specialty, type of hospital and hospital size.

The level of statistical significance was set at 1 per mille ($p<0.001$) for patient-based analyses and at 5% ($p<0.05$) for analyses of data aggregated at hospital- or country-level.

The standardised infection ratio (SIR) and the standardised antimicrobial use ratio (SAUR) were calculated as the number of observed patients divided by the number of predicted (or expected) patients with at least one HAI or antimicrobial, respectively. The number of predicted patients with one or more HAI or on one or more antimicrobial was calculated by summing up, for each country, the individual probabilities for each patient (values between 0 and 1) after fitting the European model. Standardised ratios <1 indicate a lower prevalence than predicted, standardised ratios >1 indicate a higher prevalence than predicted based on the (country's) patient case mix after applying the European risk model. We preferred to use the terms 'predicted' instead of the more commonly used term 'expected' (statistically speaking these terms are synonyms in this context) because the term 'expected value' might be misinterpreted as referring to 'good practice'. In the case of the prevalence of HAIs and antimicrobial use, the predicted or expected value after applying the risk model based on the total European risk model does not mean that this value is a good practice standard.

Weighted prevalence

Prevalence and incidence burden estimates were calculated as the total number of patients with an HAI and on antimicrobials, respectively, on any given day (prevalence) and, for HAIs only, the total number of patients acquiring at least one HAI per year.

The number of patients with an HAI or on antimicrobials on any given day was calculated by applying the national prevalence figures with 95% CIs on the total number of beds in acute care hospitals, multiplied by the occupancy rate in the year for which national denominator data were available. The occupancy rate was defined as the (national) number of patient-days in acute care hospitals × 100 / (number of beds in acute care hospitals × 365 days).

Country-weighted prevalence estimates for EU/EEA were calculated as the sum of the country-specific estimated number of patients with an HAI (for HAI prevalence) resp. patients on antimicrobials (for prevalence of antimicrobial use), divided by the sum of the country-specific occupied beds.

Prevalence-to-incidence conversion

Estimates of the total number of patients per year with an HAI were calculated after conversion of the national prevalence percentages to incidence of HAIs using the formula by Rhame and Sudderth [38]:

$$I_{estimated} = P\frac{LA}{(LN\text{-}INT)}$$

P = Prevalence, defined by the percentage of patients with at least one HAI on the survey day.
LA = Average length of hospital stay, derived from the number of patient-days and the number of discharges for the year preceding the PPS in the hospitals participating in the survey (hospital questionnaire data).
LN = Average length of hospital stay of infected patients (admission to discharge date). Since the discharge date was not known at the time of the PPS, the length of stay of infected patients was calculated as up to survey date.
INT = Average length between date of admission and date of onset of HAI. If a patient had multiple infections on the day of the survey, the date of onset of the first infection is considered.

The term (LN-INT) or the length (duration) of infection (LOI) in the Rhame and Sudderth formula was estimated using the same method as in the 2011-2012 ECDC PPS [6]. After establishing the best mathematical relationship between the length of stay until the day of the PPS (date) in patient-based data with the average length of stay from hospital denominator data, the LOI was estimated from the LOI until the day of the PPS (date of PPS – date of onset HAI +1) as the average between the mean and the median [mean LOI_{PPS} + median LOI_{PPS}]/2. Because of the inherent poor precision of the prevalence-to-incidence conversion, confidence intervals were intentionally kept large, taking the lower limit of the estimate using the mean LOI_{PPS} and the upper limit of the estimate using the median LOI_{PPS}. In addition, sensitivity analyses of the prevalence-to-incidence conversion were carried out using a method developed by Willrich et al. [39], in which the estimates of the length of stay and length of infection were based on a Grenander estimator for discrete monotonously decreasing distributions [40]. Results of these sensitivity analyses were reported elsewhere (online appendix reference [1]).

Confidence intervals

To adjust for clustering of HAIs and antimicrobial use in selected hospitals (also referred to as over-dispersion or intra-cluster correlation), the national prevalence figures for HAIs and antimicrobial use were reported with 95% CIs adjusted for the design effect using the survey ('svy') procedure in Stata v12. To calculate CI around EU/EEA estimates, the number of patients with at least one HAI obtained from the lower and upper limits of the country-specific 95% CIs were summed up and divided by the total number of occupied beds (for prevalence) or the total number of discharges (for estimated incidence) in the EU/EEA. These 'cumulative 95% CI' (95% cCI) therefore reflect a larger, more conservative uncertainty than would be obtained by

calculating 95% CI directly on the EU/EEA totals, which is in accordance with the limitations of the prevalence measurement and the uncertainty inherent to the conversion of prevalence to incidence.

Validation study analysis

The sensitivity (percentage of truly positive patients that were detected/reported) and specificity (percentage of truly negative patients that were detected/reported) of the primary PPS teams were calculated for each national validation study by applying the percentages of false negatives to the total number of negative patients in the national primary PPS and the percentage of false positives to the total number of positive patients. This was done because the sensitivity and specificity depend on the prevalence, which is often biased in the validation sample because the ECDC PPS validation protocol recommended to select high risk wards for validation to improve the precision of the validation estimates. In addition to the validation approach, whereby the national validator's interpretation of the PPS protocol is considered to be the gold standard, we also calculated the interrater reliability using Cohen's kappa statistic, whereby the national validators are considered as the second rater [41]. For the interpretation of the magnitude of the kappa statistic, we used a conventional [42] and a recent more conservative approach [43].

To correct the EU/EEA prevalence estimates for the results of the national validation studies, the EU/EEA mean percentage of false positives was applied to the total estimated number of patients with HAI on any given day and the EU/EEA mean percentage of false negatives was applied to the total estimated number of patients without HAI on any given day. The lower limit of the cumulative confidence interval of the corrected estimate was calculated applying the lower limit of the weighted EU/EEA prevalence estimate, the upper limit of 95% confidence interval of the percentage of false positives and the lower limit of the 95% confidence interval of the percentage of false negatives. Similarly, the upper limit of the cumulative confidence interval of the corrected estimate was calculated applying the upper limit of the weighted EU/EEA prevalence estimate, the lower limit of 95% confidence interval of the percentage of false positives and the upper limit of the 95% confidence interval of the percentage of false negatives.

The validation-corrected HAI prevalence was converted using the Rhame and Sudderth formula to estimate the corrected HAI incidence and total number of patients acquiring at least one HAI each year in 2016-2017 in EU/EEA acute care hospitals.

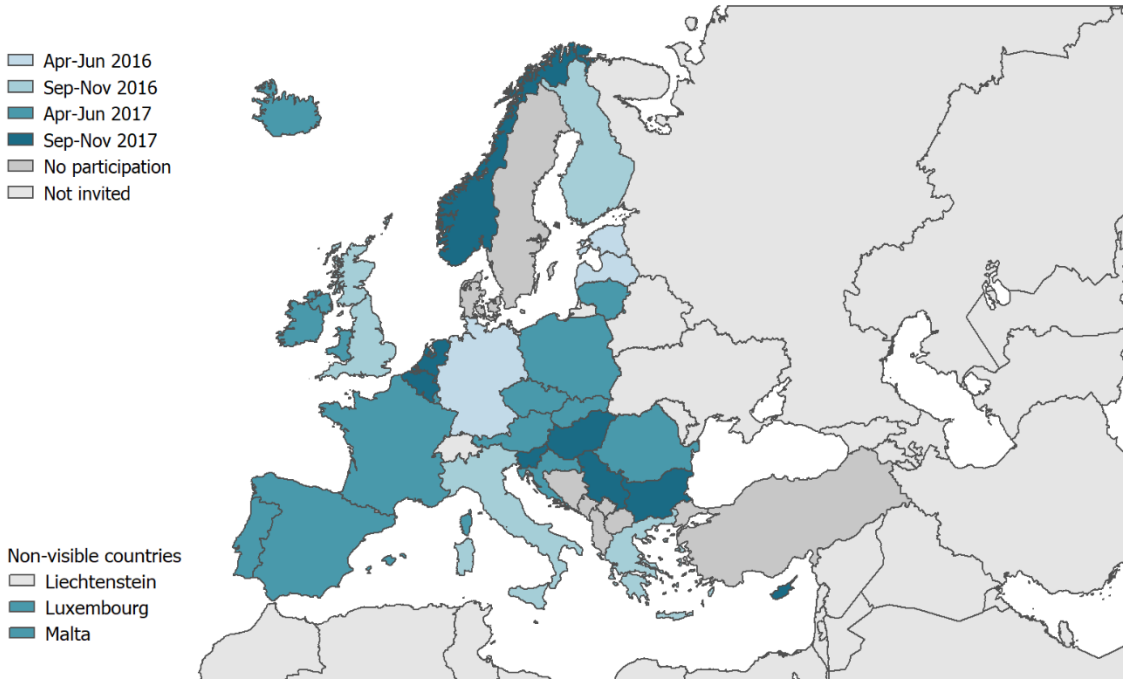
Results

Participation

From May 2016 to November 2017, a total of 29 countries – all EU Member States except Denmark and Sweden, two EEA countries (Norway and Iceland) and one EU candidate country (Serbia) – participated in the second European PPS. The majority of countries performed their PPS in May and June 2017 (Figure 1). Since the surveys in the four UK administrations (England, Northern Ireland, Scotland, Wales) were organised independently, data from 32 different national/sub-national surveys were submitted to ECDC. For simplicity, the term 'country' was used for all 32 data sources throughout the report.

On average, the PPS data collection in a country (first ward in first hospital until last ward in last hospital) lasted 56 days (median 59 days). Overall, 2 257 hospitals participated, but Germany and France only submitted a representative sample of hospitals to ECDC, resulting in data from 1 735 hospitals and 424 847 patients that were submitted to ECDC. To obtain similar precision in prevalence estimates for all participating countries, further representative sub-samples of hospitals were drawn for countries that were overrepresented (Hungary, Italy, Poland, Portugal, Spain and UK-England) in the original sample. After this adjustment, a total of 325 737 patients from 1 274 hospitals were included in the final European sample. Aggregated results were only reported for the EU/EEA, corresponding to 310 755 patients from 1 209 acute care hospitals.

Figure 1. Period of participation in the second EU-wide PPS, 2016–2017



The recommended systematic random sampling methodology was not followed by all countries. Good or optimal representativeness was obtained in 30 of 32 national surveys (94%) (Table 1):

- by strictly following the recommendation (optimal);
- by inviting all hospitals, achieving a good response and drawing a systematic sample, if appropriate (good or optimal);
- by selecting a sufficient number of representative hospitals using another methodology (good); or by including all (optimal) or nearly (>75%) all (good) hospitals or hospital beds in smaller countries.

Overall, approximately 15% of all acute care hospitals in EU/EEA countries and the UK and Serbia were included in the PPS sample. In two countries (Bulgaria and the Netherlands), the number of hospitals or hospital beds included in the PPS was too small to consider the samples as representative of the total hospital population. These hospitals were nevertheless included, but care should be taken in interpreting results from these countries.

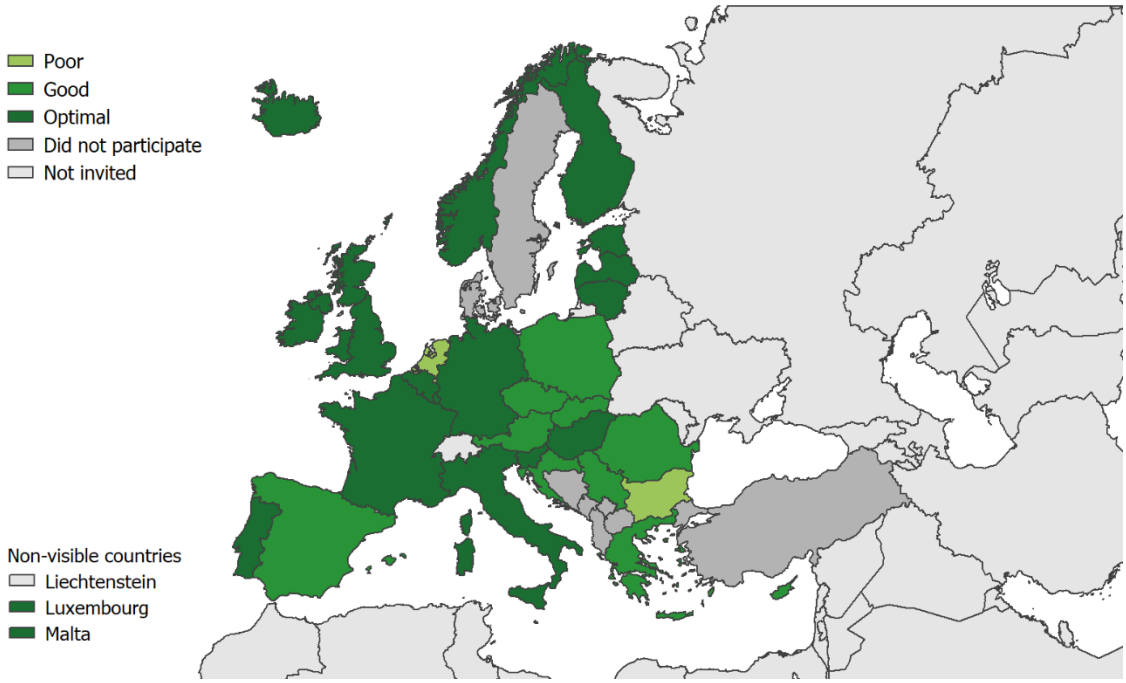
Table 2. Total number of acute care hospitals and hospital beds, and participation in the ECDC PPS by country, 2016-2017

Country	N of acute care hospitals in the country [a]	N of administrative hospital groups in the country	N of hospital bedsin acute care hospitals [b]	N of hospitals in final PPS database	Hosp. in PPS, % of total	N of patients in PPS	N of beds in PPS, % of total [c]	Sample represen-tativeness [d]
Austria	162	N/A	48 816	49	30	13 461	28	Good
Belgium	197	102	52 035	43	22	11 800	23	Optimal
Bulgaria	241	N/A	44 164	12	5	2 200	5	Poor
Croatia	34	N/A	12 171	34	100	10 466	86	Good
Cyprus	83	N/A	2 918	8	10	1 036	36	Good
Czechia	144	N/A	48 511	45	31	15 117	31	Good
Denmark	52	N/A	15 895	NP	NP	NP	NP	NP
Estonia	27	N/A	6 355	23	85	4 220	66	Optimal
Finland	59	N/A	16 135	51	86	9 079	56	Optimal
France	1 237	N/A	213 398	50	4	16 522	8	Optimal
Germany	1 857	N/A	494 751	49	3	11 324	2	Optimal
Greece	123	N/A	27 540	42	34	9 401	34	Good
Hungary	94	N/A	65 947	38	40	20 588	31	Optimal
Iceland	8	7	939	2	25	633	80*	Optimal
Ireland	60	N/A	12 000	60	100	10 333	86	Optimal

Country	N of acute care hospitals in the country [a]	N of administrative hospital groups in the country	N of hospital bedsin acute care hospitals [b]	N of hospitals in final PPS database	Hosp. in PPS, % of total	N of patients in PPS	N of beds in PPS, % of total[c]	Sample represen-tativeness[d]
Italy	1 134	N/A	185 053	56	5	14 773	8	Optimal
Latvia	24	N/A	6 364	14	58	3 807	60	Optimal
Lithuania	64	73	18 380	62	97	12 415	68	Optimal
Luxembourg	12	N/A	2 789	12	100	2 018	72	Optimal
Malta	4	4	1 313	4	100	961	73	Optimal
Netherlands	79	79	35 258	19	24	4 441	13	Poor
Norway	43	19	13 078	43	100	9 628	74	Optimal
Poland	936	N/A	163 827	80	9	21 712	13	Good
Portugal	225	N/A	30 457	93	41	16 982	56	Optimal
Romania	311	N/A	101 776	40	13	11 443	11	Good
Slovakia	107	N/A	30 057	50	47	9 145	30	Good
Slovenia	21	N/A	7 536	20	95	5 720	76	Optimal
Spain	576	N/A	129 901	96	17	19 546	15	Good
Sweden	144	N/A	21 366	NP	NP	NP	NP	NP
UK-England	158	158	109 617	32	20	20 148	18	Optimal
UK-Northern Ireland	16	5	5 642	16	100	3 813	68	Optimal
UK-Scotland	46	16	15 101	45	98	11 623	77	Optimal
UK-Wales	21	7	6 400	21	100	6 400	100	Optimal
EU/EEA	**8 299**		**1 945 490**	**1 209**	**15**	**310 755**	**16**	**Optimal or good 29/31 countries**
Serbia	65	N/A	28 803	65	100	14 982	100	Optimal

*(a) Total number of hospital sites: in some countries, this number was corrected to a combination of hospital sites and administrative hospital groups (second column) because hospital indicator data were sometimes provided for a hospital group rather than by hospital site (e.g. Norway, where the actual number of hospital sites is 53) (b) Data submitted to ECDC (national denominator data) or data extracted from Eurostat, year 2016; also see Annex 1 (Table A1.7) for national denominator data reported in TESSy. (c) Number of surveyed patients as a percentage of the number of beds in acute care hospitals in the country (d) Sample representativeness appreciation based on compliance with recommended sampling methodology of hospitals and sample size (see text).*Estimation of percentage of acute care beds by national PPS coordinator in Iceland .*

Figure 2. Sample representativeness in the ECDC PPS by country, 2016–2017



Sample representativeness appreciation based on compliance with recommended sampling methodology of hospitals and sample size (see text).

In Iceland, the representativeness was evaluated to be good because the number of included beds was estimated to represent more than 80% of all acute care beds in the country, even though the PPS sample only included two hospitals (the two main acute care hospitals in the country). The other hospitals in Iceland are small and represent a mixture of advanced primary care centres and nursing homes with only few truly acute care beds. For six countries, a sample of all submitted hospitals was taken, either following the indications of the country (variable `sample hospital') or randomly by ECDC, in order to avoid overrepresentation of these countries in the final database: Hungary (38/99 hospitals), Italy (56/153), Poland (80/179), Portugal (93/125), Spain (96/276) and UK-England (32/40 hospitals). Validated hospitals were forced to be included in the sample.

The large majority of hospitals (91.7%) used the patient-based (standard) protocol option. The unit-based (light) protocol option was used by all hospitals in Germany, by five of 34 hospitals in Croatia, by seven of 23 hospitals in Estonia and by two of 50 hospitals in Slovakia. In Norway, all 43 hospitals used the national protocol and data were converted to the light format (see methods). The number of days spent by the surveyors to collect data for 100 patients (excluding data entry and verification) was 2.3 days on average for the light protocol option (median 1.6 days) and 3.1 days for the standard protocol (median 2.4 days). The median time spent to collect data for 100 patients varied from 0.8 days in Norway to 5.3 days in Bulgaria. The median number of days spent for complete data collection by hospital was four days by hospital (IQR: 2–7 days). The median time frame from the start of the PPS until the end of the PPS (including weekends) by hospital was eight days (IQR: 2–16 days). The median number of days spent for complete data collection varied from one day in small hospitals (<200 beds) to 11 days in hospitals of 900 beds or more. However, the median time spent to collect data for 100 patients decreased with increasing hospital size, from 2.9 days per 100 patients in hospitals with less than 200 beds to 1.4 days per 100 patients in hospitals of 900 beds or more. Similarly, it was higher in primary hospitals (2.7 days per 100 patients) than in secondary (2.4 days per 100 patients) or tertiary (1.7 days per 100 patients) hospitals.

Hospital and patient characteristics

Hospital type and size

The mean size of hospitals (total number of beds) included in the PPS was 381 beds (Table 3). The median size of hospitals included in the PPS was 272 beds and varied between 148 beds in Finland and 757 in UK-England. The mean number of acute care beds in included hospitals was 334 beds (median 240 beds) and the mean number of ICU beds was 17 (median nine beds), with 79.4% of hospitals reporting at least one ICU bed (mean/median number of ICU beds excluding hospitals with zero ICU beds: 21/12). Less than one third (28.4%) of the hospitals reported to have excluded at least one ward from the PPS, often in agreement with the protocol (accident and emergency wards, day-case centres), but sometimes in disagreement with the exclusion criteria specified for the second PPS (e.g. psychiatric wards were frequently excluded in Finland, the Netherlands, Norway and Serbia).

Of all included hospitals, 30.2% were primary hospitals, 34.1% were secondary hospitals, 20.0% were tertiary hospitals and 13.7% were specialised hospitals. The type of hospital was not reported for 2.2% of hospitals. Among specialised hospitals for

which the specialty was specified, there were 27 surgical or orthopaedic hospitals, 12 paediatric, 12 obstetric hospitals, 19 cardiopulmonary (including cardiovascular surgery), 12 psychiatric hospitals, 15 oncology hospitals, 4 infectious disease hospitals, 6 geriatric or rehabilitation hospitals, two ophthalmology and/or otolaryngology centres and 21 other (19 'private/independent' and two 'mixed').

Table 3. Type and size of hospitals included in the ECDC PPS 2016–2017

	N of hospitals	% of hospitals	N of patients	% of patients	Hospital size (number of beds)					
					Mean	P10	P25	P50	P75	P90
Primary	363	30.2	52 860	17.0	232	52	84	153	292	481
Secondary	412	34.1	109 286	35.2	390	135	205	338	509	723
Tertiary	242	20.0	122 738	39.5	730	192	385	652	978	1281
Specialised	165	13.7	21 487	6.9	198	31	85	150	244	403
Unknown	27	2.2	4 384	1.4	211	43	97	156	228	472
Total	**1 209**	**100.0**	**310 755**	**100.0**	**381**	**70**	**135**	**272**	**515**	**843**

N=number; P=percentile.

Figure 3. Hospital size (number of hospital beds, left) and type of hospital (right) in 1 209 EU/EEA hospitals included in the ECDC PPS 2016–2017

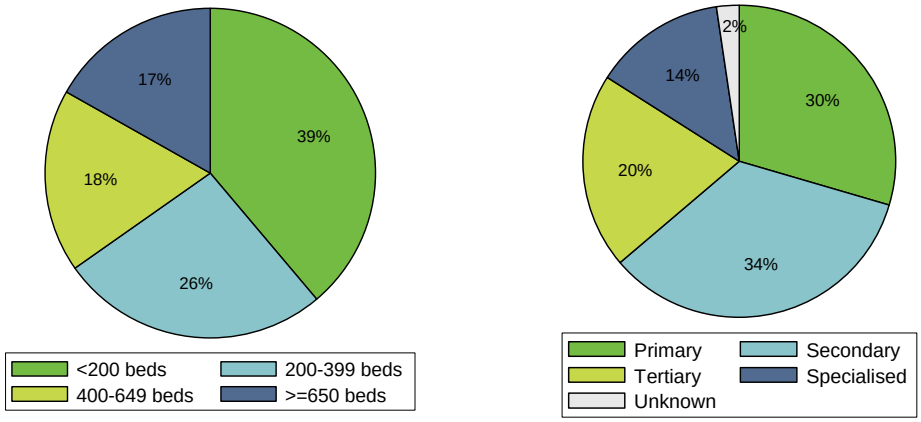
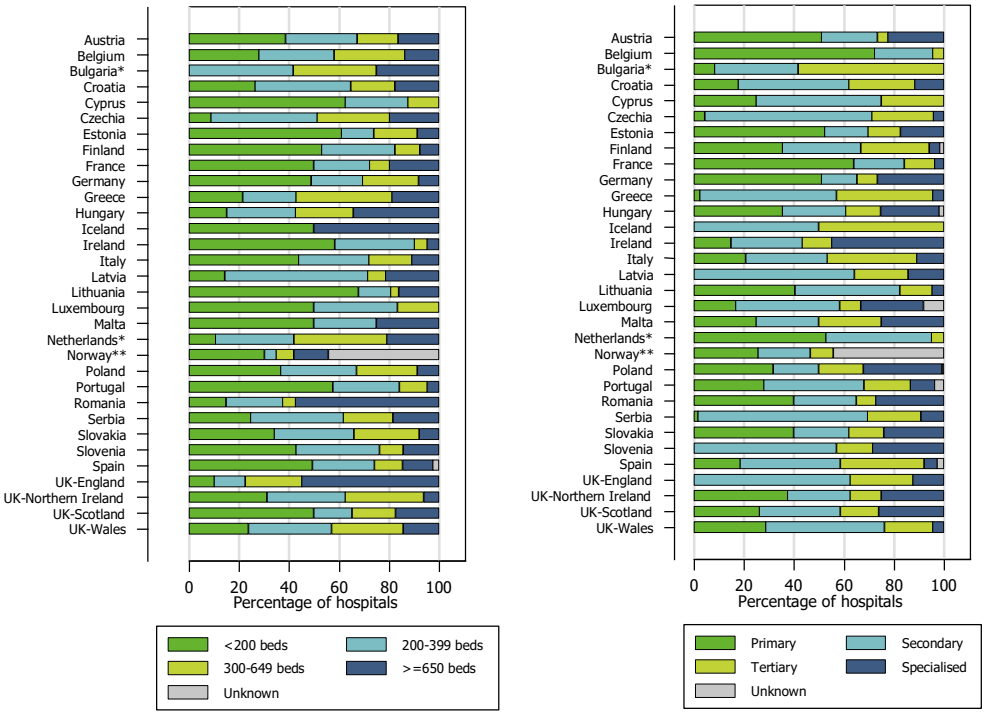


Figure 4. Hospital size (number of hospital beds, left) and type of hospital (right) by country



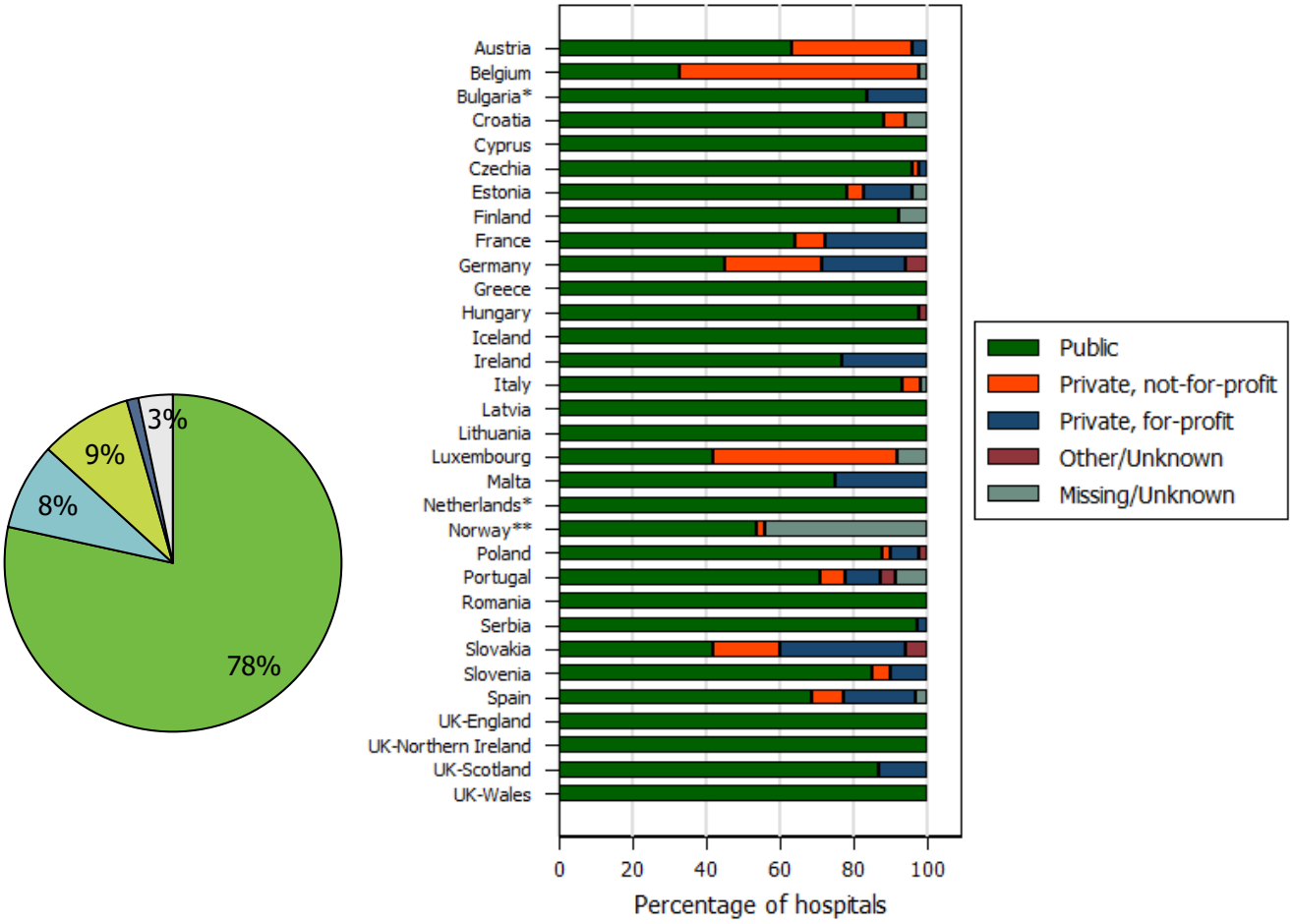
**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national protocol.*

Hospital ownership

Hospital ownership was a new variable in the second ECDC PPS and was reported by 1 127 (93.2%) of 1 209 EU/EEA hospitals (Figure 5). Omitting missing values, public hospitals represented 80.4% of the total, private not-for-profit hospitals 9.0% and private for-profit hospitals 9.5%. The type of hospital ownership varied substantially by country. Where no private hospitals were reported, these hospitals were usually not included in the national PPS sample (e.g. not invited), as reported by the national PPS coordination teams.

Hospital ownership varied significantly according to hospital type and size. Private not-for-profit hospitals were more likely to be primary hospitals (51.5% *vs* 26.1%, p<0.001), while private for-profit hospitals were more frequently reported to be specialised (35.5% *vs* 11.4%, p<0.001). Public hospitals had the highest number of beds (mean 422, median 305), followed by private not-for-profit (mean 295, median 221) and private for-profit hospitals (mean 192, median 126).

Figure 5. Hospital ownership in EU/EEA hospitals (left) and by country (right)



**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national protocol.*

Length of stay

The average length of stay (LOS) in the participating hospitals, based on the hospital statistics collected at hospital level (number of discharges and patient-days in the most recent year) was 8.4 days and 5.1 days for respectively the mean of hospital means and the overall aggregated mean. The aggregated mean LOS varied from 2.5 days in UK-England to 7.9 days in Hungary, Iceland and Lithuania. The hospital median LOS was 5.9 days (IQR: 4.1 – 7.3). The median occupancy rate in participating hospitals in the most recent year (year preceding the PPS for 94% of hospitals) was 72.7%.

At national level, the average LOS in 30 countries that provided national denominator data for the number of all discharges and patient-days in acute care hospitals was 5.9 days (country median: 5.9 days). Considering national denominator data for acute care beds only (provided by 18 countries), the average LOS was 5.4 days (country median: 5.2 days). The aggregated LOS of hospitals participating in the PPS (based on hospital denominator data of the previous year) correlated well with the overall national mean LOS (Spearman's rho 0.72, p<0.001) and with the national LOS for acute care beds only (rho 0.57, p<0.001) (Figure 6).

In patient-based data (standard protocol, n=29 countries), the median LOS from admission until the survey date was six days at patient-level (same as in 2011-2012), at hospital-level (median of hospital medians) and at country-level (median of hospital medians by country). However, the patient-level mean LOS from admission until the survey date was 27.7 days (mean of hospital means 25.9 days, mean of aggregated country means 25.2 days), much higher than the average LOS reported by these hospitals and more than twice as high as in the ECDC PPS 2011-2012, when long-term care wards in acute care hospitals were excluded. In the first PPS, only 0.25% of the patients had a length of stay of more than one year. These values were considered to be the result of date errors and were recoded to missing. In the second ECDC PPS in 2016-2017 however, 1.2% of patients had a length of stay of more than one year, 43.3% of which were hospitalised in a long-term care ward (which were excluded for the first PPS). Because of the inclusion of long-term wards in the second ECDC PPS, a length of stay of more than 365 days was not recoded to missing in the 2016-2017 PPS. Patients with a long length of stay had a large influence on the mean length of stay until the day of the PPS of the hospital or the country, but much less on the median LOS until the day of the PPS. The mean LOS until the survey day was on average 4.6 times higher than the hospital LOS from hospital denominator data. The median LOS until the survey day was on average almost identical to the average LOS from hospital data (regression coefficient 1.03) when excluding UK-England, UK-Scotland and UK-Wales which were outliers in the correlation (Figure 12). The Spearman correlation coefficient rho between the hospital LOS and the median LOS until survey day was 0.52 (p<0.01) with UK-England, UK-Scotland and UK-Wales included, but 0.81 (p<0.001) when these three observations were excluded.

Figure 6. Correlation between the aggregated mean length of stay (in days) in participating hospitals (hospital data) and the mean length of stay for all hospitals in the country (national data), including all beds (left) and acute care beds only (right)

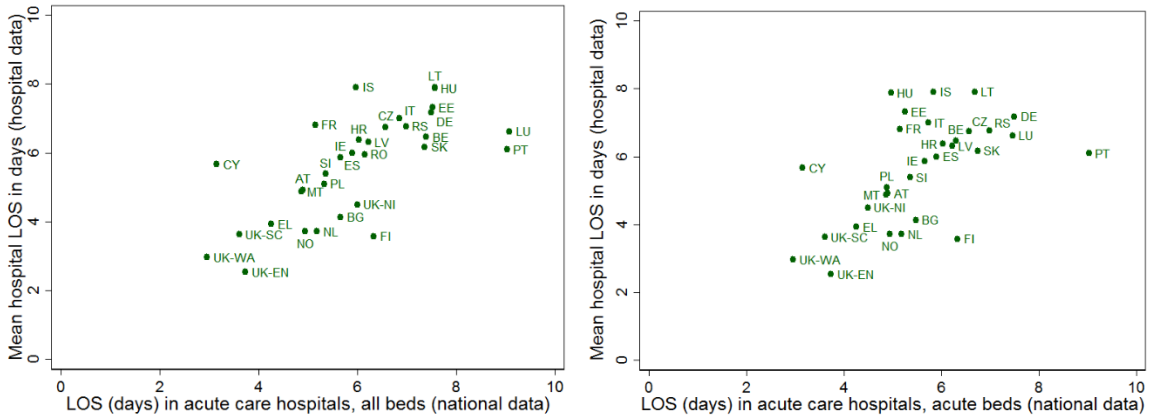
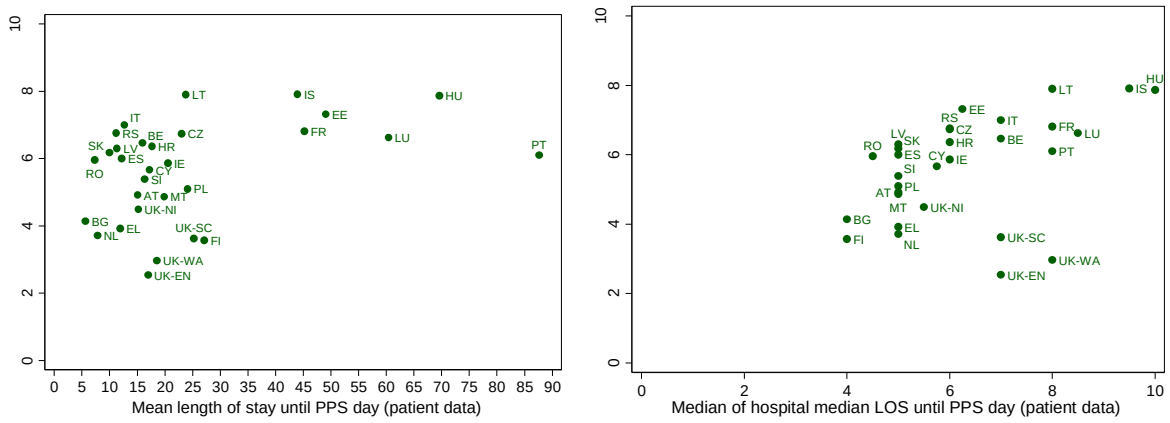


Figure 7. Correlation between the mean length of stay (in days) in participating hospitals (hospital data) and the mean (left) and median (right) length of stay from date of admission until the survey date (patient data, n=30 countries with patient-based data)



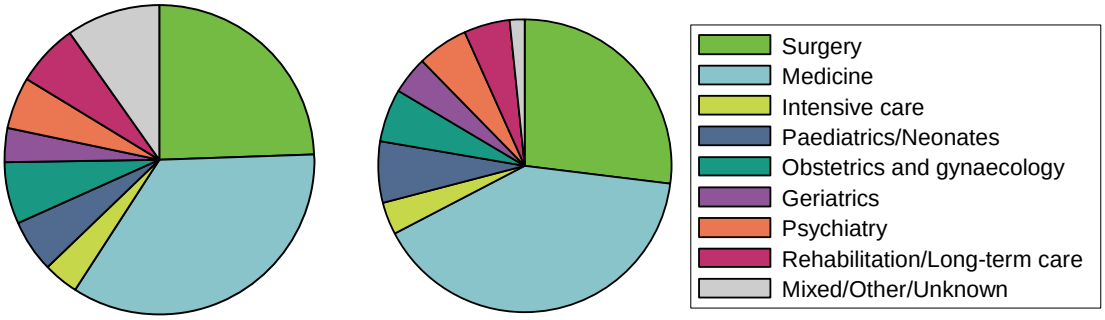
Ward and patient/consultant specialty

Medical specialties such as general medicine, cardiology or neurology were the most common and accounted for 34.8% of the ward specialties and 40.4% of the specialties of the main disease of the patient or of the consultant in charge of the patient (Figure 8). Surgical specialties were the second most common category of ward specialties and patient/consultant specialties with 24.4% and 26.9%, respectively. Overall, the patient/consultant specialty corresponded to the ward specialty for only 83.4% of the patients. The main reason for this was that 13.8% of patients with a medical specialty and 11.4% of the patients with a surgical specialty were admitted to 'mixed', long-term care or rehabilitation wards. Similarly, of 11 467 patients admitted to an ICU, 2 618 patients (22.8%) were reported with a non-ICU patient/consultant specialty. Of those, cardiology accounted

for 16.4%, general medicine 9.8%, general surgery 9.4%, cardiac surgery 6.7%, neurosurgery 6.6%, neurology 6.4%, neonatology 5.7%, digestive surgery 4.7%, pneumology 3.9% and a variety of more than 30 other patient/consultant specialties accounted for the remaining 30.9%. For these patients, patient/consultant specialties were recoded to the intensive care ward specialty for further analysis because of the higher risk of HAI and antimicrobial use associated with the stay in the ICU, except for paediatric and neonatal ICU which were categorised as paediatrics and neonatology. After recoding, intensive care specialties represented 3.6% of the total patient/consultant specialties.

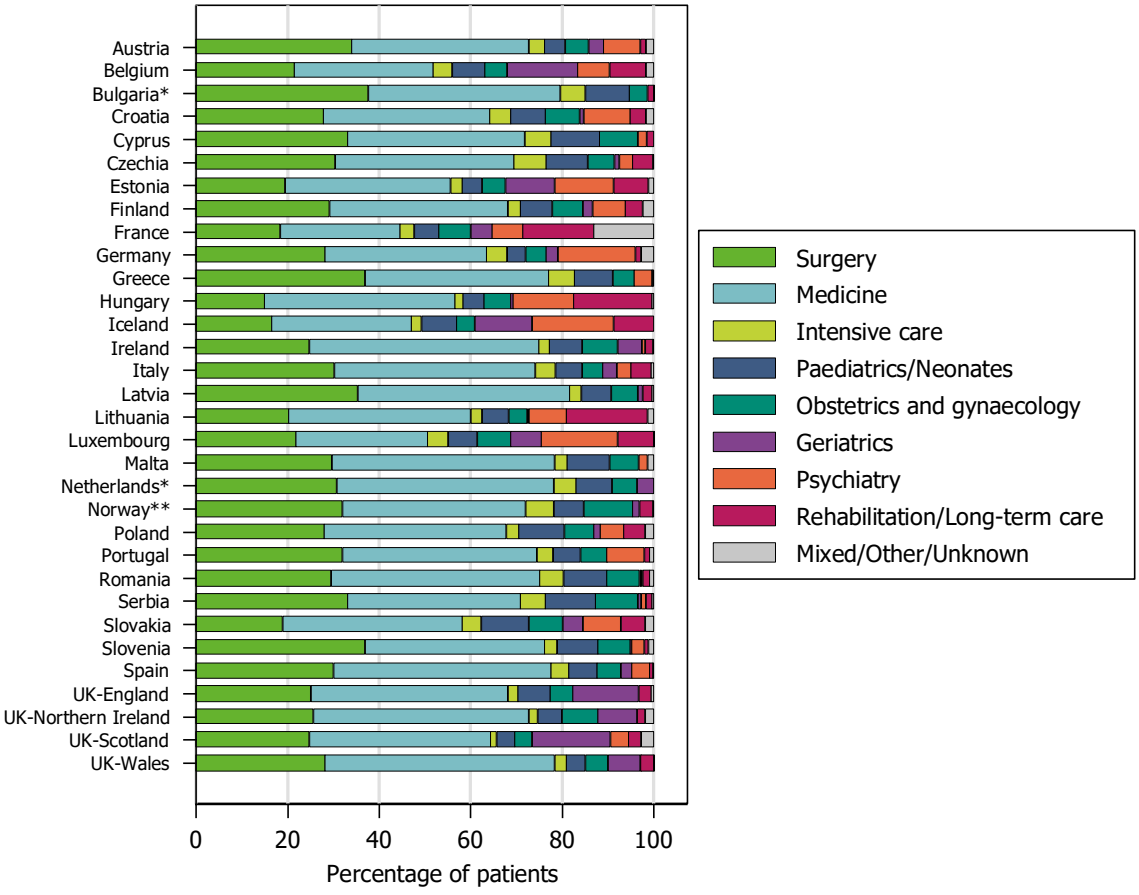
The distribution of patient/consultant specialties varied substantially between countries (Figure 9). The percentage of (adult) ICU specialties varied between 1.5% in UK-Scotland and 7.1% in Czechia. Rehabilitation and long-term care ranged from 0% in Malta and the Netherlands to more than 15% in Hungary, France and Lithuania. The detailed distribution of patient/consultant specialties by country is given in Annex 1 (Table A1.2).

Figure 8. Comparison of ward specialty (left) versus patient/consultant specialty (right)



Serbia excluded. For this comparison, the patient specialty `Paediatrics/Neonates' in the right pie chart includes the specialties PEDGEN, PEDNEO, ICUPED, ICUNEO, SURPED and healthy neonates (PEDBAB and GOBAB).

Figure 9. Patient/consultant specialty by country



**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national protocol. The patient specialty `Paediatrics/Neonates' in this figure includes the specialties PEDGEN (general paediatrics), PEDNEO (neonatology), ICUPED (paediatric ICU), ICUNEO (neonatal ICU), SURPED (paediatric surgery) and healthy neonates (PEDBAB and GOBAB).*

Patient demographics and risk factors (patient-based data only)

Patient-based (standard protocol option) data were submitted by 25 EU/EEA countries and the four UK administrations (283 055 patients from 1 103 hospitals) and Serbia. The distribution of the patient demographics and risk factors is given in Table 4 and Table 5. Details by country are given in Annex 1 (Table A1.1).

The median age of patients was 66 years. This varied according to country from 60 years in Romania to 74 years in UK-Wales. Overall, 9.5% of the patients were under 18 years old, 37.8% were aged between 18 and 64 years and 52.7% were aged 65 years or older.

The average male-to-female ratio was 0.91:1 with the highest proportion of female patients in Hungary (M:F ratio 0.69:1) and Lithuania (0.77:1) and the highest proportion of male patients in Greece (1.15:1) and Spain (1.08:1).

Twenty-five percent of the patients had surgery since hospital admission, the lowest in UK-Northern Ireland (16.0%) and the highest in Italy (32.2%).

'Rapidly fatal' (within one year), 'ultimately fatal' (within five years) and non-fatal diagnoses were reported for 6.2%, 16.3% and 66.6% of the patients, respectively. The percentage of patients with an expected rapidly fatal outcome varied from 2.1% in Bulgaria and Latvia to 9.4% in Czechia. Information on the McCabe score was not available from 11% of the patients and varied between 0% (Spain) and 100% (Malta and UK-Wales).

A peripheral vascular catheter was present in 48.7% of patients, varying between 27.1% in France and 72.8% in Greece. Urinary catheters were present in 17.7% of patients varying between 5.6% in Lithuania and 35.1% in Greece. Central vascular catheters were present in 7.5% of patients, varying from 3.2% in Lithuania to 14.9% in Italy. Only 2.2% of patients were intubated at the time of the survey and this varied from 0.6% in Lithuania to 4.5% in Greece.

Table 4. Patient demographics, patient-based data

	N of patients	Median age (yrs)	Age category						Sex ratio M:F	Median length of stay until day of PPS (days)
			% < 1 month	% 1–11 months	% 1–17 years	% 18–64 years	% 65–84 years	% 85+ years		
EU/EEA	283 055	66	3.2	1.8	4.6	37.8	40.1	12.6	0.91:1	6
Country P25	3 810	63	2.9	1.2	3.8	35.4	37.5	9.4	0.85:1	6
Country P50	9 401	66	3.6	1.4	4.6	37.6	40.2	11.9	0.90:1	6
Country P75	14 945	68	4.2	2	5.8	40.9	41.6	13.9	0.96:1	8

P: percentile.

Table 5. Patient risk factors, patient-based data

	N of patients	% Surgery since admission	McCabe score				Invasive device use			
			% Non-fatal	% Ultimately fatal	% Rapidly fatal	% Missing	% CVC	% PVC	% Urinary catheter	% Intubation
EU/EEA	283 055	24.9	66.6	16.3	6.2	11.0	7.5	48.7	17.7	2.2
Country P25	3 810	20.1	62.0	10.1	3.5	1.4	5.1	36.4	13.3	1.5
Country P50	9 401	26.0	69.9	17.7	5.0	4.6	6.8	48.7	16.5	1.9
Country P75	14 945	29.3	75.6	20.1	6.9	15.8	8.7	60.4	19.9	3.1

CVC: central vascular catheter; PVC: peripheral vascular catheter; P: percentile; see Annex 1 (Table A1.1) for data by country.

Healthcare-associated infections

Main results - aggregated

Prevalence and type of infection

Out of the total of 310 755 patients in the database, 18 286 patients (5.9%; 95% confidence interval 5.8–6.0%) were reported to have at least one HAI. Of those, 17 640 (96.5%) patients had one HAI, 615 (3.4%) had two HAIs and 32 (0.2%) had three or more HAIs on the day of the survey. A total of 19 624 HAIs (1.07 HAI per infected patient) were reported. Ninety-six percent of patients with an HAI were receiving at least one antimicrobial on the day of the survey.

The most frequently reported types of HAI were pneumonia and lower respiratory tract infections (21.4% and 4.3%, respectively), urinary tract infections (18.9%), surgical site infections (18.3%), bloodstream infections (10.8%) and gastro-intestinal infections (8.9%), with *C. difficile* infections accounting for 54.6% of the latter or 4.8% of all HAIs. Systemic infections (n=1 069 HAIs or 5.4% of total) included clinical sepsis in neonates (n=123) and treated infections of unknown origin in adults and children (SYS-CSEP, n=744). Skin and soft tissue infections represented 4.2% of the total. Of these, 35.4% were skin infections, 35.4% soft tissue infections (necrotising fasciitis, infectious gangrene, necrotising cellulitis, infectious myositis, lymphadenitis, or lymphangitis), 20.4% decubitus ulcers and 3.1% burn infections. The remaining types of HAI (n=1 526) made up 7.8% of HAI cases and included 557 eye, ears, nose and throat (EENT) infections (2.8%, of which 53.0% were infections of the oral cavity, 22.1% were upper respiratory tract infections, pharyngitis, laryngitis or epiglottitis and 13.8% were conjunctivitis or other eye infections), 259 bone and joint infections (1.3%, of which 45.6% were osteomyelitis, 37.1% were joint or bursa infections and 9.6% were disc space infections), 226 microbiologically confirmed catheter-related infections without positive blood culture (1.2%, of which 55.8% related to a central vascular catheter and 44.2% related to a peripheral vascular catheter), 196 cardiovascular system infections (1.0%, of which 45.9% were endocardidtis, 31.1% were arterial or venous infections and 11.7% were mediastinitis), 167 central nervous system infections (0.9%, of which 57.5% were meningitis cases and 28.1% were intracranial infections) and 114 reproductive tract infections (0.6%, of which 25.4% were endometritis and 57.9% were other infections of the male or fenale reproductive tract). The detailed distribution of the types of HAI by country is summarised in Annex 1 (Table A1.3).

Table 6. Prevalence of HAIs by type of HAI and relative frequency of types of HAI

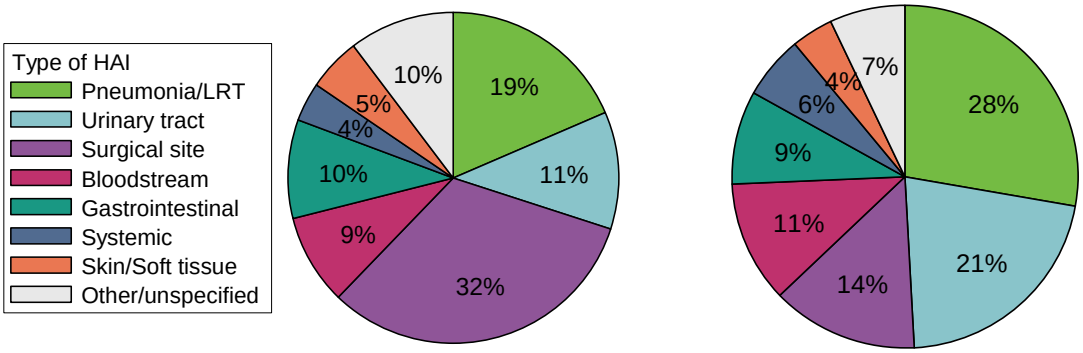
Type of HAI	N of patients with HAI	HAI%	N of HAIs	Relative frequency %
All types of HAI	**18 286**	**5.9**	**19 624**	**100**
Pneumonia	4 195	1.3	4 200	21.4
Other lower respiratory tract infections	836	0.3	838	4.3
Surgical site infections	3 590	1.2	3 601	18.3
Urinary tract infections	3 707	1.2	3 709	18.9
Bloodstream infections	2 099	0.7	2 115	10.8
Catheter-related infections without bloodstream infection	225	0.1	226	1.2
Cardiovascular system infections	196	0.1	196	1.0
Gastro-intestinal system infections[a]	1 735	0.5	1 743	8.9
Skin and soft tissue infections	822	0.3	823	4.2
Bone and joint infections	259	0.1	259	1.3
Central nervous system infections	167	0.1	167	0.9
Eye, ear, nose or mouth infection	553	0.2	557	2.8
Reproductive tract infections	114	0.0	114	0.6
Systemic infections[b]	1 069	0.3	1 069	5.4
Other/unknown	7	0.0	7	0.0

(a) including Clostridioides difficile infections: 4.8%; (b) including clinical sepsis (SYS-CSEP and NEO-CSEP): 4.4%. HAI%: percentage of patients with at least one HAI. Relative frequency: percentage of all HAIs.

Characteristics: origin, time to infection onset, association to device use

Twenty-three percent of HAIs (n=4 450) were present on admission. Of those, 60.5% were associated with a previous stay in the same hospital (Table 7). Almost one third of HAIs present on admission were surgical site infections (Figure 10). The main types of HAI included in 'Other or unspecified' types in HAIs present on admission (10%) were bone and joint infections (3.6%) and eye, ear and nose infections (2.0%).

Figure 10. Distribution of types of HAI by presence of HAI on admission (left) and HAI onset during hospitalisation (right)



LRT: Lower respiratory tract.

A total of 14 584 HAIs (74.3%) were attributed to the current hospital stay. For 589 HAIs (3.0%), the presence on admission was unknown. Of those, 451 (76.6%) were attributed to the same hospital, 94 (16.0%) to another acute care hospital and for 44 (7.5%) the origin was unknown. The 14 584 HAIs starting during the current hospital stay occurred in 13 511 patients, yielding an overall prevalence of 4.3%. The median duration of hospital stay until onset of the HAI was 12 days (mean 24.8 days).

The presence of relevant invasive devices (intermittent or continuous) in the days preceding the HAI onset was recorded for pneumonia (presence of intubation within the 48 hours before onset), urinary tract infections (presence of a urinary catheter within the seven days before onset) and bloodstream infections (presence of a vascular catheter within the 48 hours before onset). Healthcare-associated pneumonia were device-associated in 29.7% of the cases and urinary tract infections in 59.5%. Bloodstream infections were reported catheter-related in 36.1% (central vascular catheter 29.1% and peripheral vascular catheter 7.0%) and secondary to another infection site in 34.5%. For 29.4% of the bloodstream infections, the origin was unknown, either after clinical ascertainment of possible sources of the infection (20.6%), or because data were missing (8.8%). Primary bloodstream infections were catheter-associated (vascular catheter use within 48 hours before onset) in 75.5% of the cases.

Table 7. Characteristics of HAIs: origin, association with invasive device use, origin of bloodstream infections

Characteristics of HAIs	N of HAIs	%
Total number of HAIs	**19 623**	**100.0**
Origin of HAI		
HAIs present on admission	4 450	22.7
Origin		
Same hospital	2 697	13.7
Other hospital	1 515	7.7
Other origin/unknown	828	4.2
HAIs with onset during current hospitalisation	14 584	74.3
Day of HAI onset[a]		
Day 1–2	719	4.9
Day 3–4	1 490	10.2
Day 5–7	2 494	17.1
Day 8–14	3 516	24.1
Day 15–21	2 034	13.9
> Day 21	4 182	28.7
Missing date of HAI onset	149	1.0
HAI presence at admission unknown	589	3.0
HAI associated with current ward		
Yes	11 335	57.8
No	4 452	22.7
Missing/unknown	3 839	19.6
Device-associated HAIs		
Pneumonia, total[b]	4 200	100.0
Intubation within 48h before onset	1 246	29.7
No intubation	2 690	64.0

Characteristics of HAIs	N of HAIs	%
Presence of intubation unknown	264	6.3
Urinary tract infections, total	3 709	100.0
Urinary catheter within 7d before onset	2 206	59.5
No urinary catheter	1 311	35.3
Presence of urinary catheter unknown	192	5.2
Bloodstream infections, primary[c]	1 385	100.0
Vascular catheter within 48h before onset[d]	1 046	75.5
No vascular catheter	240	17.3
Presence of vascular catheter unknown	99	7.2
Origin of bloodstream infections (BSIs)[d]		
Total BSIs	2 115	100.0
Catheter-related (C) BSI[e]	763	36.1
C-CVC	615	29.1
Of which CRI3-CVC	408	66.3
C-PVC	148	7.0
Of which CRI3-PVC	82	55.4
Secondary (S) BSI[f]	730	34.5
S-Pulmonary infection	101	4.8
S-Urinary tract infection	214	10.1
S-Surgical site infection	120	5.7
S-Digestive tract infection	137	6.5
S-Skin/soft tissue infection	74	3.5
S-Other infection sites	84	4.0
BSI of unknown origin & missing	622	29.4
BSI of unknown origin[g]	435	20.6
Missing BSI origin	187	8.8

BSI: bloodstream infection; CVC: central vascular catheter; PVC: peripheral vascular catheter; CRI: catheter-related infection (with positive catheter tip microbiological results, see case definitions); CRI3: CRI with positive blood culture.
(a) HAIs with onset during current hospitalisation only.
(b) includes pneumonia subcategories PN1-PN5, PN-Nos and pneumonia in neonates (NEO-PNEU).
(c) Primary BSI = catheter-related BSI (including CRI3) and BSI of unknown origin.
(d) Including CRI3.
(e) C=catheter-related: clinical and/or microbiological (CRI3) evidence of relationship to central (C-CVC) or peripheral (C-PVC) vascular catheter.
(f) BSI secondary to another infection site.
(g) BSI origin was verified and confirmed to be unknown.

Microorganisms isolated from HAIs

For 52.7% of HAIs a microorganism was reported, ranging from 32.0% in pneumonia and lower respiratory tract infections to 92.8% in bloodstream infections. The microorganisms most frequently isolated from HAIs were, in decreasing order, *E. coli* (16.1%), *S. aureus* (11.6%), *Klebsiella* spp. (10.4%), *Enterococcus* spp. (9.7%), *P. aeruginosa* (8.0%), *C. difficile* (7.3%), Coagulase-negative staphylococci (7.1%), *Candida* spp. (5.2%), *Enterobacter* spp. (4.4%), *Proteus* spp. (3.6%) and *Acinetobacter* spp. (3.2%). Other less common microorganisms, but important because of their epidemic potential or intrinsic resistance to antimicrobials, were *Serratia* spp., *Stenotrophomonas maltophilia* and *Aspergillus* spp., that accounted for, respectively, 1.2%, 1.0% and 0.4% of all microorganisms.

The predominant families of microorganisms were gram-positive cocci in surgical site infections and bloodstream infections, Enterobacterales in urinary tract infections and respiratory tract infections, and anaerobes (especially *C. difficile*) were the most frequently reported family in gastro-intestinal tract infections (Table 8).

Table 8. Microorganisms isolated in HAIs by type of HAI

Microorganisms	All HAIs, Number	All HAIs, %	Pneumonia/ Lower respiratory tract infections	Surgical site infections	Urinary tract infections	Bloodstream infections	Gastro-intestinal tract infections
Number of HAIs, all	19 624	100.0	5 038	3 601	3 710	2 116	1743
Number of HAIs with microorganisms, all	10 338	52.7	32.0	57.1	65.5	92.8	70.9
Number of microorganisms	13 083	100.0	2 188	3 024	2 828	1 083	1 401
Gram-positive cocci	4 153	31.7	20.2	45.9	17.6	47.6	8.9

Microorganisms	All HAIs, Number	All HAIs, %	Pneumonia/ Lower respiratory tract infections	Surgical site infections	Urinary tract infections	Bloodstream infections	Gastro-intestinal tract infections
Staphylococcus aureus	1 522	11.6	12.4	18.1	1.7	15.5	0.6
Coagulase-negative staphylococci	933	7.1	1.7	9.4	1.1	18.8	1.6
Enterococcus spp.	1 275	9.7	2.6	13.8	14.0	9.0	5.9
Streptococcus spp.	331	2.5	3.1	3.6	0.6	2.8	0.8
Other gram-positive cocci	92	0.7	0.5	0.8	0.2	0.9	0.1
Gram-negative cocci	40	0.3	1.2	0.1	0.1	0.3	0.1
Gram-positive bacilli	91	0.7	0.5	0.8	0.2	0.9	0.1
Enterobacterales	5 017	38.3	35.7	34.9	66.3	33.2	12.1
Citrobacter spp.	140	1.1	1.4	1.3	1.1	0.8	0.4
Enterobacter spp.	570	4.4	6.0	6.2	3.3	3.7	1.4
Escherichia coli	2 106	16.1	7.4	13.7	36.8	13.6	4.8
Klebsiella spp.	1 365	10.4	14.3	7.4	15.1	10.7	3.9
Proteus spp.	473	3.6	2.4	3.6	7.7	1.7	0.4
Serratia spp.	153	1.2	2.6	0.8	0.7	1.4	0.3
Other Enterobacterales	210	1.6	1.7	2.0	1.7	1.2	1.0
Non-fermenting gram-negative bacteria	1 806	13.8	31.9	10.6	10.4	10.6	3.9
Acinetobacter spp.	418	3.2	8.2	2.1	1.6	3.4	0.4
Pseudomonas aeruginosa	1 048	8.0	15.1	7.3	8.0	5.3	2.3
Stenotrophomonas maltophilia	125	1.0	3.9	0.4	0.2	0.4	0.2
Pseudomonadaceae family, other	69	0.5	0.6	0.6	0.4	0.5	0.2
Haemophilus spp.	81	0.6	3.3	0.0	0.0	0.2	0.0
Legionella spp.	3	0.0	0.1	0.0	0.0	0.0	0.0
Other gram-negative bacteria	62	0.5	0.5	0.3	0.2	0.8	0.7
Anaerobic bacilli	1 116	8.5	0.4	3.2	0.1	1.0	69.3
Bacteroides spp.	60	0.5	0.0	1.4	0.0	0.3	0.4
Clostridioides difficile	961	7.3	0.0	0.0	0.0	0.0	68.4
Other anaerobes	95	0.7	0.3	1.9	0.0	0.6	0.5
Other bacteria	32	0.2	0.5	0.2	0.1	0.1	0.0
Fungi	767	5.9	9.1	4.3	5.1	6.3	3.8
Candida spp.	679	5.2	6.8	3.9	4.8	6.1	3.6
Aspergillus spp.	52	0.4	1.7	0.1	0.2	0.1	0.0
Other parasites	36	0.3	0.6	0.3	0.1	0.1	0.2
Viruses	62	0.5	0.6	0.0	0.0	0.1	1.9
Negative codes[a]	9 302	47.4	68.0	42.9	34.5	7.3	29.1
Micro-organism not identified	937	4.8	6.8	4.1	3.6	0.7	3.6
Examination not done	2 455	12.5	22.6	9.1	7.4	0.3	6.6
Sterile examination	645	3.3	3.2	3.1	1.9	0.2	3.0
Not (yet) available/missing	5 265	26.8	35.4	26.6	21.6	6.1	15.9

(a) Negative codes: percentage of total number of HAIs.

Selected antimicrobial susceptibility testing (AST) data were available on the day of the survey for 88.7% of microorganisms reported for HAIs. Methicillin resistance was reported in 31.0% of *S. aureus* isolates with known AST results. Vancomycin resistance was reported in 11.4% of isolated enterococci and was considerably higher among *E. faecium* than *E. faecalis* (24.3% *vs* 3.6%). Resistance to third-generation cephalosporins was reported in 34.7% of all Enterobacterales included for the selected antimicrobial resistance markers (Table 9) and was the highest among *K. pneumoniae* and the lowest for *Serratia* spp. Resistance to carbapenems was reported for 7.1% of all included Enterobacterales, also the highest among *K. pneumoniae,* and in 32.2% of *P. aeruginosa* isolates and 78.2% of *A. baumannii* isolates. However, overall European resistance percentages are strongly influenced by the data of relatively few countries that reported higher numbers of these microorganisms (see below for results by country).

Table 9. Selected antimicrobial resistance markers in selected microorganisms reported in healthcare-associated infections

Microorganisms and resistance	N of isolates	N with known result	% R
Gram-positive cocci	2 797	2 451	21.9
Staphylococcus aureus, METI-R MRSA	1 522	1 355	30.9
Enterococcus spp., VAN-R (VRE)	1 275	1 096	10.8
Enterococcus faecalis, VAN-R	742	635	3.2
Enterococcus faecium, VAN-R	410	375	24.2
Enterobacterales, 3GC-R	4 936	4 369	33.3
Escherichia coli, 3GC-R	2 106	1 851	22.3
Klebsiella spp., 3GC-R	1 364	1 233	55.2
Klebsiella pneumoniae, 3GC-R	1 148	1 061	60.3
Klebsiella oxytoca, 3GC-R	151	118	13.6
Enterobacter spp., 3GC-R	570	509	40.7
Enterobacter aerogenes, 3GC-R	92	86	40.7
Enterobacter cloacae, 3GC-R	423	385	42.6
Citrobacter spp., 3GC-R	140	127	21.3
Proteus spp., 3GC-R	473	404	17.8
Serratia spp., 3GC-R	153	133	15.0
Morganella spp., 3GC-R	130	112	31.3
Enterobacterales, CAR-R	4 936	4 352	6.2
Escherichia coli, CAR-R	2 106	1 845	1.2
Klebsiella spp., CAR-R	1 364	1 219	18.3
Klebsiella pneumoniae, CAR-R	1 148	1 042	20.4
Klebsiella oxytoca, CAR-R	151	120	4.2
Enterobacter spp., CAR-R	570	513	2.7
Enterobacter aerogenes, CAR-R	92	87	2.3
Enterobacter cloacae, CAR-R	423	385	2.9
Citrobacter spp., CAR-R	140	125	0.8
Proteus spp., CAR-R	473	399	1.5
Serratia spp., CAR-R	153	136	1.5
Morganella spp., CAR-R	130	115	1.7
Other gram-negative bacteria, CAR-R	1 421	1 297	42.6
Pseudomonas aeruginosa, CAR-R	1 048	953	30.2
Acinetobacter baumannii, CAR-R	373	344	77.0

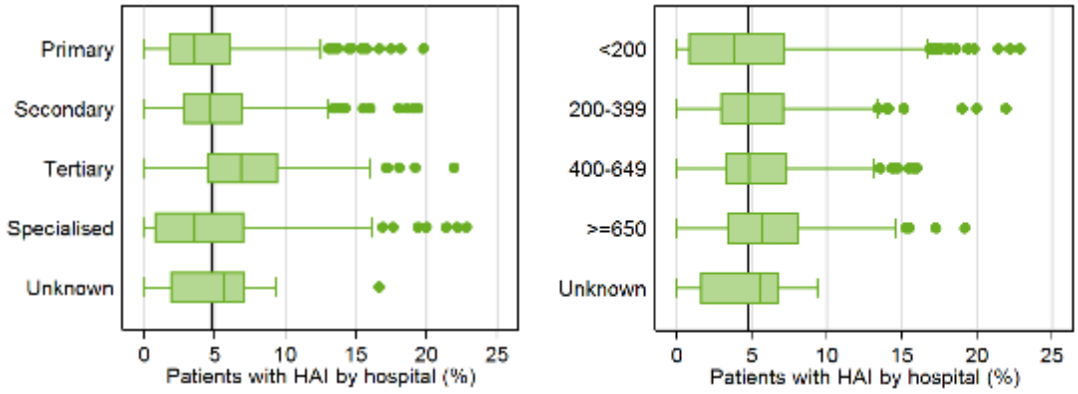
N=number, R=resistant, N with known result: N of isolates with known susceptibility results (susceptible, intermediate, resistant), %R=N R/N with known results, MRSA=meticillin-resistant Staphylococcus aureus*, VRE=vancomycin-resistant* Enterococcus *spp., METI=methicillin, VAN=vancomycin, 3GC=Third-generation cephalosporin, CAR=carbapenem.*

Results by type of hospital, medical specialty and patient risk factors

The prevalence of HAIs varied by type of hospital and considerably within each type of hospital. The median HAI prevalence was 3.6% in primary hospitals (IQR: 1.8–6.1%), 4.7% in secondary hospitals (IQR: 2.8–6.9%), 6.9% in tertiary hospitals (IQR: 4.5–9.4%) and 3.6% in specialised hospitals (IQR 0.8–7.0%) (Figure 11).

The prevalence of HAIs also increased significantly with hospital size, from a median of 3.8% (IQR: 0.8–7.2) in hospitals with fewer than 200 beds to a median of 5.7% (IQR: 3.4–8.1) in hospitals with 650 beds or more (Figure 11).

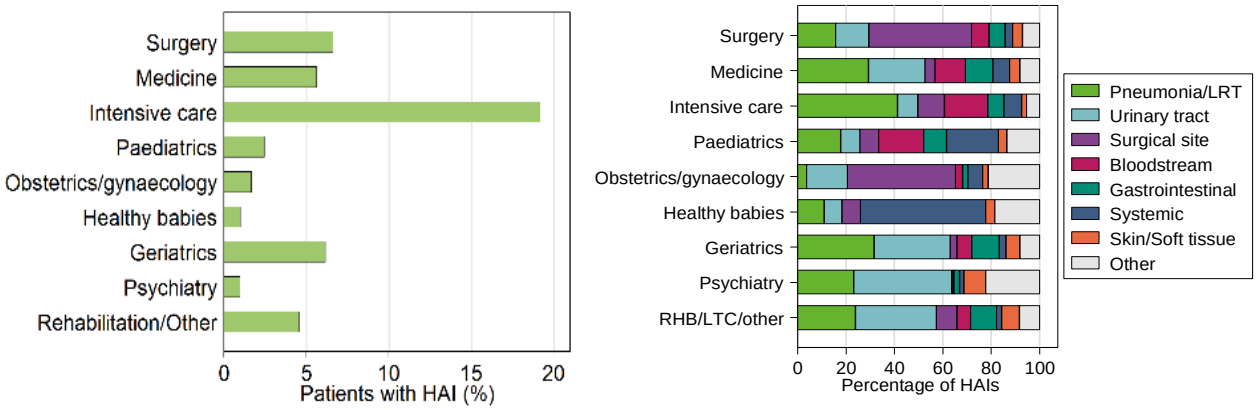
Figure 11. Prevalence of HAI (percentage patients with an HAI) by hospital type (left) and size (n of beds) (right), n=1 209 hospitals



Vertical black line= median.

HAI prevalence was the highest among patients admitted to ICUs, where 19.1% of patients had at least one HAI, compared 6.6% in common surgical specialties or 5.6% in common internal medicine specialties (Figure 12). Patients in ICUs accounted for 4.6% of the total hospital population, but for 15.0% of all patients with an HAI. The most common types of HAI in the ICU were respiratory infections (pneumonia and lower respiratory tract infections) and bloodstream infections. Urinary tract infection was the dominant type of HAI in geriatrics, psychiatry and rehabilitation/other specialties, while surgical site infection was the most common type of HAI in surgery and obstetrics and gynaecology. Among paediatric patients, clinical sepsis accounted for an important segment of HAIs, as shown by the high proportion of systemic infections in Figure 12.

Figure 12. Prevalence of HAIs (percentage of patients with an HAI) (left) and distribution of types of HAI (right) by patient/consultant specialty



LRT: Lower respiratory tract. RHB: Rehabilitation. LTC: long-term care

Patient risk factors could be analysed for standard (patient-based) protocol data only and included 297 003 patients. The overall HAI prevalence among these patients was 6.0% (Table 10). All risk factors except hospital size (not included in final model) were significantly associated with HAI prevalence at the $p<0.001$ level after adjustment for all factors in the model. The strongest independent associations (adjusted odds ratio ≥2 or ≤0.5) were observed for length of stay in the hospital before the onset of HAI, the presence of intubation and urinary catheters (before the onset of pneumonia and urinary tract infections, respectively), for the high-risk specialties haematology and neonatal ICU, and for the low-risk specialties obstetrics and maternity, and psychiatry. The association with the presence of central and peripheral vascular catheters was not examined because of the association of parenteral treatment with HAIs. The discriminatory power of the model as measured by the area under the ROC curve was 0.78 for the final model when performed on the full database.

Table 10. Patient risk factors for HAI with crude and adjusted odds ratios derived from multiple logistic regression model, n=283 055 patients in 29 countries (standard protocol data only)

	N of patients	% of total	N of pts with ≥1 HAI	Pts with HAI %	Crude OR	(95%	CI)	Adj OR*	(95%	CI)
All patients	283 055	100.0	17 066	6.0	-			-		
Age										
5-44 years	50 216	17.7	1 782	3.5	ref.	-		ref.	-	
<1 month	9 024	3.2	250	2.8	0.8	(0.7 -	0.9)	1.2	(0.9 -	1.5)
1-11 months	4 967	1.8	278	5.6	1.6	(1.4 -	1.8)	1.1	(0.9 -	1.3)
1-4 years	4 250	1.5	138	3.2	0.9	(0.8 -	1.1)	0.9	(0.7 -	1.0)
45-74 years	120 440	42.6	8 086	6.7	2.0	(1.9 -	2.1)	1.2	(1.1 -	1.2)
75-84 years	58 570	20.7	4 164	7.1	2.1	(2.0 -	2.2)	1.2	(1.1 -	1.3)
≥85 years	35 588	12.6	2 368	6.7	1.9	(1.8 -	2.1)	1.2	(1.1 -	1.3)
Gender										
Female/other/unknown	148 737	52.5	7 749	5.2	Ref.	-		Ref.	-	
Male	134 318	47.5	9 317	6.9	1.4	(1.3 -	1.4)	1.1	(1.1 -	1.2)
Length of stay (days)[a]										
1-3 days	86 862	30.7	2 441	2.8	ref.	-		ref.	-	
4-7 days	72 429	25.6	4 142	5.7	2.1	(2.0 -	2.2)	1.8	(1.7 -	1.9)
8-14 days	53 644	19.0	4 171	7.8	2.9	(2.8 -	3.1)	2.3	(2.2 -	2.4)
15-29 days	34 805	12.3	3 505	10.1	3.9	(3.7 -	4.1)	3.0	(2.8 -	3.2)
>=30 days	35 032	12.4	2 804	8.0	3.0	(2.8 -	3.2)	2.6	(2.4 -	2.7)
Unknown	283	0.1	3	1.1	0.4	(0.1 -	1.2)	0.4	(0.1 -	1.2)
McCabe score										
Non-fatal	188 438	66.6	8 171	4.3	ref.	-		ref.	-	
Ultimately fatal	46 012	16.3	4 578	9.9	2.4	(2.3 -	2.5)	1.6	(1.5 -	1.6)
Rapidly fatal	17 532	6.2	2 357	13.4	3.4	(3.3 -	3.6)	1.9	(1.8 -	2.0)
Unknown	31 073	11.0	1 960	6.3	1.5	(1.4 -	1.6)	1.2	(1.2 -	1.3)
Surgery since admission (code)										
No surgery	210 400	74.3	10 256	4.9	ref.	-		ref.	-	
NHSN surgery										
NHSN surgery, not specified	25 188	8.9	2 431	9.7	2.1	(2.0 -	2.2)	1.7	(1.6 -	1.8)
AAA-Abdominal aortic aneurysm repair	205	0.1	31	15.1	3.5	(2.4 -	5.1)	1.6	(1.0 -	2.3)
AMP-Limb amputation	936	0.3	134	14.3	3.3	(2.7 -	3.9)	1.9	(1.6 -	2.4)
APPY-Appendix surgery	594	0.2	17	2.9	0.6	(0.4 -	0.9)	0.8	(0.5 -	1.4)
AVSD-Shunt for dialysis	55	0.0	9	16.4	3.8	(1.9 -	7.8)	2.5	(1.2 -	5.3)
BILI-Bile duct, liver or pancreatic surgery	646	0.2	127	19.7	4.8	(3.9 -	5.8)	2.5	(2.0 -	3.0)
BRST-Breast surgery	621	0.2	16	2.6	0.5	(0.3 -	0.8)	0.7	(0.4 -	1.2)
CARD-Cardiac surgery	1 191	0.4	200	16.8	3.9	(3.4 -	4.6)	1.5	(1.2 -	1.7)
CBGB-Coronary artery bypass graft with both chest and donor site incisions	323	0.1	66	20.4	5.0	(3.8 -	6.6)	1.9	(1.4 -	2.5)
CBGC-Coronary artery bypass graft with chest incision only	185	0.1	22	11.9	2.6	(1.7 -	4.1)	1.1	(0.7 -	1.8)
CEA-Carotid endarterectomy	95	0.0	8	8.4	1.8	(0.9 -	3.7)	1.3	(0.6 -	2.8)
CHOL-Gallbladder surgery	746	0.3	55	7.4	1.6	(1.2 -	2.0)	1.5	(1.1 -	2.0)
COLO-Colon surgery	2 022	0.7	364	18.0	4.3	(3.8 -	4.8)	2.2	(2.0 -	2.5)
CRAN-Craniotomy	1 262	0.4	229	18.1	4.3	(3.7 -	5.0)	1.7	(1.4 -	2.0)
CSEC-Caesarean section	1 775	0.6	41	2.3	0.5	(0.3 -	0.6)	2.2	(1.5 -	3.1)
FUSN-Spinal fusion	463	0.2	46	9.9	2.2	(1.6 -	2.9)	1.7	(1.2 -	2.3)
FX-Open reduction of fracture	2 852	1.0	185	6.5	1.4	(1.2 -	1.6)	1.1	(0.9 -	1.3)
GAST-Gastric surgery	647	0.2	110	17.0	4.0	(3.3 -	4.9)	2.3	(1.8 -	2.8)
HER-Herniorrhaphy	794	0.3	54	6.8	1.4	(1.1 -	1.9)	1.7	(1.2 -	2.2)
HPRO-Hip prosthesis	2 801	1.0	219	7.8	1.7	(1.4 -	1.9)	1.5	(1.3 -	1.7)
HTP-Heart transplant	31	0.0	7	22.6	5.7	(2.5 -	13.2)	1.7	(0.7 -	4.2)
HYST-Abdominal hysterectomy	409	0.1	31	7.6	1.6	(1.1 -	2.3)	2.1	(1.4 -	3.1)
KPRO-Knee prosthesis	1 569	0.6	76	4.8	1.0	(0.8 -	1.3)	1.2	(0.9 -	1.5)
KTP-Kidney transplant	177	0.1	29	16.4	3.8	(2.6 -	5.7)	1.6	(1.0 -	2.4)
LAM-Laminectomy	706	0.2	57	8.1	1.7	(1.3 -	2.2)	1.5	(1.1 -	2.0)
LTP-Liver transplant	104	0.0	35	33.7	9.9	(6.6 -	14.9)	3.5	(2.3 -	5.5)
NECK-Neck surgery	482	0.2	83	17.2	4.1	(3.2 -	5.1)	3.0	(2.3 -	4.0)
NEPH-Kidney surgery	496	0.2	42	8.5	1.8	(1.3 -	2.5)	1.3	(0.9 -	1.8)
OVRY-Ovarian surgery	297	0.1	15	5.1	1.0	(0.6 -	1.7)	1.6	(0.9 -	2.7)
PACE-Pacemaker surgery	268	0.1	24	9.0	1.9	(1.3 -	2.9)	1.7	(1.1 -	2.6)
PRST-Prostate surgery	390	0.1	20	5.1	1.1	(0.7 -	1.7)	0.8	(0.5 -	1.3)

	N of patients	% of total	N of pts with ≥1 HAI	Pts with HAI %	Crude OR	(95% CI)		Adj OR*	(95% CI)	
PVBY-Peripheral vascular bypass surgery	429	0.2	57	13.3	3.0	(2.3 -	4.0)	2.2	(1.6 -	3.0)
REC-Rectal surgery	394	0.1	68	17.3	4.1	(3.1 -	5.3)	2.7	(2.0 -	3.5)
RFUSN-Refusion of spine	125	0.0	9	7.2	1.5	(0.8 -	3.0)	1.2	(0.6 -	2.5)
SB-Small bowel surgery	543	0.2	107	19.7	4.8	(3.9 -	5.9)	2.4	(1.9 -	3.0)
SPLE-Spleen surgery	64	0.0	12	18.8	4.5	(2.4 -	8.4)	2.4	(1.2 -	4.7)
THOR-Thoracic surgery	635	0.2	101	15.9	3.7	(3.0 -	4.6)	2.1	(1.6 -	2.7)
THYR-Thyroid and/or parathyroid surgery	380	0.1	8	2.1	0.4	(0.2 -	0.8)	0.6	(0.3 -	1.3)
VHYS-Vaginal hysterectomy	247	0.1	7	2.8	0.6	(0.3 -	1.2)	0.8	(0.4 -	1.8)
VSHN-Ventricular shunt	169	0.1	36	21.3	5.3	(3.7 -	7.6)	2.3	(1.5 -	3.4)
XLAP-Exploratory laparotomy	739	0.3	134	18.1	4.3	(3.6 -	5.2)	2.5	(2.0 -	3.0)
Minimal/non-NSHN surgery	17 662	6.2	1 355	7.7	1.6	(1.5 -	1.7)	1.6	(1.5 -	1.7)
Unknown	2 938	1.0	133	4.5	0.9	(0.8 -	1.1)	1.0	(0.8 -	1.2)
Presence of invasive devices										
Intubation	6 059	2.1	1 741	28.7	6.9	(6.5 -	7.3)	2.0	(1.8 -	2.1)
Urinary catheter	49 802	17.6	7 096	14.2	3.7	(3.6 -	3.8)	2.2	(2.1 -	2.2)
Central vascular catheter [b]	21 038	7.4	4 725	22.5	5.9	(5.6 -	6.1)			
Peripheral vascular catheter [b]	137 112	48.4	10 090	7.4	1.6	(1.5 -	1.6)			
Patient/consultant specialty (code)										
General surgery	18 976	6.7	1 362	7.2	ref.	-		ref.	-	
Digestive tract surgery	4 632	1.6	488	10.5	1.5	(1.4 -	1.7)	1.3	(1.2 -	1.5)
Orthopaedics and traumatology	8 405	3.0	523	6.2	0.9	(0.8 -	1.0)	1.0	(0.9 -	1.1)
Orthopaedics	9 899	3.5	573	5.8	0.8	(0.7 -	0.9)	0.9	(0.8 -	1.0)
Traumatology	3 871	1.4	247	6.4	0.9	(0.8 -	1.0)	1.0	(0.9 -	1.2)
Cardio surgery	1 955	0.7	273	14.0	2.1	(1.8 -	2.4)	1.6	(1.4 -	1.9)
Cardiovascular surgery	722	0.3	95	13.2	2.0	(1.6 -	2.4)	1.5	(1.2 -	1.9)
Vascular surgery	3 545	1.3	287	8.1	1.1	(1.0 -	1.3)	0.9	(0.8 -	1.1)
Thoracic surgery	1 246	0.4	94	7.5	1.1	(0.8 -	1.3)	0.9	(0.7 -	1.2)
Neurosurgery	4 887	1.7	447	9.1	1.3	(1.2 -	1.5)	1.1	(1.0 -	1.3)
Paediatric general surgery	1 328	0.5	39	2.9	0.4	(0.3 -	0.5)	0.7	(0.5 -	0.9)
Transplantation surgery	616	0.2	85	13.8	2.1	(1.6 -	2.6)	1.5	(1.2 -	1.9)
Surgery for cancer	1 140	0.4	97	8.5	1.2	(1.0 -	1.5)	1.0	(0.8 -	1.2)
Ear-nose-throat	3 584	1.3	119	3.3	0.4	(0.4 -	0.5)	0.6	(0.5 -	0.7)
Ophthalmology	1 707	0.6	14	0.8	0.1	(0.1 -	0.2)	0.2	(0.1 -	0.4)
Maxillo-facial surgery	816	0.3	44	5.4	0.7	(0.5 -	1.0)	0.8	(0.6 -	1.1)
Stomatology/ Dentistry	70	0.0	3	4.3	0.6	(0.2 -	1.8)	1.1	(0.3 -	3.6)
Burns care	260	0.1	34	13.1	1.9	(1.4 -	2.8)	1.7	(1.2 -	2.5)
Urology	6 544	2.3	391	6.0	0.8	(0.7 -	0.9)	0.8	(0.7 -	0.9)
Plastic and reconstructive surgery	1 567	0.6	115	7.3	1.0	(0.8 -	1.2)	1.2	(1.0 -	1.5)
Other surgery	1 016	0.4	47	4.6	0.6	(0.5 -	0.8)	0.7	(0.5 -	1.0)
General medicine	39 411	13.9	2 328	5.9	0.8	(0.8 -	0.9)	1.0	(0.9 -	1.0)
Gastro-enterology	7 049	2.5	346	4.9	0.7	(0.6 -	0.8)	0.9	(0.8 -	1.0)
Hepatology	476	0.2	40	8.4	1.2	(0.9 -	1.6)	1.1	(0.8 -	1.6)
Endocrinology	2 764	1.0	94	3.4	0.5	(0.4 -	0.6)	0.7	(0.5 -	0.8)
Nephrology	4 265	1.5	414	9.7	1.4	(1.2 -	1.6)	1.5	(1.3 -	1.7)
Cardiology	14 939	5.3	588	3.9	0.5	(0.5 -	0.6)	0.7	(0.6 -	0.8)
Dermatology	1 524	0.5	30	2.0	0.3	(0.2 -	0.4)	0.5	(0.3 -	0.7)
Haematology	3 334	1.2	531	15.9	2.4	(2.2 -	2.7)	2.6	(2.3 -	2.9)
Bone Marrow Transplantation	279	0.1	57	20.4	3.3	(2.5 -	4.5)	3.5	(2.6 -	4.8)
Haematology/BMT	768	0.3	138	18.0	2.8	(2.3 -	3.4)	3.0	(2.4 -	3.6)
Oncology	7 222	2.6	521	7.2	1.0	(0.9 -	1.1)	1.0	(0.9 -	1.2)
Neurology	12 854	4.5	710	5.5	0.8	(0.7 -	0.8)	1.0	(0.9 -	1.1)
Pneumology	9 933	3.5	449	4.5	0.6	(0.5 -	0.7)	0.7	(0.7 -	0.8)
Rheumatology	1 640	0.6	30	1.8	0.2	(0.2 -	0.3)	0.4	(0.3 -	0.6)
Infectious diseases	4 087	1.4	332	8.1	1.1	(1.0 -	1.3)	1.4	(1.2 -	1.6)
Medical traumatology	1 114	0.4	29	2.6	0.3	(0.2 -	0.5)	0.5	(0.3 -	0.7)
Other medical	3 853	1.4	156	4.0	0.5	(0.5 -	0.6)	0.7	(0.6 -	0.9)
Healthy neonates (maternity)	2 904	1.0	16	0.6	0.1	(0.0 -	0.1)	0.2	(0.1 -	0.4)
Healthy neonates (paediatrics)	1 163	0.4	11	0.9	0.1	(0.1 -	0.2)	0.4	(0.2 -	0.7)
Neonatology	3 351	1.2	111	3.3	0.4	(0.4 -	0.5)	0.9	(0.7 -	1.3)
Paediatrics general, not specialised	7 587	2.7	151	2.0	0.3	(0.2 -	0.3)	0.7	(0.6 -	0.8)
Medical intensive care unit (ICU)	2 625	0.9	469	17.9	2.8	(2.5 -	3.2)	1.5	(1.3 -	1.7)
Surgical ICU	2 359	0.8	554	23.5	4.0	(3.6 -	4.4)	1.5	(1.3 -	1.6)

	N of patients	% of total	N of pts with ≥1 HAI	Pts with HAI %	Crude OR	(95%	CI)	Adj OR*	(95%	CI)
Paediatric ICU	725	0.3	110	15.2	2.3	(1.9 -	2.9)	2.0	(1.5 -	2.5)
Neonatal ICU	2 220	0.8	207	9.3	1.3	(1.1 -	1.6)	1.8	(1.4 -	2.4)
Mixed (polyvalent) ICU	3 404	1.2	923	27.1	4.8	(4.4 -	5.3)	1.7	(1.6 -	2.0)
Specialised ICU	1 031	0.4	182	17.7	2.8	(2.3 -	3.3)	1.4	(1.1 -	1.6)
Other ICU	282	0.1	44	15.6	2.4	(1.7 -	3.3)	1.4	(1.0 -	1.9)
Obstetrics / Maternity	11 210	4.0	118	1.1	0.1	(0.1 -	0.2)	0.3	(0.2 -	0.4)
Gynaecology	4 916	1.7	162	3.3	0.4	(0.4 -	0.5)	0.7	(0.6 -	0.9)
Geriatrics, care for the elderly	12 203	4.3	753	6.2	0.9	(0.8 -	0.9)	0.9	(0.8 -	1.0)
Psychiatrics	15 126	5.3	165	1.1	0.1	(0.1 -	0.2)	0.2	(0.2 -	0.3)
Rehabilitation	8 528	3.0	394	4.6	0.6	(0.6 -	0.7)	0.7	(0.6 -	0.8)
Long-term care	6 512	2.3	250	3.8	0.5	(0.4 -	0.6)	0.5	(0.4 -	0.5)
Others not listed	3 049	1.1	170	5.6	0.8	(0.6 -	0.9)	0.9	(0.7 -	1.0)
Combination of specialties	1 271	0.4	92	7.2	1.0	(0.8 -	1.3)	1.2	(0.9 -	1.5)
Unknown	293	0.1	14	4.8	0.6	(0.4 -	1.1)	1.0	(0.6 -	1.7)
Birth weight										
>=2500g	6 595	2.3	126	1.9	ref.	-		ref.	-	
1500-<2500 (low birth weight, LBW)	1 867	0.7	56	3.0	1.6	(1.2 -	2.2)	0.6	(0.4 -	0.8)
<1500g (very low birth weight, VLBW)	1 185	0.4	117	9.9	5.6	(4.3 -	7.3)	1.2	(0.9 -	1.7)
Unknown/Not applicable	273 408	96.6	16 767	6.1	3.4	(2.8 -	4.0)	1.1	(0.8 -	1.5)
Type of hospital										
Primary	46 110	16.3	2 103	4.6	ref.	-		ref.	-	
Secondary	102 937	36.4	5 509	5.4	1.2	(1.1 -	1.2)	1.1	(1.1 -	1.2)
Tertiary	112 088	39.6	8 234	7.3	1.7	(1.6 -	1.7)	1.3	(1.3 -	1.4)
Specialised	19 979	7.1	1 085	5.4	1.2	(1.1 -	1.3)	1.4	(1.2 -	1.6)
Unknown	1 941	0.7	135	7.0	1.6	(1.3 -	1.9)	1.0	(0.7 -	1.4)
Hospital specialty										
General hospital/unknown	264 339	93.4	16 102	6.1	ref.	-		ref.	-	
Paediatrics/Neonates	2 468	0.9	133	5.4	0.9	(0.7 -	1.0)	0.8	(0.7 -	1.0)
Psychiatrics	3 140	1.1	63	2.0	0.3	(0.2 -	0.4)	0.9	(0.6 -	1.1)
Surgery/Orthopaedics/Traumatology	3 186	1.1	147	4.6	0.7	(0.6 -	0.9)	0.7	(0.6 -	0.9)
Heart/Lung	1 997	0.7	150	7.5	1.3	(1.1 -	1.5)	0.8	(0.6 -	1.0)
Haematology/Oncology	2 917	1.0	223	7.6	1.3	(1.1 -	1.5)	0.9	(0.7 -	1.0)
Gynaecology/Obstetrics	1 538	0.5	36	2.3	0.4	(0.3 -	0.5)	1.0	(0.7 -	1.5)
Infectious diseases	570	0.2	59	10.4	1.8	(1.4 -	2.3)	1.5	(1.1 -	2.1)
Geriatrics/Rehabilitation/Rheumatology	950	0.3	63	6.6	1.1	(0.8 -	1.4)	1.3	(1.0 -	1.8)
Other	1 950	0.7	90	4.6	0.7	(0.6 -	0.9)	0.9	(0.7 -	1.2)
Hospital size										
<200 beds	29 702	10.5	1 640	5.5	ref.	-		ref.	-	
200-399 beds	60 490	21.4	3 397	5.6	1.0	(1.0 -	1.1)	0.9	(0.9 -	1.0)
400-649 beds	68 541	24.2	3 963	5.8	1.1	(1.0 -	1.1)	0.9	(0.8 -	0.9)
650-899 beds	42 084	14.9	2 670	6.3	1.2	(1.1 -	1.2)	0.9	(0.8 -	1.0)
>=900 beds	82 238	29.1	5 396	6.6	1.2	(1.1 -	1.3)	0.8	(0.8 -	0.9)
Hospital ownership										
Public	265 185	89.0	15 827	6.0	ref.	-		ref.	-	
Private, not-for-profit	17 895	6.3	1 116	6.2	1.0	(1.0 -	1.1)	1.1	(1.1 -	1.2)
Private, for profit	8 755	3.1	358	4.1	0.7	(0.6 -	0.7)	0.8	(0.7 -	0.9)
Other/Unknown	6 202	5.5	415	6.7	1.1	(1.0 -	1.2)	1.1	(1.0 -	1.2)

**Adj. OR: Adjusted odds ratio in fixed-effect multiple logistic regression model*
(a) Length of stay in days until onset of HAI if HAI during current hospitalisation (b) CVC and PVC: adjusted odds ratios not calculated and variables not included in model because of correlation with treatment of HAI (parenteral antimicrobial treatment).

Results by country

HAI prevalence: observed and predicted based on patient case mix

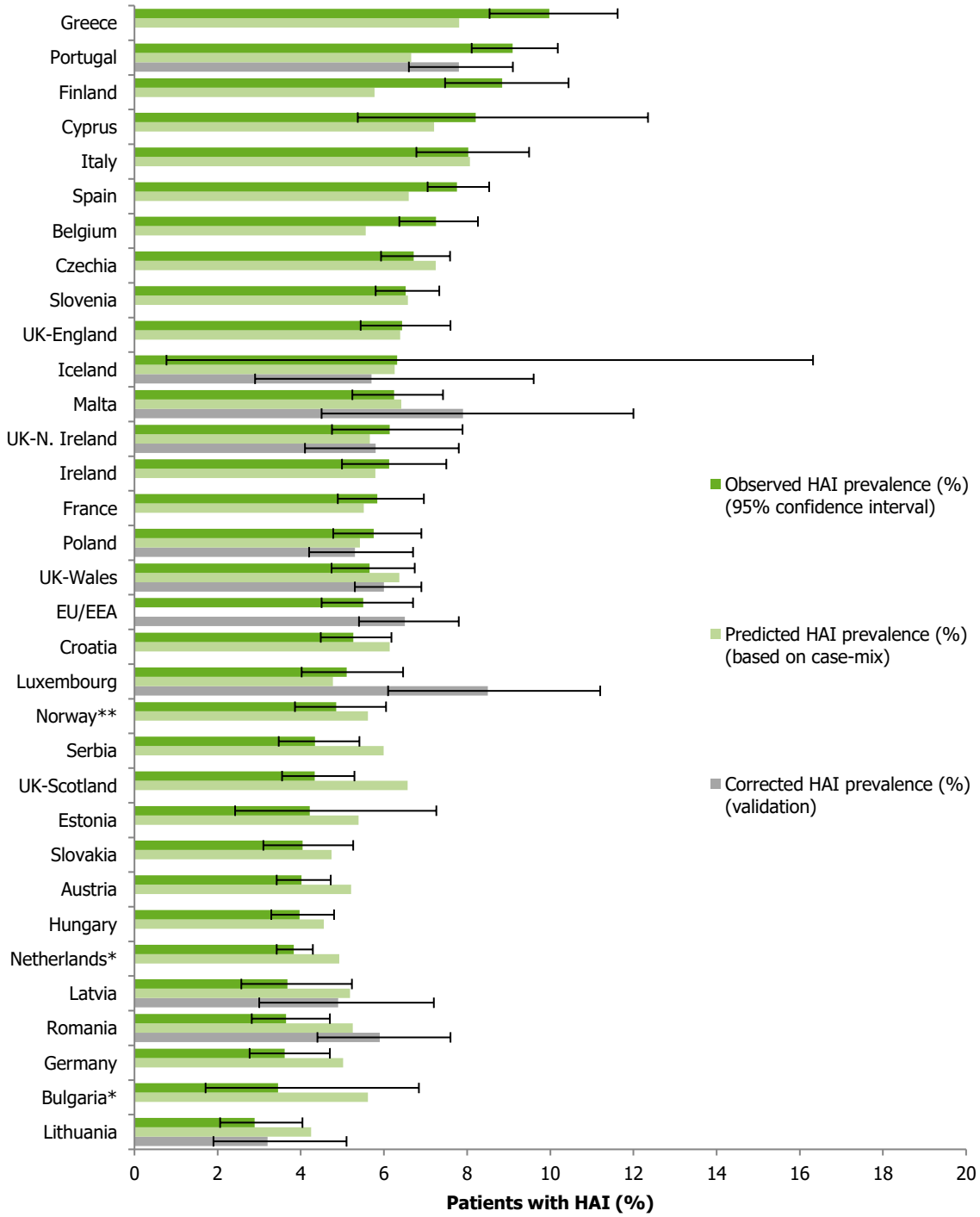
The prevalence of HAIs is known to be influenced by a variety of factors such as the type of hospital and healthcare system, the severity of the patient case mix (co-morbidities), methodological differences such as different interpretations of the case definitions for HAIs or application of the protocol, differences in microbiological sampling recommendations and/or practices, availability of diagnostic tests, differences in the level of training and skills of healthcare workers applying the definitions, and differences in reporting behaviour between hospitals and between countries. Comparing crude prevalence percentages of HAI between countries without taking into account differences in patient case mix, representativeness and confidence intervals, differences in sensitivity and specificity, and differences in diagnostic (especially microbiological) support is not meaningful, and it can lead to misleading or false conclusions.

Using the multiple logistic regression model shown in Table 10, a predicted prevalence was determined for each country applying the average European individual patient risk factors in each country and then summing up the individual patient probabilities for each country (sum of probabilities=predicted or 'expected' number of HAIs). For light protocol data (8.9% of the patients), a model including patient/consultant specialty, type of hospital and hospital size was used (model not shown). The predicted and observed HAI prevalence by country are graphically presented in Figure 13. Observed HAI prevalence percentages are also displayed with 95% CIs, indicating that, by chance, the result of the PPS might as well have been on the lower or the upper limit of the interval, e.g. if other hospitals had been randomly selected or if the survey had been performed on another day.

The HAI prevalence (percentage of patients with an HAI) by country ranged from 2.9% in Lithuania (95% CI: 2.1–4.0%) to 10.0% (95% CI: 8.5%–11.6%) in Greece. When the total number of occupied acute care hospital beds per country was taken into account, the weighted HAI prevalence in the EU/EEA was 5.5% (95% CI: 4.5%–6.7%). The mean of the country prevalence percentages was 5.7%, the country median was 5.8%.

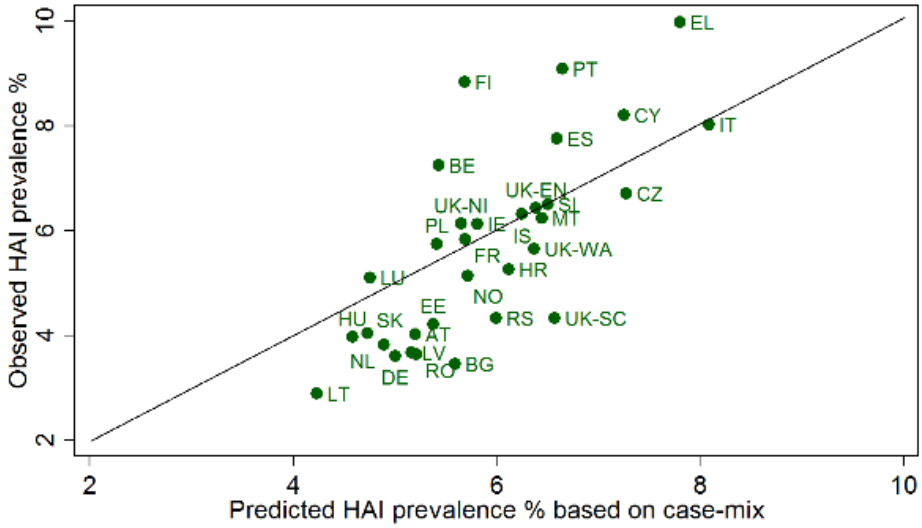
The correlation between the observed and predicted prevalence by country is shown in Figure 14 (Spearman's rho 0.78, $p<0.001$, R-squared 0.56). The ratio of the observed divided by the predicted prevalence (standardised infection ratio, SIR) varied from 0.62 in Bulgaria to 1.56 in Finland.

Figure 13. Observed HAI prevalence and HAI prevalence corrected after validation with 95% confidence intervals and predicted HAI prevalence based on patient case-mix and hospital characteristics, by country



**Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol. The grey bars represent the prevalence corrected according to results of validation studies (only shown for countries with a representative validation sample, see Table 11).*

Figure 14. Correlation between the observed and predicted prevalence of healthcare-associated infections HAIs, by country



*Line: Observed prevalence = predicted prevalence (Standardised Infection Ratio (SIR) =1). Countries below the line have a SIR lower than 1, countries above the line have a SIR higher than 1. The smaller the distance between the dot and the line, the closer the observed prevalence comes to the predicted prevalence based on patient case mix. *Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol.*

Validation of HAI data

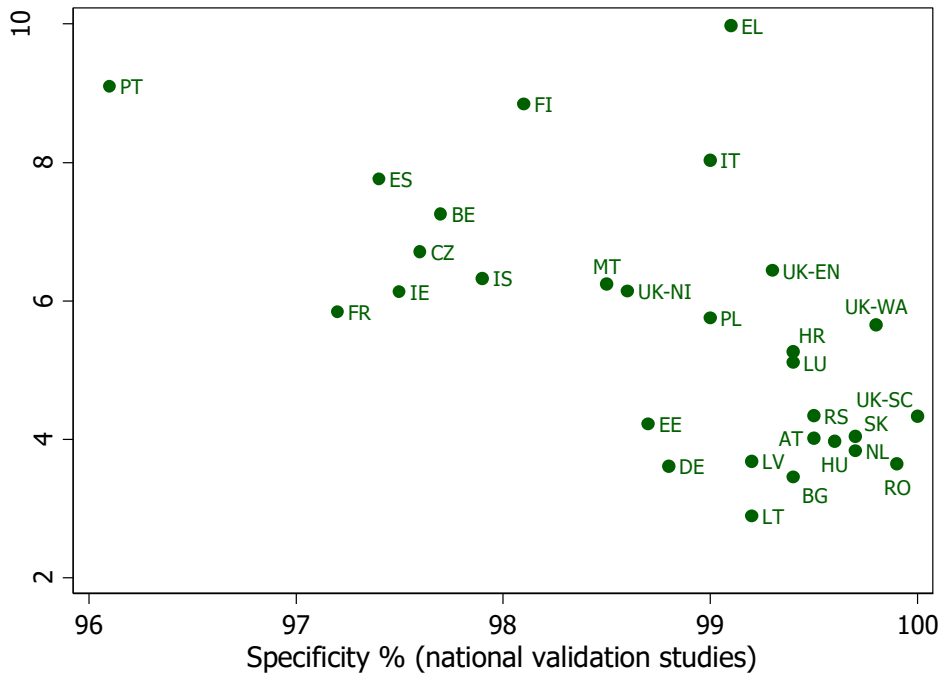
National validation studies

In 2016-2017, 28 EU/EEA countries (counting UK administrations separately) and Serbia performed a validation survey during the national PPS using the ECDC PPS validation protocol [27], including a total of 241 validated hospitals and 12 477 validated patient files. Cyprus, Norway and Slovenia did not perform a validation study. Most of the countries performed the validation only for the recommended minimum sample, while 10 countries (Iceland, Latvia, Lithuania, Luxembourg, Malta, Poland, Portugal, Romania, UK-Northern Ireland and UK-Wales) provided a nationally representative sample, with the largest validation survey in Portugal (2 171 patients from 26 hospitals). All validation PPS data were collected by a national validation team, in 97% of hospitals on the same day as the primary PPS in the validated hospitals and wards. On average, 2.3% (country range: 0.3–5.6%) of patients who were reported as not having an HAI by the primary PPS data collectors were found to have an HAI by the national validation teams (false negatives). On the other hand, one in five (mean: 20.3%, country range: 0–46.2%) patients reported as having an HAI did not have an HAI according to the national validation team (false positives). When applying the percentages false positives and false negatives of the validation studies to the (primary) HAI prevalence results in these countries, the sensitivity of the primary PPS data collectors for detecting and reporting an HAI was on average 69.4% and ranged from 40.1% in Romania to 94.4% in Finland (Table 11). The specificity for detecting and reporting an HAI was 98.8% on average and ranged from 96.1% in Portugal to 100% in UK-Scotland. There was a significant negative correlation between the HAI prevalence in the primary PPS (pPPS) and the specificity (Spearman's rho -0.62, $p<0.001$); thus, high-prevalence countries tended to have lower specificity and vice versa (Figure 15). However, there was no significant positive correlation between the HAI prevalence in the primary PPS and the sensitivity (Spearman's rho 0.19, NS). The association of the pPPS HAI prevalence with the specificity was independent of the patient case-mix index (the predicted HAI prevalence) in multiple linear regression analysis.

The mean corrected HAI prevalence in countries performing a validation study was 6.5% compared to an average observed prevalence of 5.6% before correction. The estimated country-weighted corrected HAI prevalence, calculated by applying the mean percentages false negatives and false positives to the country-weighted EU/EEA prevalence, was (also) 6.5% (95% CI 5.4-7.8), compared to 5.5% (95% CI 4.5-6.7) before correction (see section `Burden estimates').

Expressing the results of the validation studies as interrater reliability between the primary PPS data collectors and the national validators - whereby the latter are not considered as the gold standard – the mean kappa for the presence of an HAI in EU/EEA hospitals was 0.75 (95% CI: 0.71-0.80), ranging between less than 0.60 in France, Ireland and Spain and more than 0.90 in Croatia, Slovakia and UK-Wales (Table 11).

Figure 15. Correlation between the observed prevalence of HAIs and the specificity of the primary PPS staff for reporting an HAI, by country



Spearman's rho -0.62, p<0.001

Table 11. Results of national PPS validation surveys: HAI prevalence

Country	N of hospitals	N of patients	FN %	FP %	Se % (95% CI)	Sp % (95% CI)	pPPS HAI %	Corr. HAI % (95% CI)	Kappa
Austria	5	254	4.3	10.5	46.8 (26.7-66.7)	99.5 (98.5-99.9)	4.0	7.7 (4.7-11.3)	0.71
Belgium	5	260	1.3	30.3	80.5 (51.3-96.0)	97.7 (96.2-98.8)	7.3	6.3 (4.0-9.7)	0.75
Bulgaria*	7	384	0.3	14.3	92.7 (63.0-99.8)	99.4 (98.5-99.9)	3.9	3.6 (2.5-5.3)	0.86
Croatia	5	261	0.4	11.1	92.0 (62.5-99.8)	99.4 (98.4-99.9)	5.3	5.1 (3.7-7.4)	0.91
Czechia	6	285	2.4	33.3	67.0 (40.1-87.2)	97.6 (96.2-98.8)	6.7	6.7 (4.0-10.3)	0.68
Estonia	5	251	2.7	30.0	53.2 (27.7-78.9)	98.7 (97.7-99.3)	4.2	5.6 (3.1- 9.2)	0.70
Finland	5	274	0.5	19.4	94.4 (70.7-99.9)	98.1 (96.5-99.2)	8.8	7.6 (5.7-10.5)	0.86
France	5	272	1.9	46.2	62.9 (25.5-88.6)	97.2 (95.5-98.8)	5.7	4.9 (2.0-8.8)	0.56
Germany	10	432	0.7	33.3	77.6 (40.8-95.7)	98.8 (97.7-99.6)	3.6	3.1 (1.5-5.2)	0.70
Greece	8	353	5.6	7.8	64.7 (50.7-77.6)	99.1 (98.2-99.6)	10.0	14.2 (11.3-17.9)	0.85
Hungary	5	252	1.4	11.6	70.1 (40.8-92.5)	99.6 (99.0-99.9)	3.7	4.6 (3.0-7.5)	0.89
Iceland	*2*	*262*	*2.1*	*40.0*	*66.2 (33.8-89.0)*	*97.9 (95.7-98.7)*	*6.3*	*5.7 (2.9-9.6)*	*0.60*
Ireland	6	317	4.1	37.5	49.9 (27.3-71.3)	97.5 (96.0-98.8)	6.1	7.7 (4.5-11.6)	0.55
Italy	5	254	4.2	16.4	74.6 (52.4-89.7)	99.0 (97.5-99.8)	8.0	9.6 (8.4-15.3)	0.83
Latvia	*11*	*457*	*2.1*	*21.7*	*59.0 (35.5-78.8)*	*99.2 (98.3-99.7)*	*3.7*	*4.9 (3.0-7.2)*	*0.70*
Lithuania	*21*	*605*	*1.4*	*30.3*	*60.2 (34.3-81.3)*	*99.2 (98.4-99.6)*	*2.9*	*3.2 (1.9-5.1)*	*0.67*
Luxembourg	*12*	*432*	*4.1*	*11.1*	*53.6 (38.1-68.5)*	*99.4 (98.6-99.8)*	*5.1*	*8.5 (6.1-11.2)*	*0.76*
Malta	*4*	*233*	*3.3*	*22.2*	*61.4 (34.6-82.5)*	*98.5 (96.7-99.6)*	*6.2*	*7.9 (4.5-12)*	*0.69*
Netherlands*	4	178	3.6	8.3	50.2 (24.1-74.8)	99.7 (98.4-100)	3.8	7.0 (3.6-11.2)	0.74
Poland	*19*	*681*	*0.7*	*19.4*	*86.9 (69.1-96.4)*	*99.0 (98.4-99.4)*	*5.1*	*4.7 (3.7-6.1)*	*0.85*
Portugal	*26*	*2172*	*2.7*	*40.4*	*68.1 (59.2-75.9)*	*96.1 (95.5-96.7)*	*8.9*	*7.8 (6.6-9.1)*	*0.61*
Romania	*8*	*721*	*3.6*	*3.7*	*40.1 (29.2-51.8)*	*99.9 (99.7-100)*	*2.4*	*5.9 (4.4-7.6)*	*0.78*
Slovakia	5	330	0.6	6.3	86.1 (56.3-98.2)	99.7 (98.7-100)	4.0	4.4 (2.9-6.2)	0.90
Spain	5	250	5.2	29.4	53.7 (29.7-73.8)	97.4 (95.1-99.1)	7.8	10.2 (5.9-15.1)	0.55
UK-England	10	336	1.4	10.5	82.1 (60.3-94.8)	99.3 (98.3-99.8)	6.5	7.0 (5.2-9.5)	0.88
UK-Northern Ireland	*13*	*521*	*1.0*	*21.2*	*83.4 (62.7-94.7)*	*98.6 (97.5-99.4)*	*6.1*	*5.8 (4.1-7.8)*	*0.80*
UK-Scotland	9	255	1.6	0.0	73.9 (37.7-91.2)	100 (97.9-100)	4.3	5.9 (2.8-8.2)	0.74
UK-Wales	*10*	*969*	*0.6*	*2.6*	*91.2 (80.7-97.0)*	*99.8 (99.4-100)*	*5.7*	*6.0 (5.3-6.9)*	*0.95*
EU/EEA total/mean	**236**	**12228**	**2.3**	**20.3**	**69.4 (63.3-75.4)**	**98.8 (98.4-99.1)**	**5.6**	**6.5 (5.6-7.4)**	**0.75**
Serbia	5	249	1.3	10.0	75.7 (45.0-94.3)	99.5 (98.5-99.9)	4.3	5.2 (3.2-7.9)	0.87

*N of hospitals: number of validated hospitals; N of patients: number of validated patients; FN: false negatives; FP: false positives; Se: sensitivity; Sp: specificity; CI: confidence interval; pPPS HAI %: HAI prevalence (% of patients with HAI) of the primary national PPS (see Table 20 for confidence intervals); Corr HAI %: corrected HAI prevalence after adjustment for validation results. Kappa: kappa statistic for the presence of an HAI; *Poor country representativeness in Bulgaria and the Netherlands. Results in italics were considered representative validation results at country level; Cyprus, Norway and Slovenia did not perform a validation survey.*

External validation study

A total of 25 countries accepted a visit of the external validation team during the national validation study, i.e. all countries listed in Table 11 except Iceland, Ireland and Slovakia. In addition, Norway, which did not perform a national validation study, accepted a visit by the external validation team. Cyprus and Slovenia did not perform national validation and also declined participation in external validation, both because of a lack of human resources in the PPS coordinating centres.

For the assessment of the sensitivity and specificity of detecting HAIs by the national validation teams, a total of 113 HAI cases and 139 non-HAI cases were reviewed. The external validators found two (1.8%) false positives and four (3.0%) false negatives. The lack of laboratory data (particularly the absence of microbiology tests) in combination with lack of or illegible notes and poorly written patient charts were frequently encountered problems.

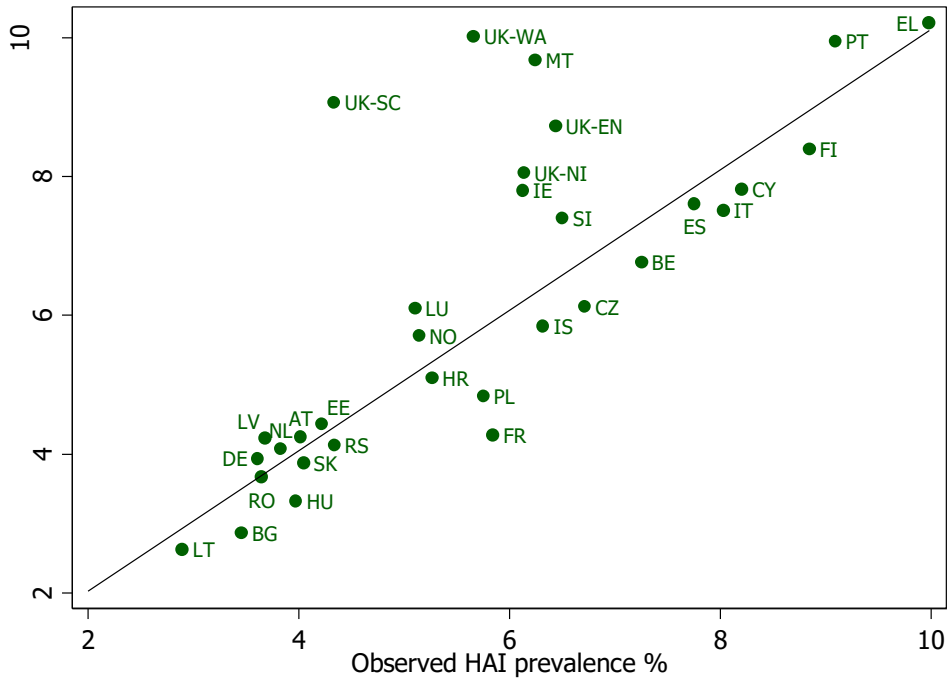
Case vignettes

A total of 1 058 completed case vignettes were received by ECDC from 106 national validators from 24 countries (all participating countries except Czechia, France, Norway, Romania, Slovenia, UK-England and UK-Wales). The overall kappa for the presence of an HAI was 0.72 when comparing validators with the gold standard answer proposed by the authors of the case vignettes. Omitting difficult cases which provoked discussion between validators and ECDC, the kappa was 0.86.

HAI versus antimicrobial treatment of a hospital infection

Figure 16 shows good correlation (Spearman's rho 0.80, p<0.001) between the percentage of patients with confirmed HAI as per case definition (observed HAI prevalence) and the prevalence of patients receiving at least one antimicrobial for the treatment of a 'hospital infection' ('physician-indicated HAI prevalence'). The physician-indicated prevalence of treated 'hospital infections' was 6.2% (country range 2.6%-11.2%), and on average 10% higher than the observed HAI prevalence. In countries below the diagonal line in Figure 16, prescribers tended to report an infection as 'hospital-acquired' less frequently than the PPS data collectors while in countries above the line (especially Malta, the Netherlands, UK-Scotland and UK-Wales), the PPS data collectors reported a lower prevalence, which may be related to the lack of diagnostic evidence to confirm an HAI as per the case definition or to a lower sensitivity of the primary PPS data collectors due to incomplete verification of different data sources of signs and symptoms.

Figure 16. Correlation between the observed prevalence of HAI and the prevalence of antimicrobial use for physician-labelled 'treatment of a hospital infection', by country



X-axis: observed HAI prevalence (reported by the primary PPS data collectors); Y-axis: percentage of patients receiving antimicrobials for treatment intention of a hospital infection (HI); line: HAI prevalence equal to prevalence of antimicrobial treatment for hospital infection.

Onset and origin of HAIs

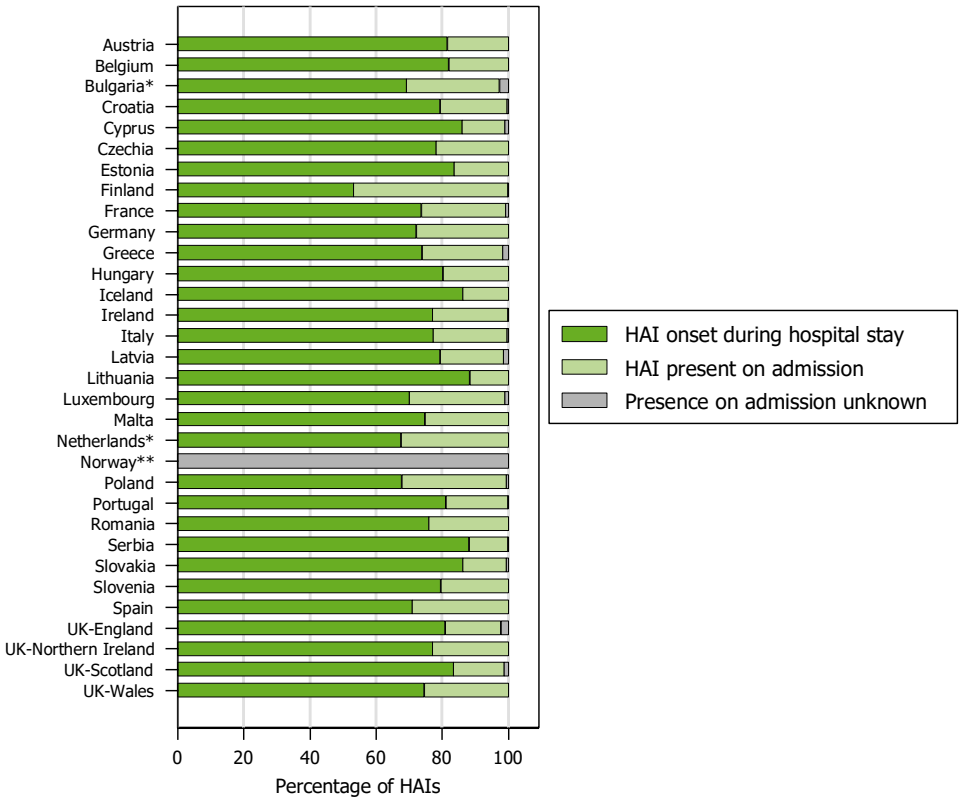
The percentage of HAIs present on admission ranged from 11.4% in Lithuania to more than 30% in Poland (31.6%), the Netherlands (32.4%) and Finland (46.6%) (Figure 17). Data were not available for Norway.

The percentage of HAIs attributed to the current hospital stay or to a previous stay in the same hospital ranged from less than 75% in Luxembourg (71.8%) and Finland (74.9%) to 95.3% in Malta and 97.7% in Iceland (Figure 18).

For HAIs starting during the current hospitalisation, median time from hospital admission until HAI onset varied from seven days in Finland (mean 18.7 days) and Romania (mean 12.4 days) to 15 days in Portugal (mean 35.3) and UK-Wales (mean 23.7), and 16 days in Iceland (mean 44.0 days). The percentage of HAIs with onset before the third day of hospital stay ranged from 0.1% in Estonia to 12.0% in UK-England (Figure 19).

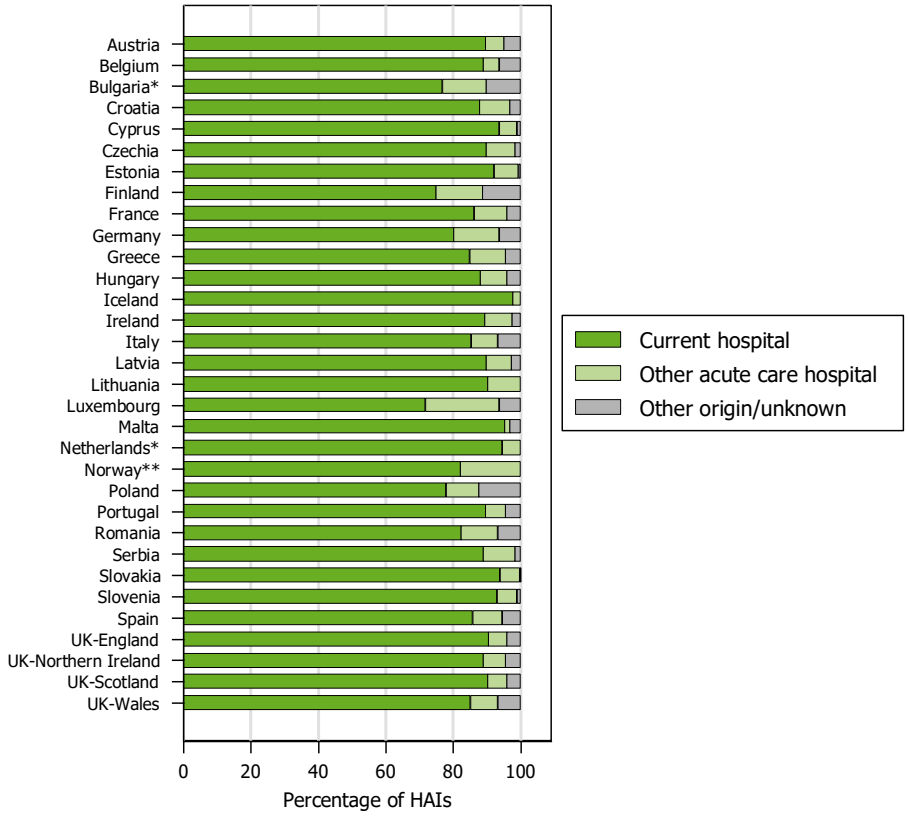
The association of HAI with the ward where the patient was hospitalised at the time of the PPS was a new variable in the 2016-2017 ECDC PPS and was collected by 23 EU/EEA countries and the four UK administrations and Serbia (Figure 20). Excluding countries that did not collect the variable (France, Greece, the Netherlands and Norway), HAIs were on average associated with the current ward in 67.9% of cases and this varied between 52.6% in Spain and 81.6% in UK-Northern Ireland.

Figure 17. Percentage of HAIs present on admission, by country,



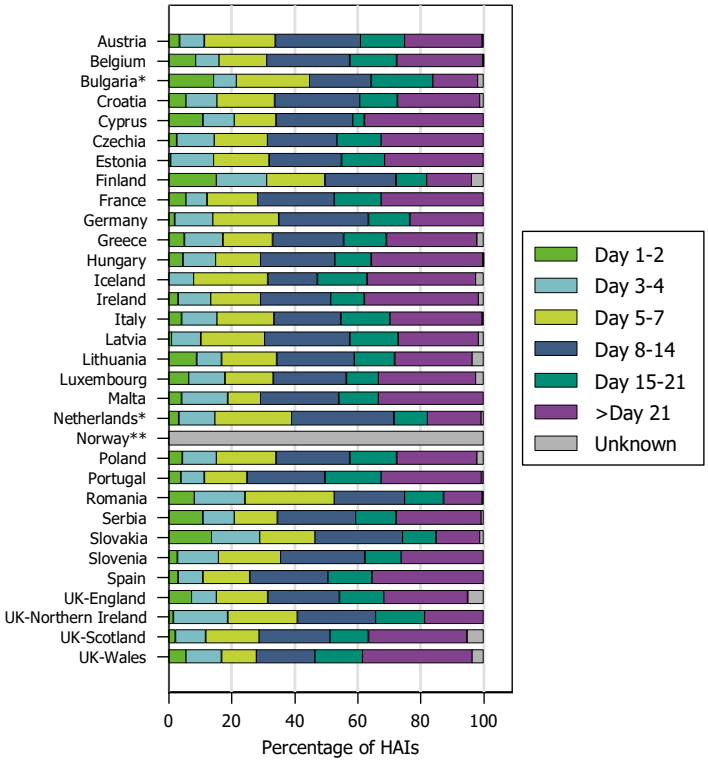
**Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol.*

Figure 18. Origin of HAIs, by country



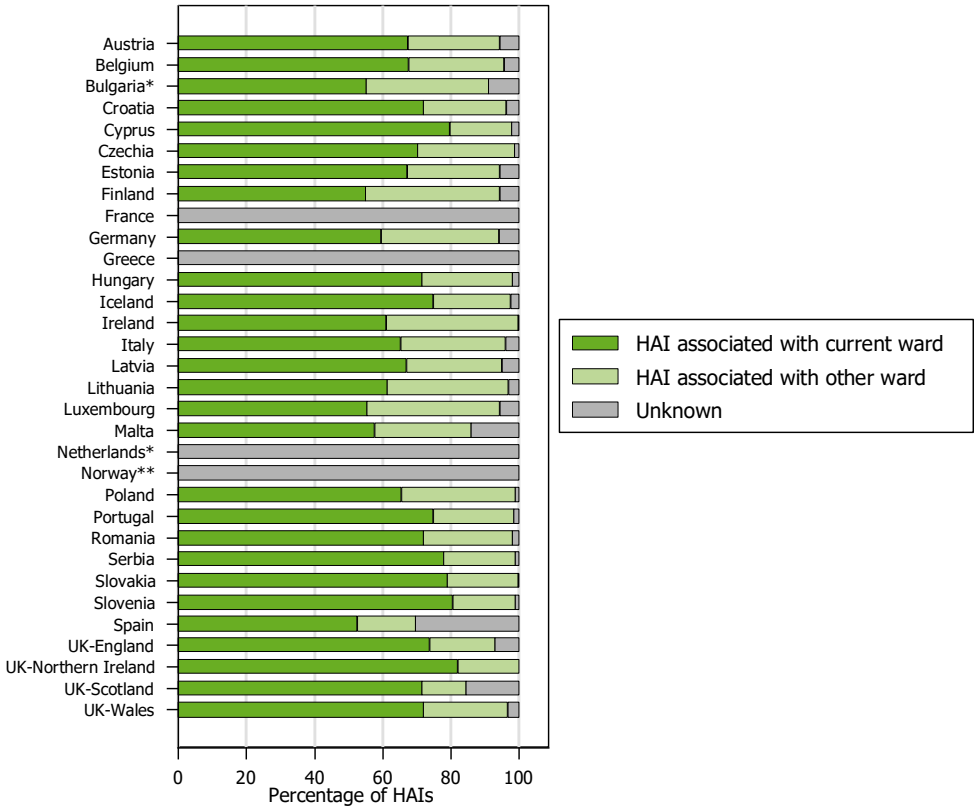
**Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol: aggregated HAI numerator data were collected separately by HAI origin (in two categories).*

Figure 19. Day of onset of HAIs not present on admission, by country



**Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol.*

Figure 20. HAIs associated with the current ward, by country



**Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol.*

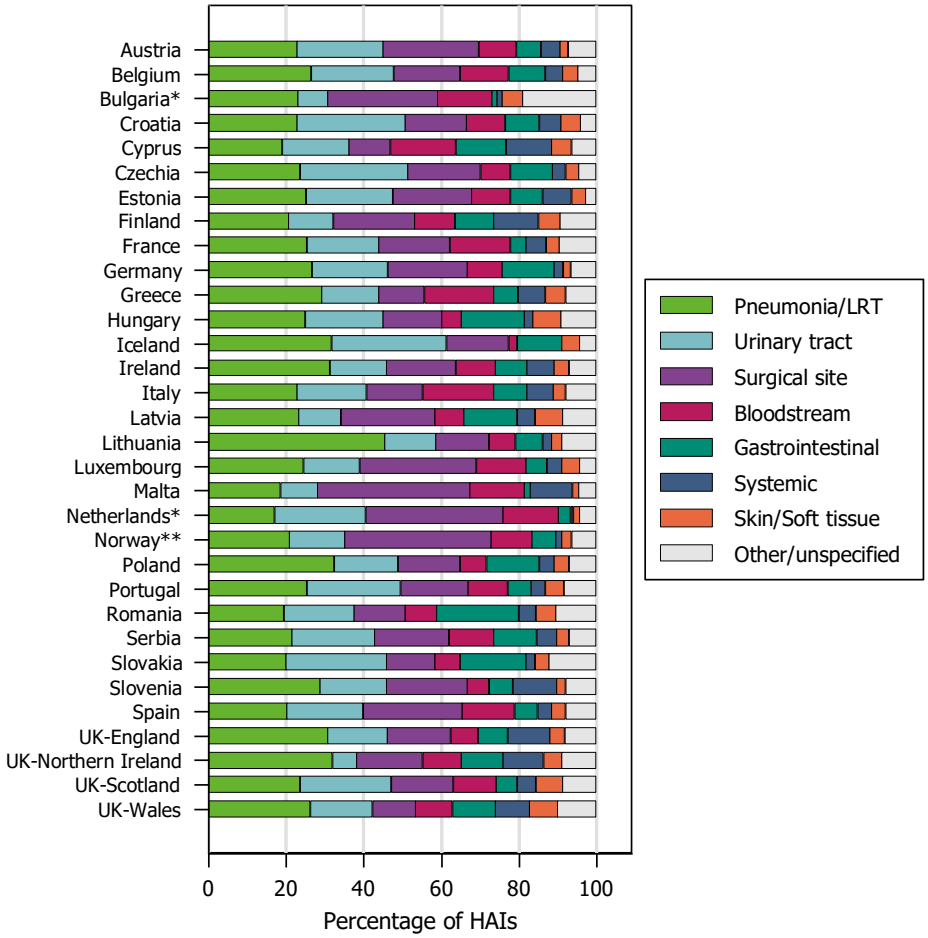
Types of HAIs

Pneumonia and lower respiratory tract infection, surgical site infection and urinary tract infection were the most frequently reported types of HAI in the majority of countries (Figure 21, Annex 1).

The percentage of pneumonia and lower respiratory infections varied between 17.0% in the Netherlands and 45.4% in Lithuania. Pneumonia were microbiologically confirmed (PN1, 2 or 3) in 17.1% cases, ranging from 0% in Iceland and Malta to 93.8% in Bulgaria. Urinary tract infections varied between 6.2% in Northern-Ireland and 29.5% in Iceland and were microbiologically confirmed (UTI-A) in 67.2% of cases, from 31.3% in Latvia to 89.9% in Finland. The proportion of surgical site infections varied between 10.6% in Cyprus and 39.1% in Malta. Superficial surgical site infections accounted for 28.1% of surgical site infections, from 12.8% in France to 55.1% in Slovakia. Bloodstream infections represented the highest proportion of HAIs in Italy with 18.3% and Greece with 17.8% and the lowest in Iceland with 2.3%. Bloodstream infections were secondary to another infection in 34.5% of cases, ranging from 0% in Lithuania to 65.4% in the Netherlands and 100% in Iceland. Gastro-intestinal infections were the lowest in Bulgaria with 1.3%, whereas in Romania they represented 21.3% of all HAIs. With 4.2% overall, skin and soft tissue infections were a small category of HAIs4, varying from 1.6% in Malta and the Netherlands to 7.2% in Hungary and UK-Wales.

Certain HAI diagnoses relied on laboratory tests more than others. Inter-country variation on epidemic/endemic clones, sampling, microbiology testing and laboratory methodology may have influenced the distribution of certain HAI-types. For example, the percentage of *C. difficile* infections varied from 1.3% in Bulgaria and 1.4% in France to 14.1% of all HAIs in Slovakia and 17.6% in Romania (Figure 22).

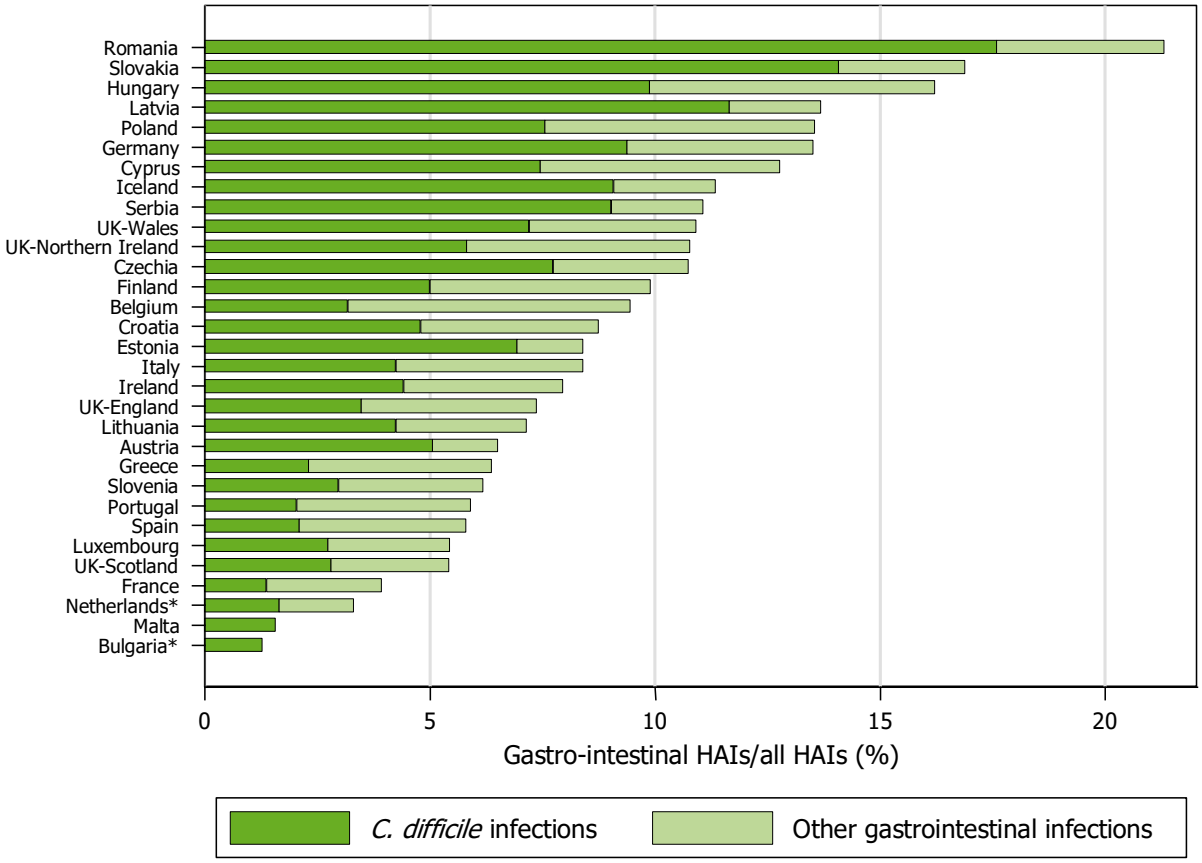
Figure 21. Types of HAI, by country



**Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol.*

LRT: Lower respiratory tract.

Figure 22. *Clostridioides difficile* infections and other gastro-intestinal infections (excluding hepatitis) as a percentage of all HAIs, by country



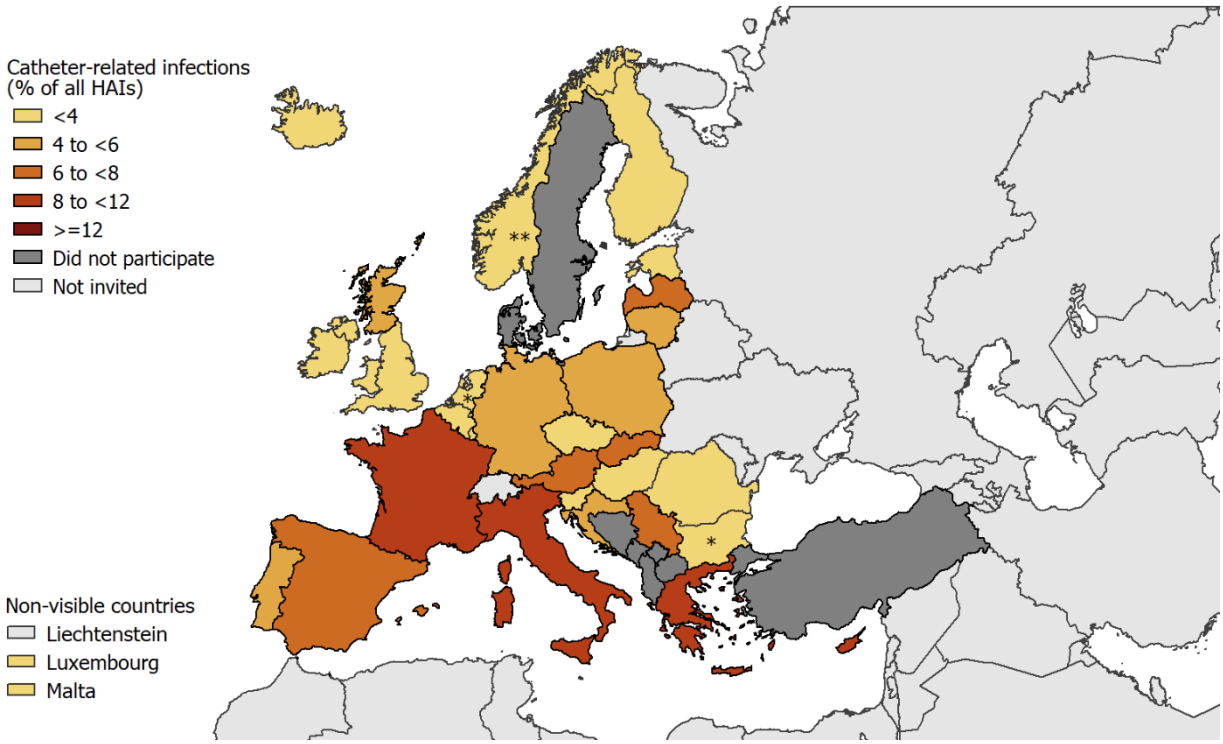
**Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS.*

Clinical sepsis, the prevalence of which is influenced by the non-availability of diagnostic tests, accounted for 81.1% of systemic infections and 4.4% of all HAIs, ranging from 0% in Iceland, Latvia and Romania to 11.1% in Slovenia.

The proportion of 'other/unspecified' types of HAI varied from 3.0% in Estonia to 19.2% in Bulgaria (Figure 21). Oral cavity infections accounted for 6.6% of all HAIs in UK-Northern Ireland and 4.1% in UK-Scotland, while none were reported in Bulgaria, Estonia, Iceland, Latvia and Norway. Bone and joint infections varied from 0% in Cyprus and <0.5% in Finland and Estonia to 10.3% of all HAIs in Bulgaria. Central and peripheral vascular catheter-related infections without positive blood culture (CRI1 and CRI2) ranged from 0% in Iceland, Luxembourg, Malta, the Netherlands, Norway and UK-Northern Ireland to 6.7% in Austria. Infections of the cardiovascular system varied between 0% in several countries and 18.0% of all HAIs in Germany and 17.9% in Norway. The detailed distribution of types of HAI by country is summarised in Annex 1 (Table A1.3).

Catheter-related infections, with or without positive blood culture or positive catheter tip culture (BSI with origin C-CVC or C-PVC, NEO-CNSB or NEO-LCBI with origin C-CVC or C-PVC, CRI of all types and CVS-VASC) made up 5.4% of all HAIs, ranging from 0% in Iceland and 2.9% in Luxembourg to 11.1% in Greece (Figure 23).

Figure 23. Relative frequency of catheter-related infections as a total of all HAIs, by country

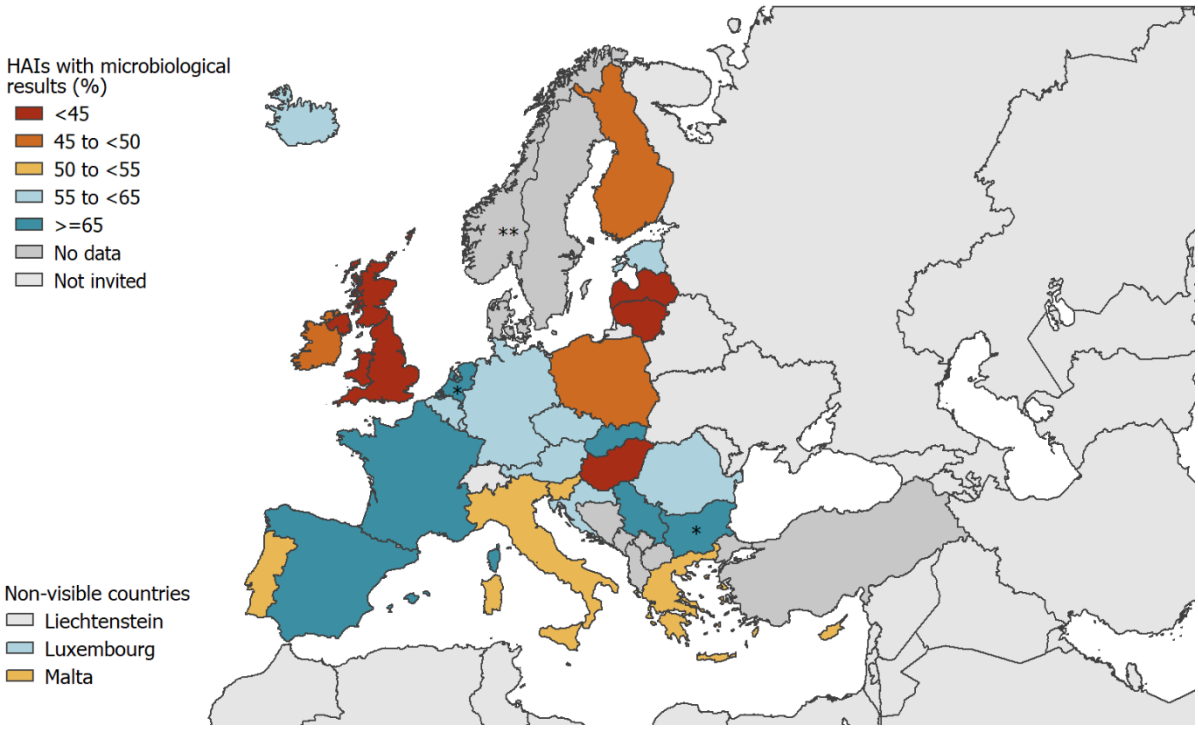


Catheter-related infections with or without positive blood culture or positive catheter tip culture = BSI with origin C-CVC or C-PVC, NEO-CNSB or NEO-LCBI with origin C-CVC or C-PVC, CRI of all types and CVS-VASC.
**Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol.*

Microorganisms isolated from HAIs

The percentage of HAIs documented with microbiological results ranged from 35.3% in UK-Northern Ireland to 73.1% in Bulgaria (Figure 24). The detailed distribution of microorganisms and negative results (no examination done, result not (yet) available, sterile examination or microorganism non identified) is given by country in Annex 1 (Table A1.4).

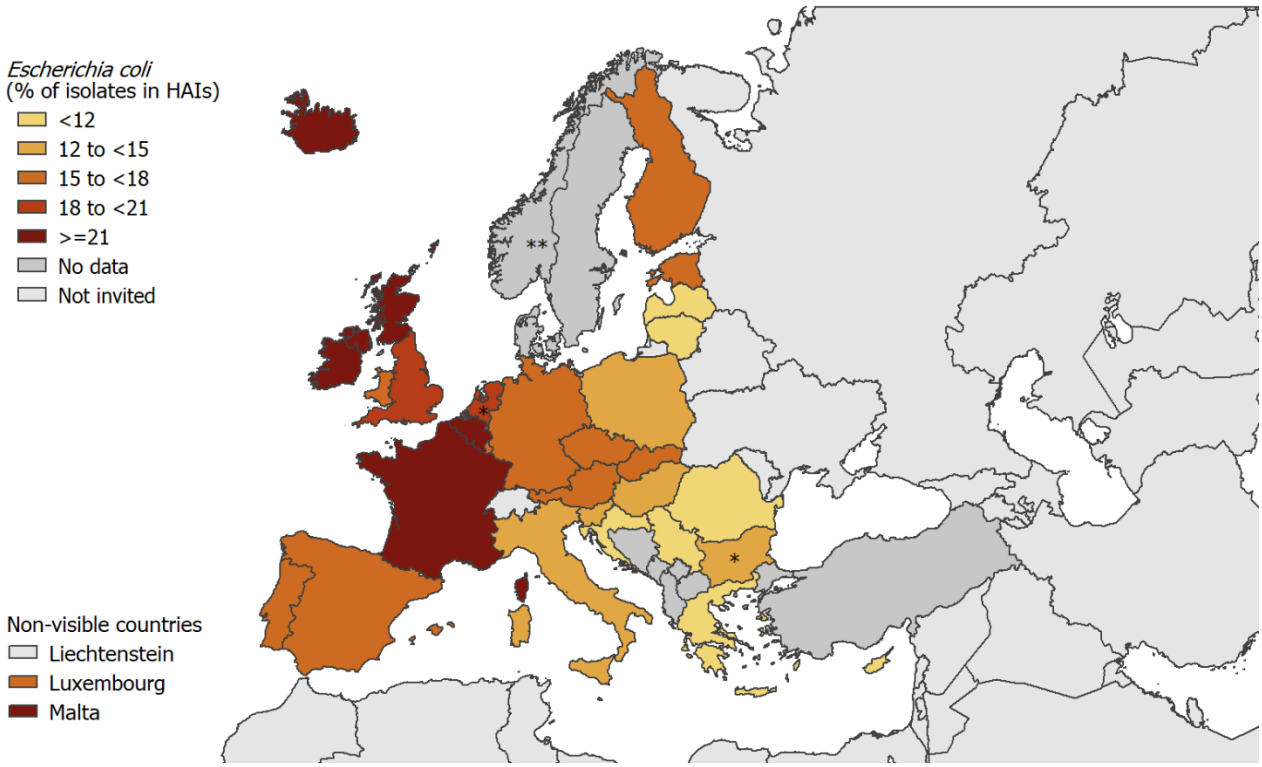
Figure 24. Percentage of HAIs with positive microbiological results on the day of the PPS



**Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol.*

The microorganisms most frequently reported overall were *E. coli*, *S. aureus*, *Enterococcus* spp., *P. aeruginosa*, *Klebsiella* spp., coagulase-negative staphylococci, *Candida* spp., *Clostridioides difficile*, *Enterobacter* spp., *Proteus* spp., and *Acinetobacter* spp. (Table 8). These 11 microorganisms accounted for a total of 86.6% of reported microorganisms in Europe, ranging from 59.2% in Iceland to 93.6% in Latvia (Table 12). The highest percentage of *E. coli* was observed in Malta (39.0%) and the lowest in Latvia (5.2%). *E. coli* was one of the first three most common microorganisms in most of the countries, except in Cyprus, Greece, Latvia and Romania (**Error! Reference source not found.**). *Staphylococcus aureus* was most commonly reported by UK-Scotland (20.1%) and least commonly by Greece (4.7%) (Figure 26). The percentage of enterococci varied between 0% in Iceland to 15.4% of all microorganisms in Luxembourg (Figure 27). *Pseudomonas aeruginosa* ranged from 1.3% in Latvia to 18.6% in Cyprus. *Klebsiella* spp. (84.1% of which were *K. pneumoniae*) varied from less than 4% in Iceland to 17.4% in Portugal (Figure 28). The percentage of coagulase-negative staphylococci was the lowest in Malta (2.4%) and the highest in Cyprus (11.9%) and Austria (11.8%). The highest percentages of *Candida* spp. were reported from Luxembourg (8.8%), Slovenia (8.3%) and Greece (8.3%). Most *Candida* spp. were *Candida albicans* (57.1%), followed by *Candida glabrata* (12.6%). *Clostridioides difficile* was the most common microorganism in four countries (Hungary, Latvia, Romania and Slovakia), the highest percentage reported from Romania (26.0%) and Latvia (22.1%), the lowest *Clostridioides difficile* percentages were reported by Bulgaria (1.5%) and France (1.4%) (Figure 29). The percentage of *Enterobacter* spp. was 6% or more in Belgium, Cyprus, Estonia, France, Luxembourg, the Netherlands and Slovenia. *Proteus* spp. were most common in Bulgaria (8.8%). *Acinetobacter* spp. represented 10% or more of the reported microorganisms in five countries (Croatia, Latvia, Romania, Bulgaria and Greece), ranging from 10.0% to 16.4% (Figure 30).

Figure 25. Relative frequency of *Escherichia coli* isolates as a percentage of all isolates of microorganisms reported for HAIs, by country



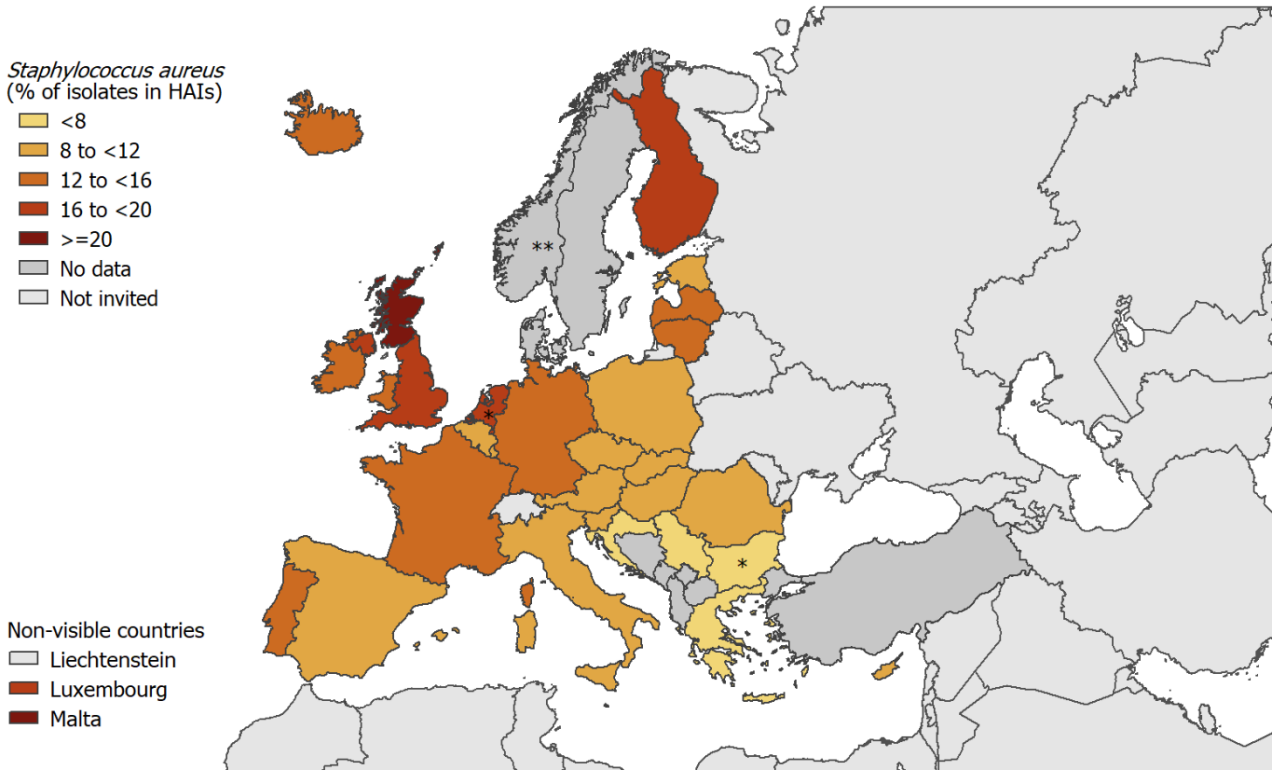
**Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol.*

Table 12. Relative frequency (percentage) of the most commonly reported microorganisms for HAIs, by country

	Total number of isolates	*Escherichia coli*	*Staphylococcus aureus*	*Enterococcus* spp.	*Pseudomonas aeruginosa*	*Klebsiella* spp.	Coagulase-negative staphylococci	*Candida* spp.	*Clostridioides difficile*	*Enterobacter* spp.	*Proteus* spp.	*Acinetobacter* spp.
Austria*	399	16.0	10.5	10.8	6.8	6.8	11.8	5.8	7.0	5.0	2.5	0.8
Belgium	721	22.5	11.2	8.7	6.5	7.4	6.5	3.9	4.2	6.8	3.3	1.4
Bulgaria	68	13.2	7.4	5.9	13.2	16.2	10.3	0.0	1.5	1.5	8.8	13.2
Croatia*	402	11.4	8.0	11.2	16.2	8.7	5.7	5.7	7.0	2.2	7.0	10.0
Cyprus	59	10.2	8.5	8.5	18.6	6.8	11.9	6.8	11.9	6.8	0.0	3.4
Czechia*	923	16.4	9.3	10.0	6.9	15.9	5.6	6.2	9.2	2.5	6.1	0.7
Estonia*	162	16.0	11.1	11.1	10.5	8.0	3.1	3.7	8.6	7.4	2.5	0.6
Finland	508	17.1	19.7	7.5	4.5	4.7	9.1	4.7	8.7	4.5	2.6	1.2
France	1 037	21.2	14.8	10.0	7.2	5.1	8.9	3.1	1.4	7.8	2.5	1.4
Germany	323	16.4	13.3	13.6	6.2	5.6	6.5	5.0	12.7	2.2	3.1	0.3
Greece	713	5.9	4.8	7.2	12.5	16.3	6.5	8.3	3.6	3.1	3.1	16.4
Hungary	503	13.9	11.5	12.7	9.1	9.7	3.0	2.6	17.3	2.8	5.2	3.0
Iceland	27	22.2	14.8	0.0	3.7	3.7	3.7	3.7	14.8	3.7	3.7	0.0
Ireland	386	23.3	14.8	9.3	3.4	5.2	8.0	6.0	7.8	3.1	2.8	0.3
Italy	879	13.0	8.9	9.2	8.1	12.5	10.0	7.5	6.3	4.3	3.2	3.1
Latvia	77	5.2	14.3	10.4	1.3	7.8	5.2	1.3	22.1	5.2	5.2	15.6
Lithuania	180	10.6	14.4	10.0	5.6	14.4	8.9	2.2	8.9	1.7	6.1	6.1
Luxembourg	91	16.5	11.0	15.4	6.6	12.1	5.5	8.8	3.3	6.6	6.6	0.0
Malta	41	39.0	9.8	2.4	7.3	4.9	2.4	4.9	2.4	2.4	4.9	0.0
Netherlands	161	20.5	16.8	12.4	3.7	6.8	6.2	3.1	1.9	10.6	5.0	1.2
Norway**	-											
Poland	792	14.1	9.5	9.5	7.2	14.0	7.8	4.7	13.0	4.2	2.9	6.1
Portugal	1 100	17.0	13.2	12.2	9.7	17.4	4.8	5.1	3.1	3.4	2.9	1.1
Romania	308	6.5	9.4	4.2	9.4	15.3	4.9	3.2	26.0	1.0	2.9	10.7
Slovakia	328	15.2	9.5	6.7	7.3	13.1	4.9	4.9	17.4	4.0	4.6	3.0
Slovenia	301	13.3	10.0	10.0	7.0	8.3	7.6	8.3	4.0	9.3	4.3	1.0
Spain	1 449	16.0	9.5	11.1	9.9	9.2	10.8	6.1	2.4	4.7	3.9	2.0
UK-England	607	19.4	16.8	7.6	7.9	7.6	3.1	4.4	7.9	4.9	2.6	0.3
UK-Northern Ireland	99	21.2	19.2	10.1	2.0	5.1	5.1	4.0	15.2	1.0	3.0	1.0
UK-Scotland	283	23.0	20.1	8.5	2.1	6.7	5.3	4.6	5.3	2.1	2.5	0.4
UK-Wales	158	17.7	14.6	7.0	4.4	4.4	2.5	5.1	17.1	2.5	1.9	1.3
EU/EEA	**13 085**	**16.1**	**11.6**	**9.7**	**8.0**	**10.4**	**7.1**	**5.2**	**7.3**	**4.4**	**3.6**	**3.2**
Country P25	159	13.2	9.5	7.5	4.8	5.9	4.9	3.7	3.7	2.4	2.7	0.6
Country P50	326	16.2	11.2	9.8	7.1	7.9	6.0	4.8	7.9	3.9	3.2	1.3
Country P75	687	20.2	14.8	11.0	9.3	13.0	8.7	6.0	12.9	5.2	5.0	3.3

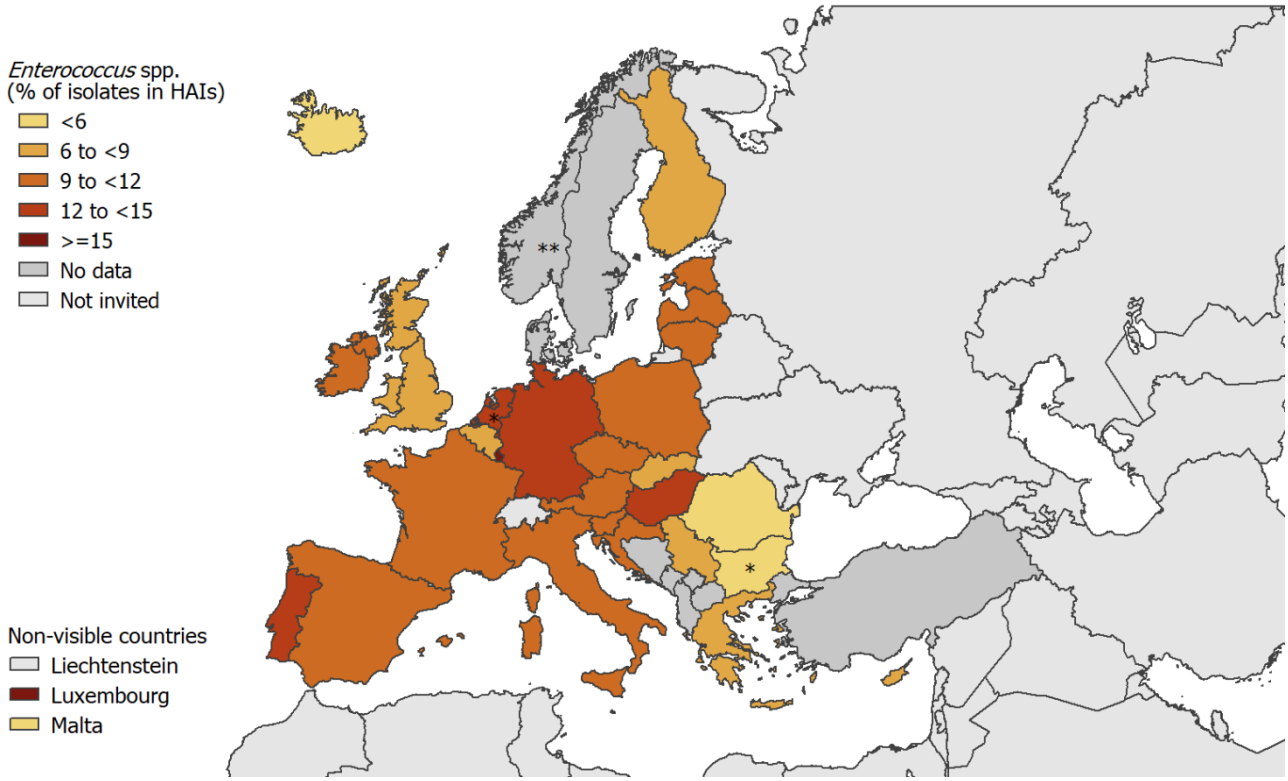
P=percentile.
**Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol which did not include microbiological data.*

Figure 26. Relative frequency of *Staphylococcus aureus* as a percentage of all isolates of microorganisms reported for HAIs, by country



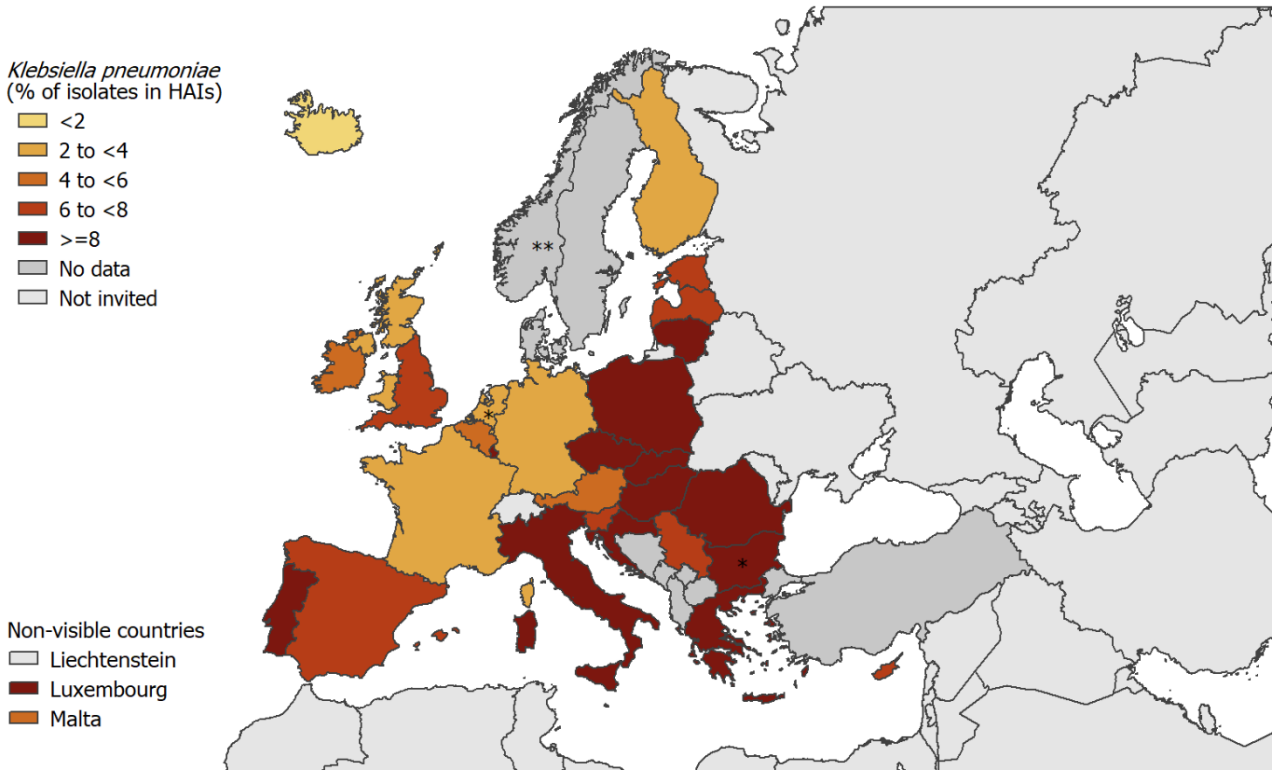
**Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol.*

Figure 27. Relative frequency of *Enterococcus* spp. as a percentage of all isolates of microorganisms reported for HAIs, by country



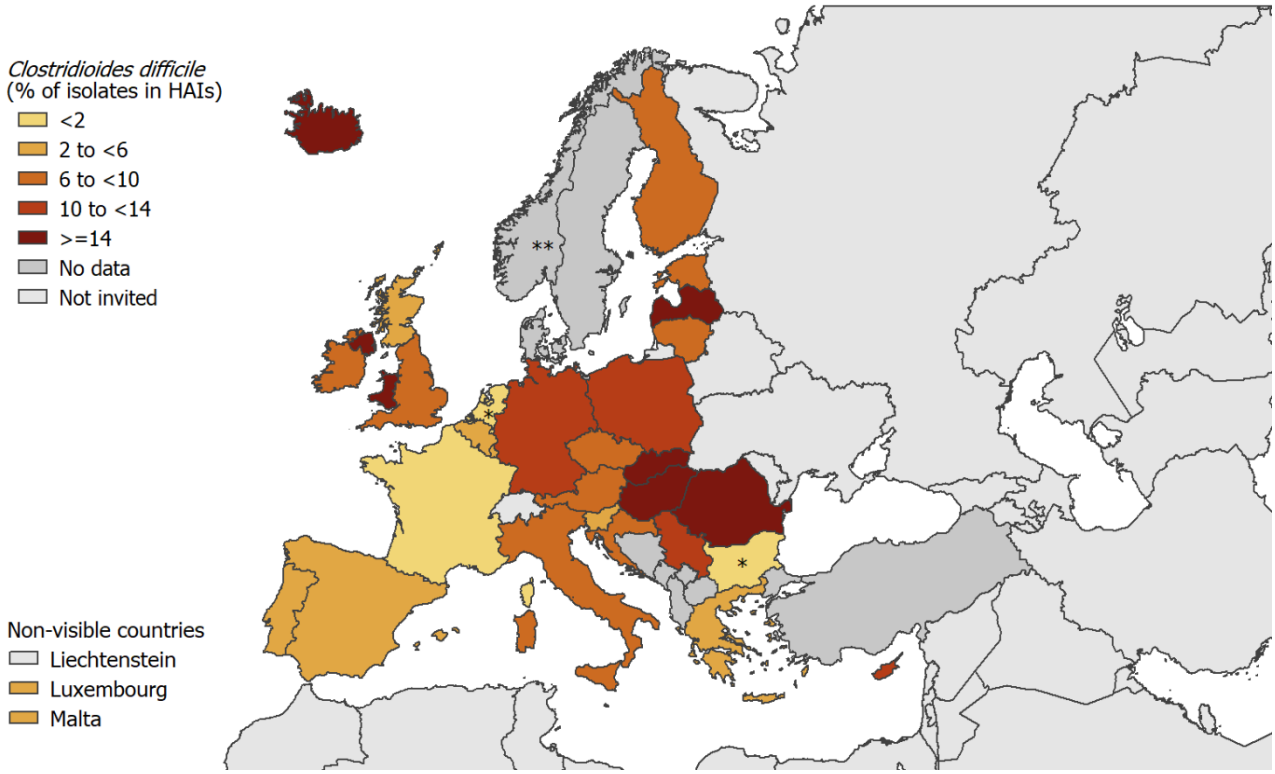
**Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol.*

Figure 28. Relative frequency of *Klebsiella pneumoniae* as a percentage of all isolates of microorganisms reported for HAIs, by country



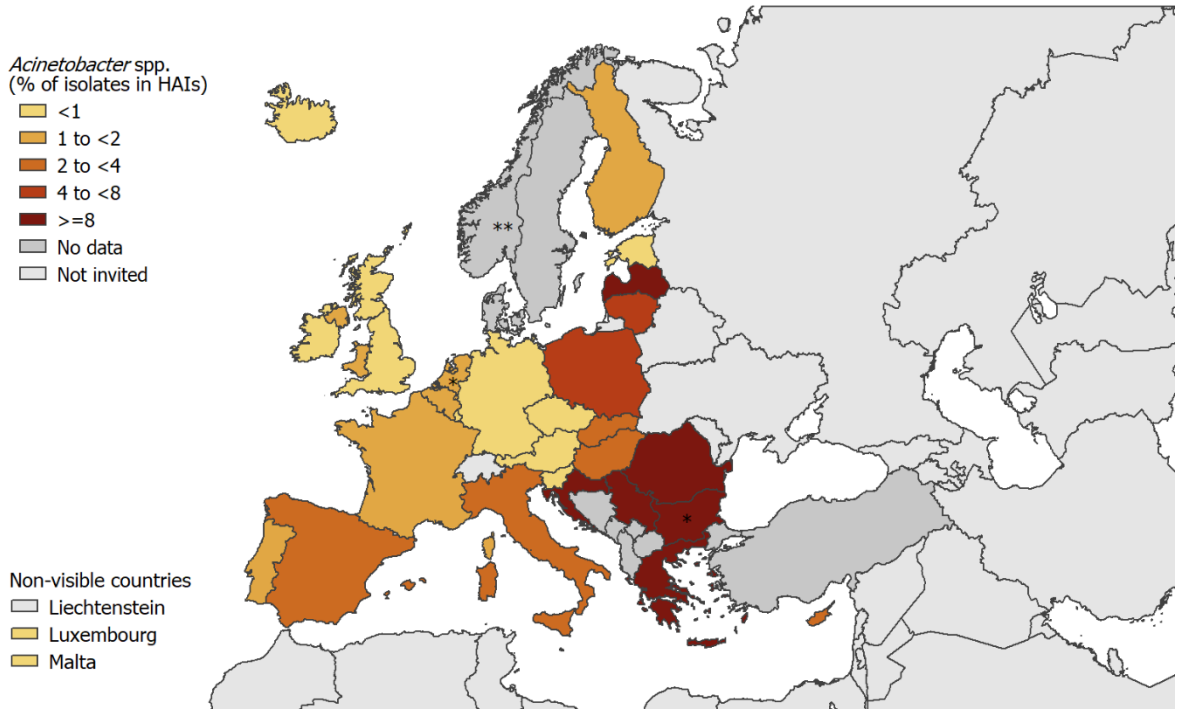
**Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol.*

Figure 29. Relative frequency of *Clostridioides difficile* as a percentage of all isolates of microorganisms reported for HAIs, by country



**Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol.*

Figure 30. Relative frequency of *Acinetobacter* spp. as a percentage of all isolates of microorganisms reported for HAIs, by country

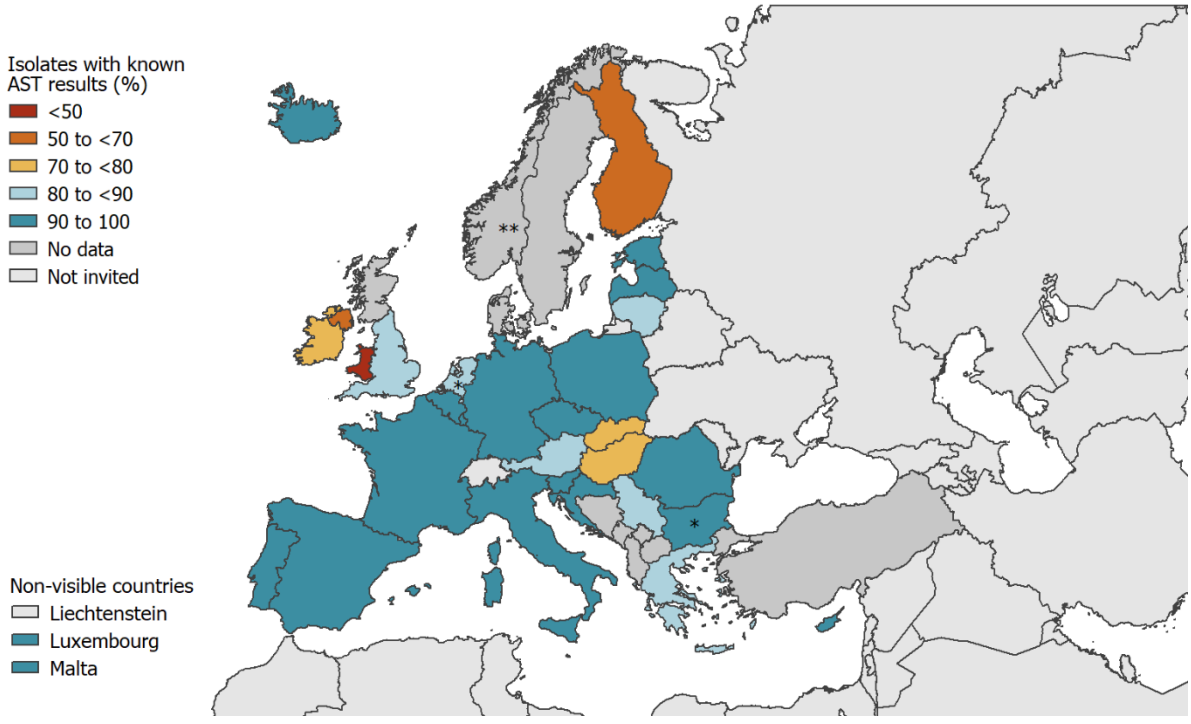


**Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol.*

Antimicrobial resistance in HAIs

The percentage of microorganisms with known AST results for the selected AMR markers of the PPS protocol varied between 41.2% of reported microorganisms in UK-Wales and 100% in Iceland and Malta (Figure 31).

Figure 31. Percentage of isolates with known AST results (first-level AMR markers combined) for healthcare-associated infections, by country

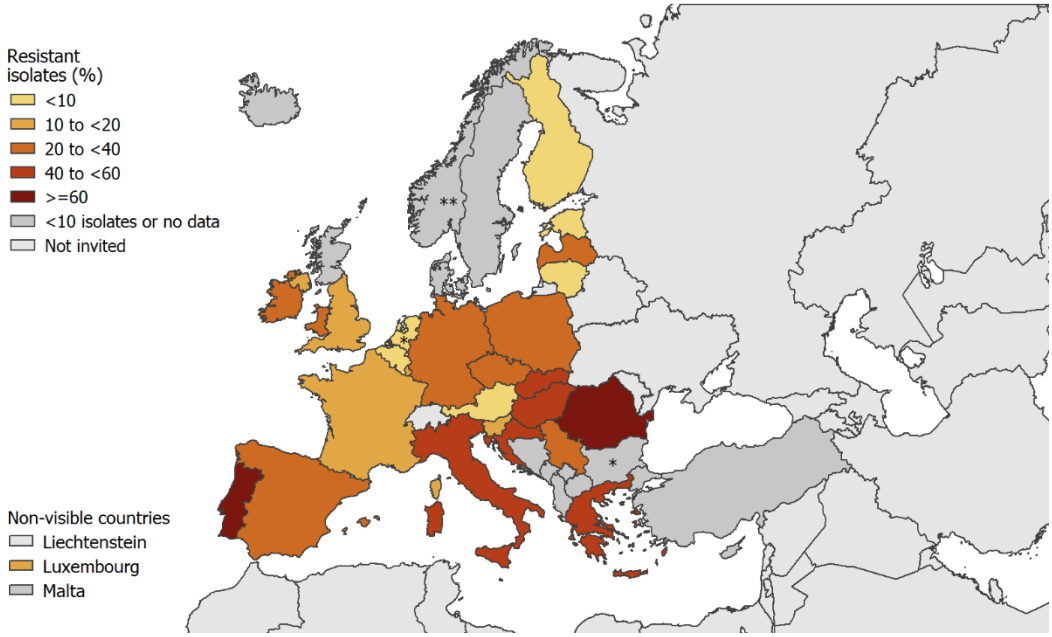


First-level antimicrobial resistance markers in PPS: MRSA, VRE, Enterobacterales non-susceptible to third-generation cephalosporins, Pseudomonas aeruginosa *and* Acinetobacter baumannii *non-susceptible to carbapenems. *Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol.*

Staphylococcus aureus

Twenty-five countries reported at least 10 isolates of *S. aureus* with known AST results for meticillin. Eleven countries reported less than 20% meticillin resistance (MRSA) in *S. aureus* isolates from HAIs. Austria and Estonia did not report any no MRSA isolate. In Portugal and Romania, over 60% *S. aureus* isolates were MRSA (Figure 32).

Figure 32. Percentage of *Staphylococcus aureus* isolates resistant to (MRSA) in healthcare-associated infections, by country (n=1 337 isolates)

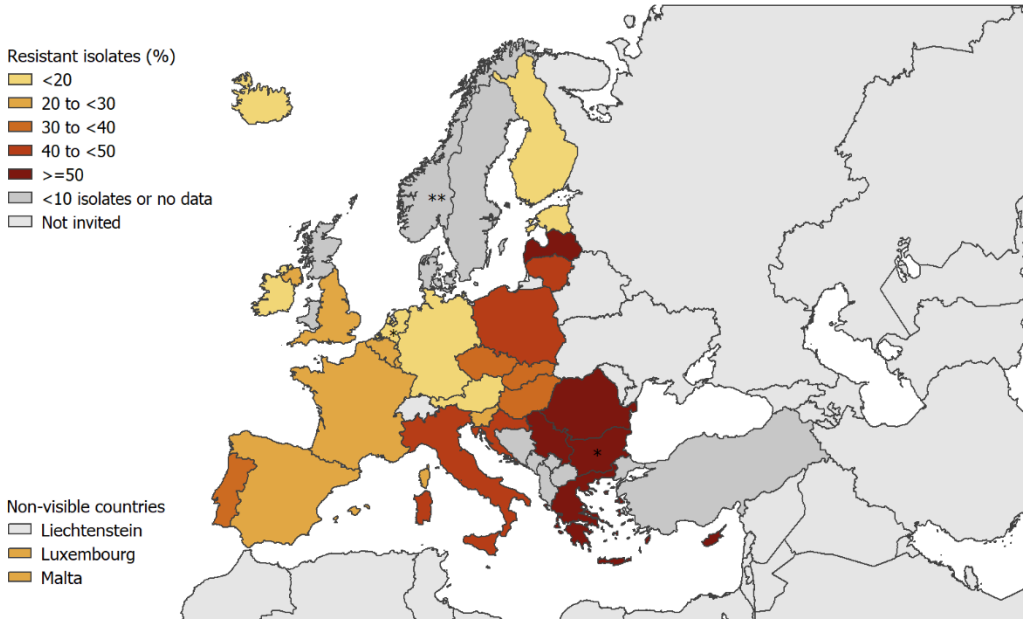


*Countries with <10 isolates with known antimicrobial susceptibility results not shown. *Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol.*

Enterobacterales

Resistance to third-generation cephalosporins among Enterobacterales isolates from HAIs was the lowest in Iceland (0%) and over 40% in nine of 28 countries that reported at least 10 isolates with known AST results (Figure 33). The highest percentage of resistance to third-generation cephalosporins was observed in Romania (74.4% of 78 isolates) and Cyprus (68.8% of 16 isolates).

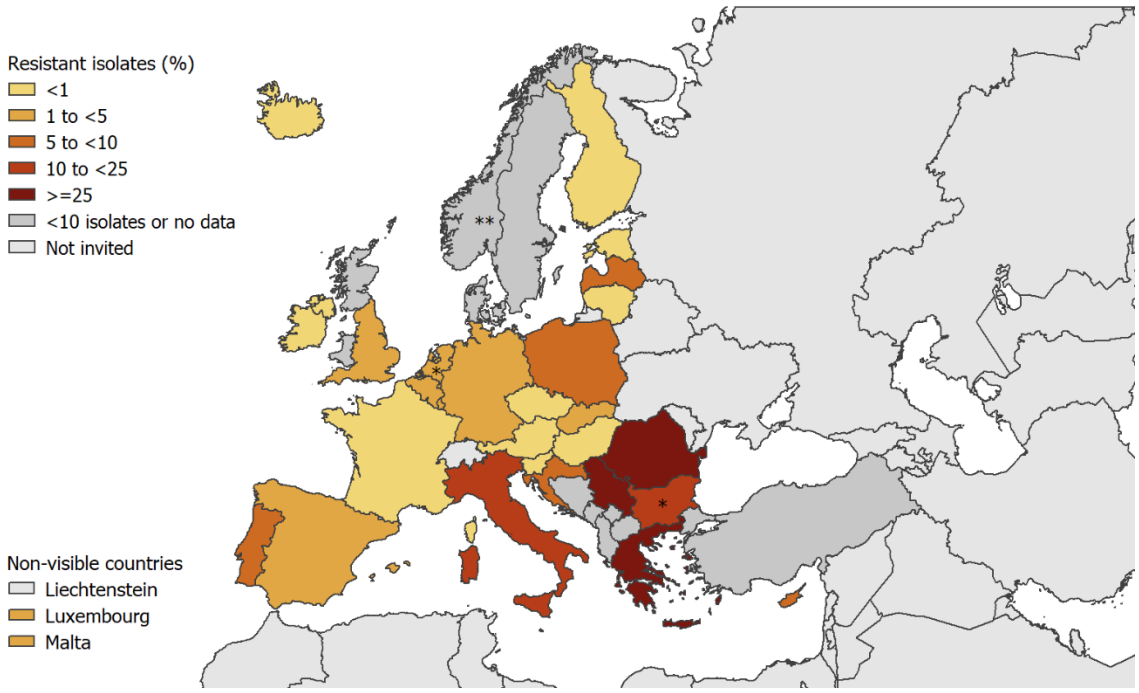
Figure 33. Percentage of Enterobacterales isolates resistant to third-generation cephalosporins in healthcare-associated infections, by country (n=4 368 isolates)



*Countries with <10 isolates with known antimicrobial susceptibility results not shown. *Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol.*

Five of 28 countries did not report any Enterobacterales isolate resistant to carbapenems. Two countries reported over 20% of enterobacteria isolates resistant to carbapenem with the highest level in Greece (43.7%) (Figure 34).

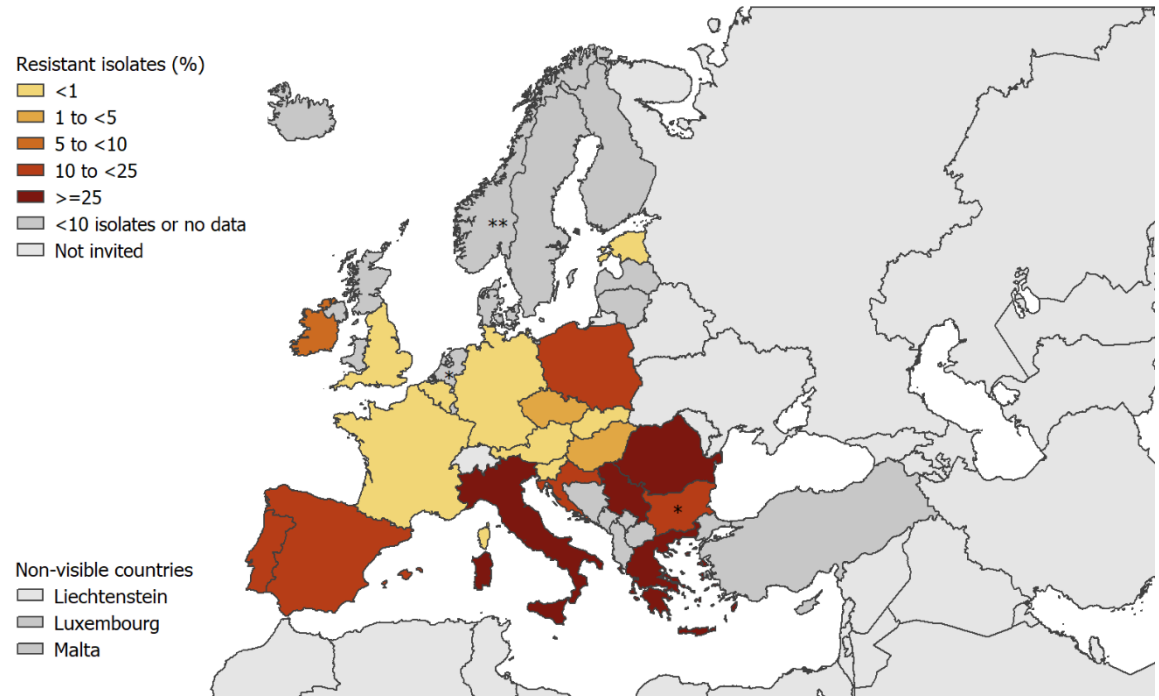
Figure 34. Percentage of Enterobacterales isolates resistant to carbapenems in healthcare-associated infections, by country (n=4 344 isolates)



*Countries with <10 isolates with known antimicrobial susceptibility results not shown. *Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol.*

Nineteen countries reported at least 10 isolates of *K. pneumoniae* with known susceptibility results for carbapenems. Carbapenem resistance among *K. pneumoniae* isolates varied from 0% in eight countries to more than 25% in Italy (43.4%), Serbia (45.0%), Romania (56.5%) and Greece (74.8%) (Figure 35).

Figure 35. Percentage of *Klebsiella pneumoniae* isolates resistant to carbapenems in healthcare-associated infections, by country (n=996 isolates)

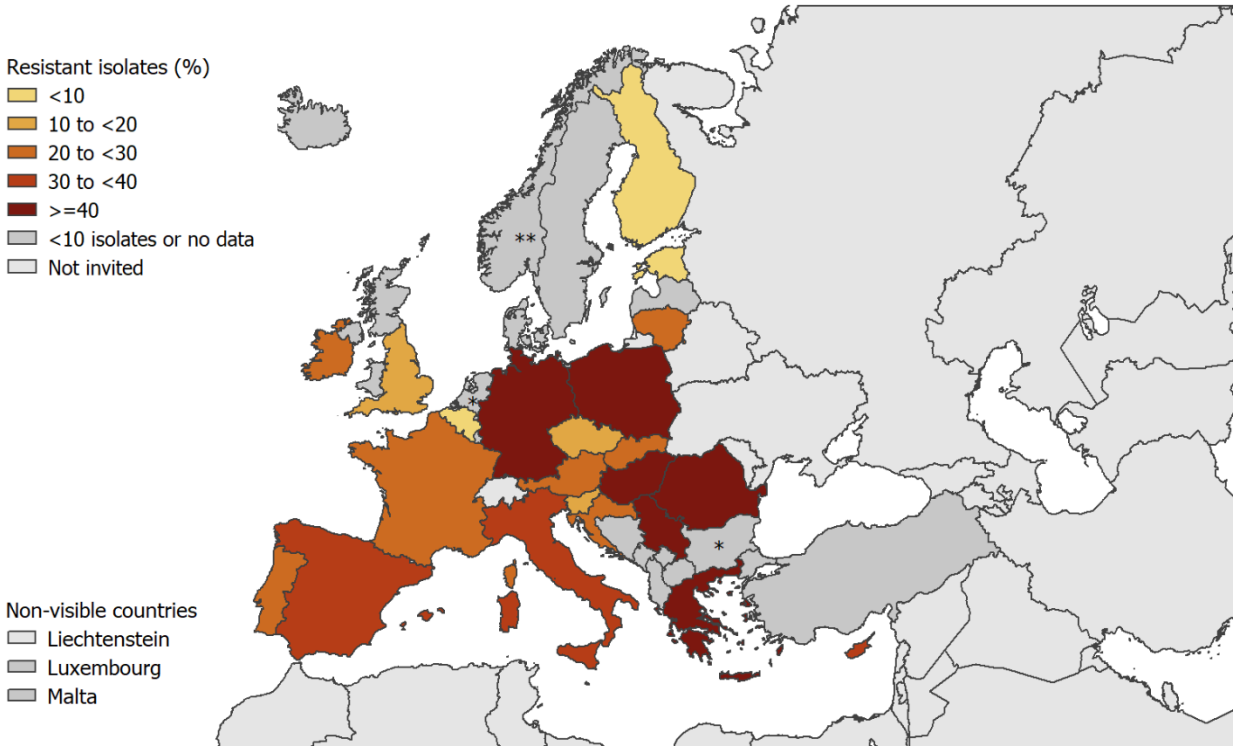


*Countries with <10 isolates with known antimicrobial susceptibility results not shown. *Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol.*

Non-fermenting gram-negative bacteria

Carbapenem AST data for at least 10 *P. aeruginosa* isolates were reported by 21 countries. The percentage of resistant isolates varied from 6.3% in Estonia and Finland to 50.0% in Germany, 55.6% in Serbia and 56.0% in Romania (Figure 36).

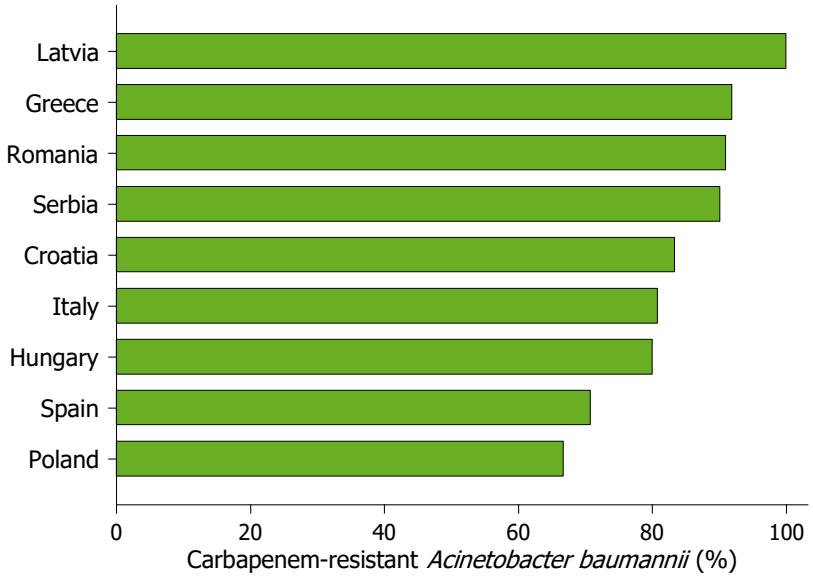
Figure 36. Percentage of *P. aeruginosa* isolates resistant to carbapenems in healthcare-associated infections, by country (n=924 isolates)



Countries with <10 isolates with known antimicrobial susceptibility results not shown.
**Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol .*

Only eight countries reported AST data for at least ten isolates of *Acinetobacter baumannii*. In these countries, resistance to carbapenems ranged from 66.7% in Poland to 100% in Latvia (Figure 37).

Figure 37. Percentage of *Acinetobacter baumannii* isolates resistant to carbapenems in healthcare-associated infections, by country (n=285 isolates)

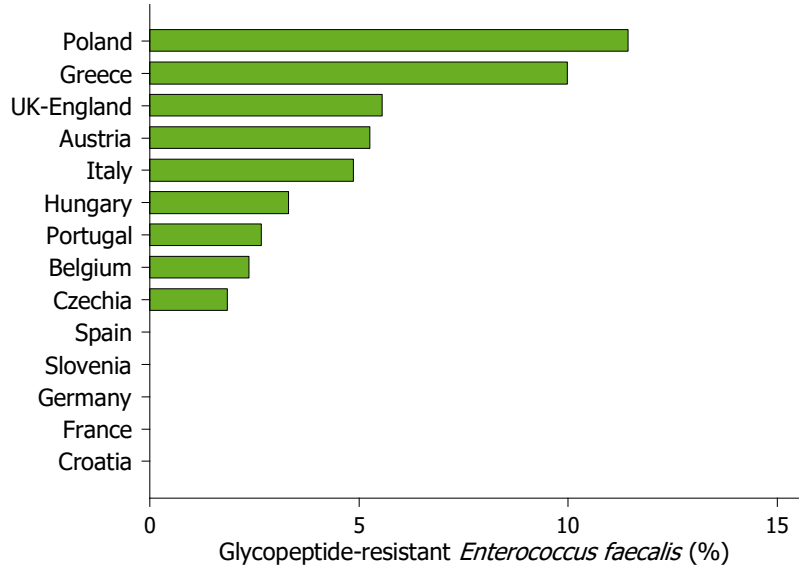


Countries with <10 isolates with known antimicrobial susceptibility results not shown.

Enterococci

Glycopeptide AST data for at least 10 *E. faecalis* isolates were reported by fourteen countries. Resistance varied from 0% in five countries to 11.4% in Poland (Figure 38).

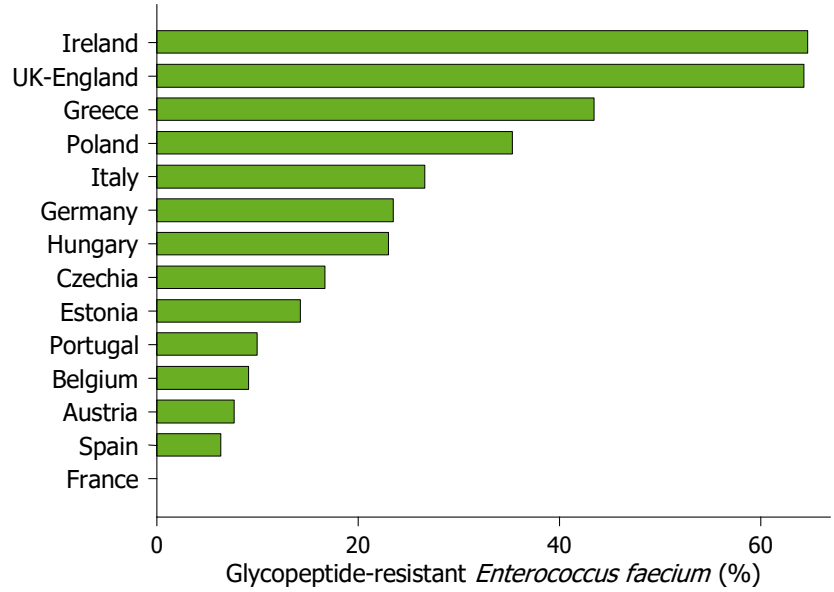
Figure 38. Percentage of *E. faecalis* isolates resistant to glycopeptide in healthcare-associated infections by country (n=573 isolates)



Countries with <10 isolates with known antimicrobial susceptibility results not shown.

Glycopeptide AST data for at least 10 *E. faecium* isolates were reported by fourteen countries. Resistance varied from 0% in France to 64.7% in Ireland and 64.3% in UK-England (Figure 39).

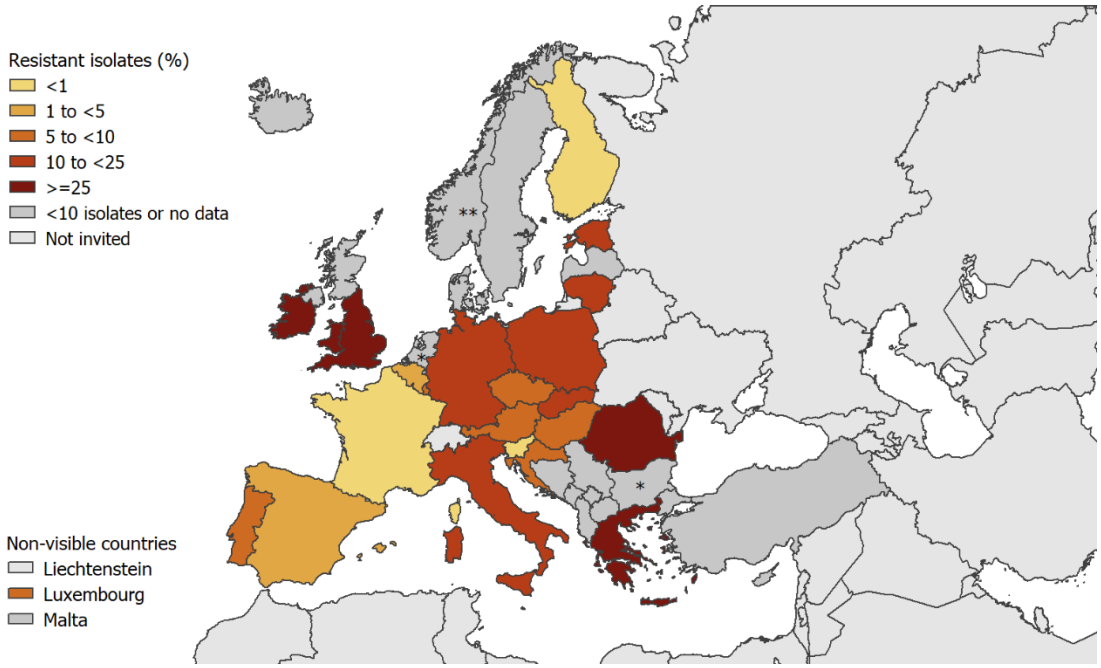
Figure 39. Percentage of *E. faecium* isolates resistant to glycopeptide in healthcare-associated infections, by country (n=313 isolates)



Countries with <10 isolates with known antimicrobial susceptibility (Croatia, Cyprus, Finland, Latvia, Lithuania, Luxembourg, the Netherlands, Romania, Slovakia, Slovenia, UK-Northern Ireland, UK-Wales): results not shown

When all *Enterococcus* species were combined, resistance data for at least 10 enterococci isolates were available for 22 countries. The percentage of glycopeptide resistance (VRE) varied from 0% in Finland, France and Slovenia to 50.0% in Ireland (Figure 40).

Figure 40. Percentage of *Enterococcus* spp. resistant to glycopeptide (VRE) isolated in healthcare-associated infections, by country (n=987 isolates)

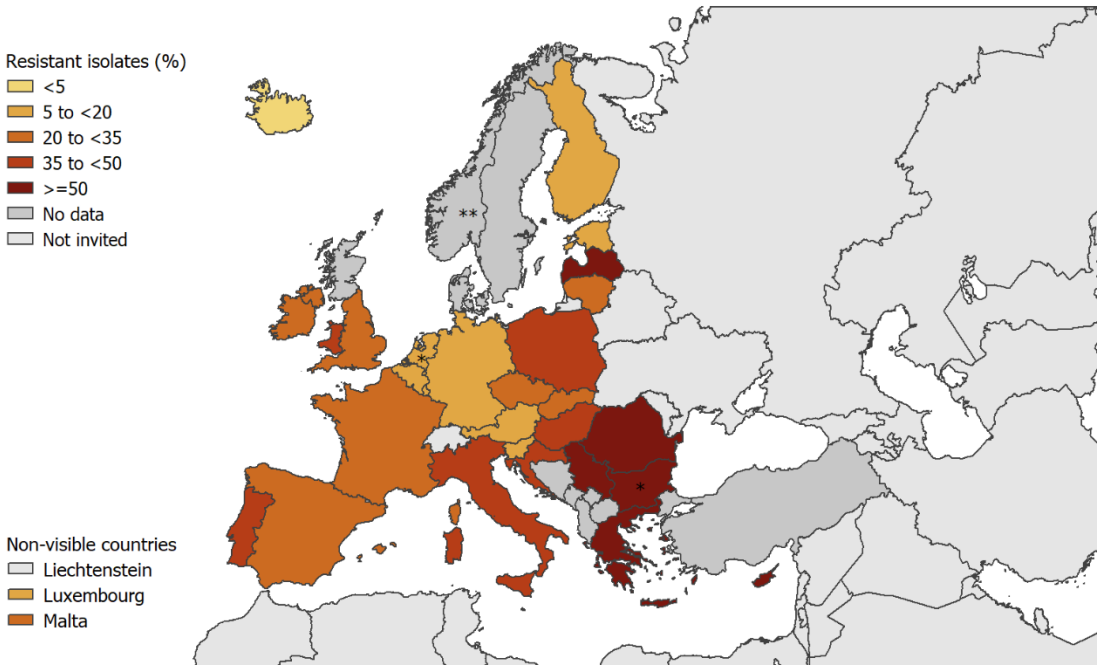


Countries with <10 isolates with known antimicrobial susceptibility results not shown.
**Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol .*

Composite index of antimicrobial resistance (AMR)

Antimicrobial susceptibility testing results for at least 10 isolates included in the composite index of AMR were available from 29 countries. Out of a total of 8 031 isolates, 2 534 isolates (all species combined), or 31.6%, were resistant to the first-level antimicrobial resistance markers. This percentage varied between 0% in Iceland and 68.9% in Romania (Figure 41). Detailed results by country and the correlation between the composite indices from the ECDC PPS and EARS-Net (Spearman's rho 0.93, p<0.001) were provided in reference [1].

Figure 41. Composite index of AMR: percentage of isolates resistant to first-level antimicrobial resistance markers, by country (n=8 031 isolates)



Composite index of antimicrobial resistance (AMR): MRSA, VRE, Enterobacterales resistant to third-generation cephalosporins, Pseudomonas aeruginosa *and* Acinetobacter baumannii *resistant to carbapenems. *Poor country representativeness in Bulgaria and the Netherlands. **Norway used a national PPS protocol.*

Antimicrobial use

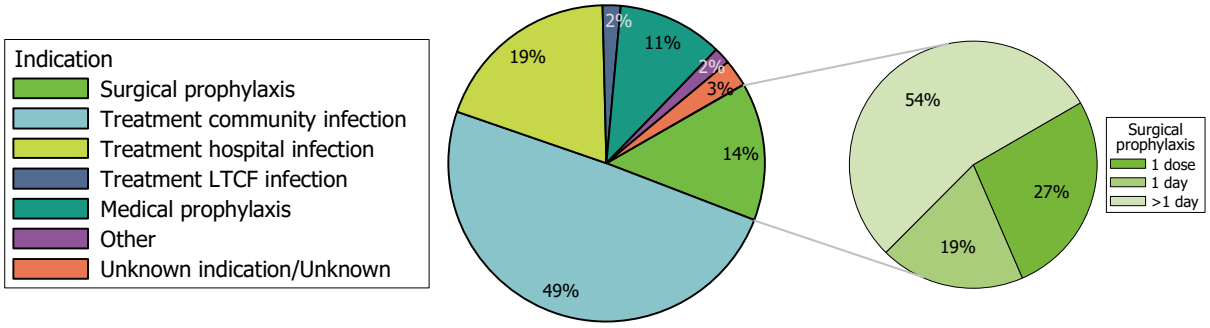
Main results, aggregated

Prevalence of antimicrobial use and indication

From a total of 310 755 patients in the database, 102 089 (32.9%) received at least one antimicrobial agent. A total of 139 591 antimicrobial agents were reported, which is an average of 1.37 agents per patient receiving antimicrobials. Of 102 089 patients on antimicrobials, 70.6% received one agent, 23.6% received two and 5.8% received three or more agents (up to a maximum of eight agents for three patients). Antimicrobials were administered parenterally in 72.8% of agents. The reason for antimicrobial use was documented in the patient's medical records for 80.3% of prescriptions.

Antimicrobials were most frequently prescribed for treatment of an infection (70.6%), of which 70.1% for a community-acquired infection (49.5% of all antimicrobials), 27.3% for a hospital infection (19.3% of total) and 2.7% for an infection acquired in a long-term care facility (1.9% of total). Surgical prophylaxis was the indication for 14.2% of prescriptions: 54.3% for more than one day (7.7% of total), 19.0% for one day (2.7% of total) and only 26.8% (or 3.8% of total) for less than one day (Figure 42). Overall, 71 385 of 310 755 patients (23.0%) were receiving treatment for an infection. The prevalence of patients receiving treatment for a hospital infection was 6.2%. The prevalence of patients receiving surgical prophylaxis was 5.4% (Table 13).

Figure 42. Indications for antimicrobial use in European acute care hospitals



LTCF: Long-term care facility.

Table 13. Indication for antimicrobial use, route of administration and documentation of the reason for antimicrobial use in the patients' notes

	Number of patients	Prevalence %	N of antimicrobials	Relative frequency %
Total	102 089	32.9	139 591	100.0
Indication for antimicrobial use				
Treatment	71 385	23.0	98 568	70.6
Community infection	50 871	16.4	69 067	49.5
Hospital infection	19 285	6.2	26 905	19.3
Other healthcare-associated infection	2 035	0.7	2 625	1.9
Surgical prophylaxis	16 892	5.4	19 797	14.2
Single dose	4 815	1.5	5 313	3.8
One day	3 450	1.1	3 755	2.7
>1 day	8 896	2.9	10 741	7.7
Medical prophylaxis	11 932	3.8	14 966	10.7
Other indication	1 827	0.6	2 421	1.7
Unknown indication, verified	1 721	0.6	1 976	1.4
Unknown/missing	1 555	0.5	1 891	1.4
Route of administration				
Parenteral	76 826	24.7	101 637	72.8
Oral	31 857	10.3	37 513	26.9
Other/unknown	419	0.1	441	0.3
Reason in notes				
Yes	82 169	26.4	112 015	80.2
No	18 153	5.8	22 838	16.4
Unknown	3 716	1.2	4 738	3.4

A total of 74 274 infections diagnosed by a physician were treated in 71 385 patients, which is an average of 1.04 infections per treated patient. The most common diagnosis site of infection was the respiratory tract (32.2%) with pneumonia and bronchitis accounting for 24.4% and 7.4%, respectively. Respiratory tract infections were more common among community-acquired infections (33.7%) and those acquired in long-term care (40.4%) than among hospital infections (27.3%). Urinary tract infections accounted for 16.6% of diagnoses, with symptomatic lower urinary tract infections accounting for 11.5% and upper urinary tract infections for 4.7%. Systemic infections, including laboratory-confirmed bacteraemia, accounted for 13.6% of diagnoses and were more common among hospital infections than community-acquired or long-term care infections (17.6% versus 12.0% and 12.5%, respectively) (Table 14).

Table 14. Site of diagnosis for antimicrobial treatment of infections

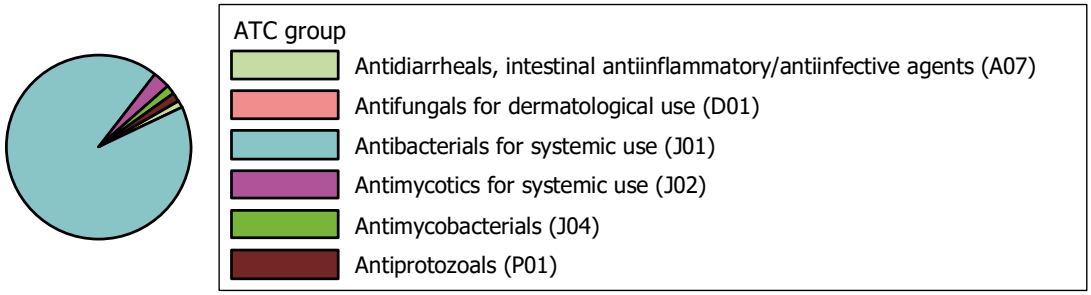
Site of diagnosis	Total	%	CI	%	HI	%	LI	%
Total N of diagnoses (N of infections)	**74 274**	**100.0**	**51 831**	**100.0**	**20 339**	**100.0**	**2 104**	**100.0**
Respiratory tract	23 882	32.2	17 480	33.7	5 552	27.3	850	40.4
Pneumonia (PNEU)	18 158	24.4	12 814	24.7	4 696	23.1	648	30.8
Acute bronchitis or exacerbations of chronic bronchitis (BRON)	5 550	7.5	4 511	8.7	843	4.1	196	9.3
Cystic Fibrosis (CF)	174	0.2	155	0.3	13	0.1	6	0.3
Urinary tract	12 300	16.6	8 170	15.8	3 619	17.8	511	24.3
Symptomatic Lower UTI (CYS)	8 564	11.5	5 252	10.1	2 918	14.3	394	18.7
Symptomatic Upper UTI (PYE)	3 470	4.7	2 746	5.3	610	3.0	114	5.4
Asymptomatic bacteriuria (ASB)	266	0.4	172	0.3	91	0.4	3	0.1
Systemic infections	10 093	13.6	6 225	12.0	3 606	17.7	262	12.5
Lab-confirmed bacteraemia (LAB)	2 867	3.9	1 251	2.4	1 535	7.5	81	3.8
Clinical sepsis, excluding FN (CSEP)	2 650	3.6	1 527	2.9	1 060	5.2	63	3.0
Febrile neutropaenia or other infection in immunocompromised host (FN)	1 115	1.5	690	1.3	392	1.9	33	1.6
Systematic inflammatory response with no clear anatomic site (SIRS)	1 395	1.9	997	1.9	352	1.7	46	2.2
Undefined, site with no systemic inflammation (UND)	2 066	2.8	1 760	3.4	267	1.3	39	1.9
Cardiovascular system	1 004	1.4	776	1.5	217	1.1	11	0.5
Gastro-intestinal system	9 200	12.4	6 884	13.3	2 164	10.6	152	7.2
GI Infections (salmonellosis, CDI) (GI)	3 679	5.0	2 386	4.6	1 205	5.9	88	4.2
Intra-abdominal sepsis including hepatobiliary (IA)	5 521	7.4	4 498	8.7	959	4.7	64	3.0
Skin/soft tissue/bone/joint – surgical site infection (SSI)	3 993	5.4	1 206	2.3	2 729	13.4	58	2.8
SSI involving skin or soft tissue but not bone (SST-SSI)	3 086	4.2	809	1.6	2 236	11.0	41	1.9
Septic arthritis, osteomyelitis of surgical site (BJ-SSI)	907	1.2	397	0.8	493	2.4	17	0.8
Skin/soft tissue/bone/joint - other	7 110	9.6	6 097	11.8	857	4.2	156	7.4
Cellulitis, wound, deep soft tissue not involving bone, not related to surgery (SST-O)	5 869	7.9	5 007	9.7	739	3.6	123	5.8
Septic arthritis, osteomyelitis, not related to surgery (BJ-O)	1 241	1.7	1 090	2.1	118	0.6	33	1.6
Central nervous system	854	1.1	629	1.2	220	1.1	5	0.2
Eye/ear/nose/throat	2 863	3.9	2 252	4.3	587	2.9	24	1.1
Endophtalmitis (EYE)	148	0.2	127	0.2	20	0.1	1	0.0
Infections of ear,mouth, nose, throat or larynx (ENT)	2 715	3.7	2 125	4.1	567	2.8	23	1.1
Genito-urinary system/obs.	1 044	1.4	856	1.7	177	0.9	11	0.5
Obstetric or gynaelogical infections, STD in women (OBGY)	694	0.9	558	1.1	132	0.6	4	0.2
Prostatitis, epididymoorchitis, STD in men (GUM)	350	0.5	298	0.6	45	0.2	7	0.3
Missing/Unknown	776	1.0	503	1.0	240	1.2	33	1.6

CI: community infection; HI: hospital infections; LI: long-term care or other healthcare-associated infections. STD: sexually transmitted diseases

Distribution of antimicrobial agents

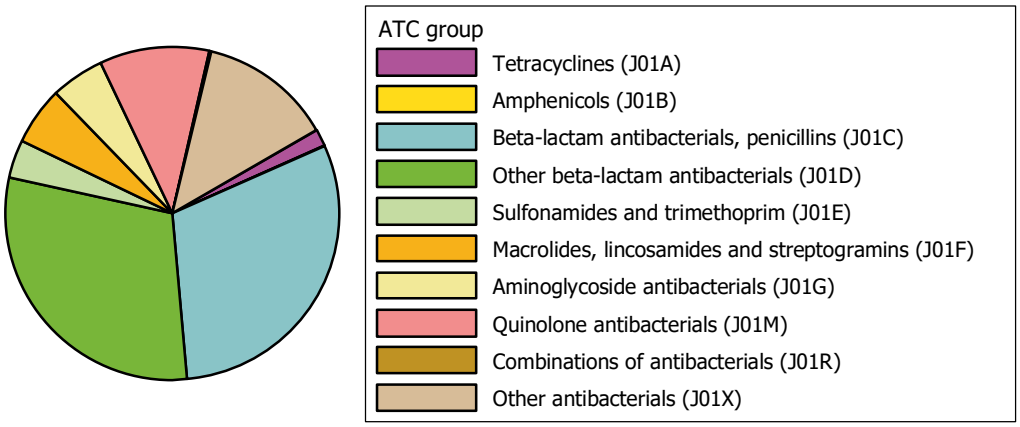
Antibacterials for systemic use (ATC group J01) represented 92.3% of all reported antimicrobials (Figure 43). Antimycotics for systemic use (ATC group J02) accounted for 3.2% overall. Triazole derivates accounted for 77.0% of antimycotics for systemic use (fluconazole 61.1%, voriconazole 6.9%, itraconazole 2.0% and posaconazole 6.9%), amphotericin B 7.4%, imidazole derivates 0.3% and other antimycotics for systemic use 15.2% (caspofungin 6.1%, anidulafungin 4.5%, micafungin 4.3%). Antimycobacterials for indications other than treatment of tuberculosis (included in ATC group J04) made up 1.7% of the total, of which rifampicin accounted for 50.6%, isoniazid for 16.9%, ethambutol for 14.7%, pyrazinamide for 12.7%, and rifabutin for 1.1%. Antiprotozoals (ATC group P01) accounted for 1.5% of all antimicrobials, 98.0% of which were oral or rectal metronidazole. ATC group A07 made up 1.3% of the total, of which oral vancomycin accounted for 35.3%, nystatin for 32.2%, rifaximin for 21.0%, oral colistin for 3.8%, fidaxomicin for 2.2% and oral amphotericin B for 1.4%. Only 18 (0.01% of total) antifungals for dermatologic use (ATC group D01) were reported.

Figure 43. Antimicrobial use in acute care hospitals on the day of the survey, by ATC level 2 group (n= 139 591 antimicrobial agents)



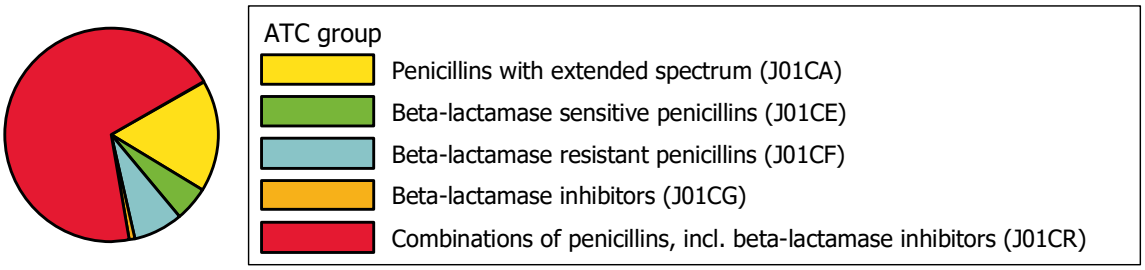
Within antibacterials for systemic use (AT group J01), the most frequently used sub-groups were penicillins (31.8%), other beta-lactam antibacterials (28.8%), quinolones (10.6%) and other antibacterials (12.7%) (Figure 44).

Figure 44. Use of antibacterials for systemic use (ATC group J01) in acute care hospitals on the day of the survey (n= 128 823 antimicrobial agents)



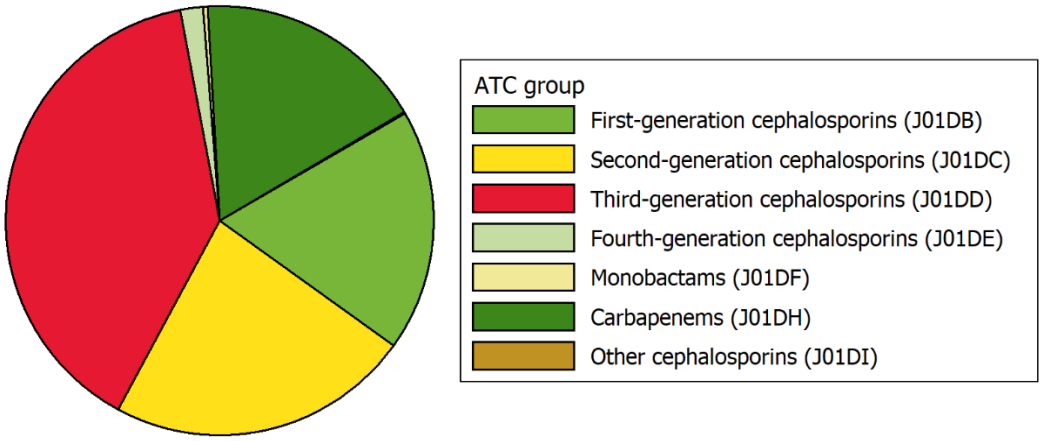
Combinations of penicillins including beta-lactam inhibitors (J01CR) accounted for 69.8% of all penicillins (Figure 45), of which amoxicillin and enzyme inhibitor (J01CR02) accounted for 54.2%, and piperacillin and enzyme inhibitor (J01CR05) for 36.6%. Penicillins with extended spectrum (J01CA) made up 16.4% of all penicillins used and included predominantly amoxicillin (53.5%) and ampicillin (31.1%).

Figure 45. Use of beta-lactam antibacterials, penicillins (ATC group C) in acute care hospitals on the day of the survey (n= 40 924 antimicrobial agents)



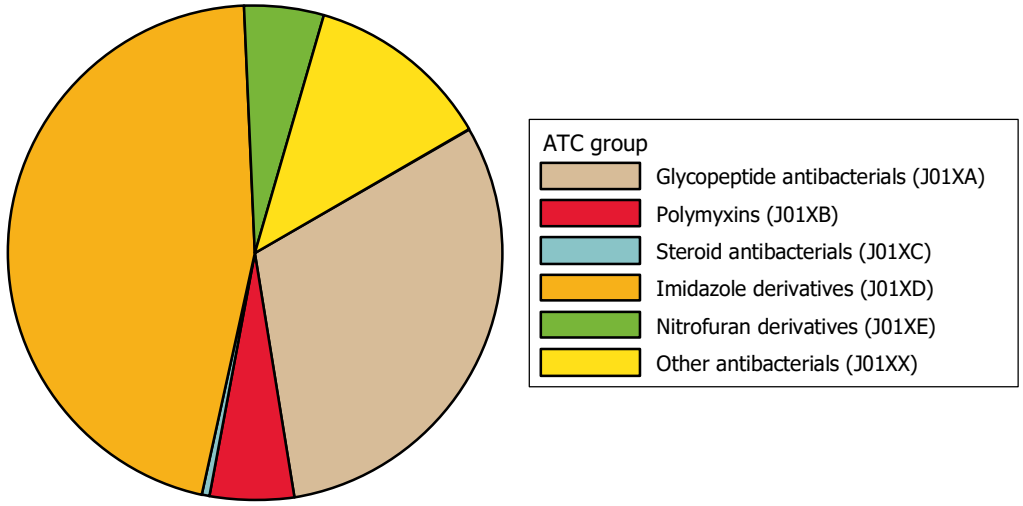
Among other beta-lactam antibacterials (J01D), third-generation cephalosporins were the most frequently used (37.2%), followed by second-generation cephalosporins (24.4%), carbapenems (18.4%), first-generation cephalosporins (18.1%) and fourth-generation cephalosporins (1.4%) (Figure 46).

Figure 46. Use of other beta-lactam antibacterials (ATC group J01D) in acute care hospitals on the day of the survey (n= 37 095 antimicrobial agents)



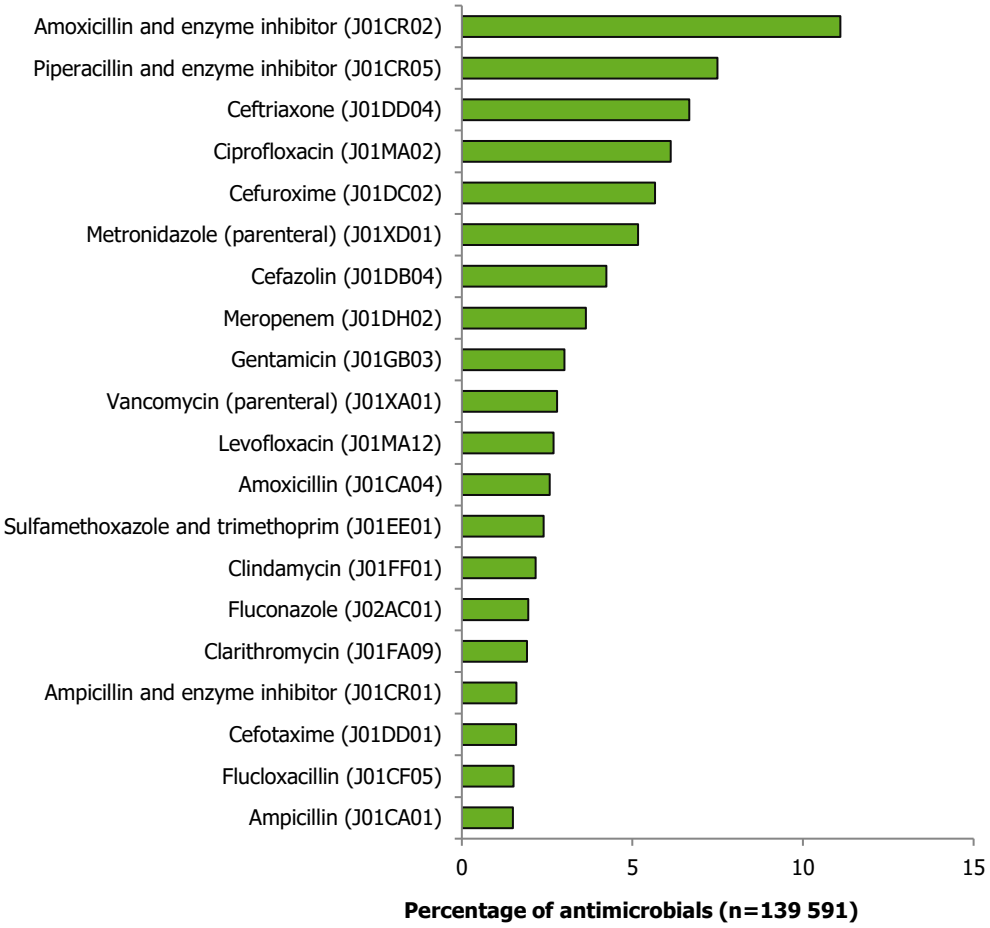
Other antibacterials (J01X), imidazole derivates (99.6% parenteral metronidazole) accounted for 44.1% of antimicrobial agents, glycopeptide antibacterials 31.6% (75.2% parenteral vancomycin and 24.3% teicoplanin), nitrofuran derivates 5.6%, polymyxins 5.3% (99.9% parenteral colistin), steroid antibacterials (fusidic acid) 0.5% and other antibacterials (J01XX) 12.9% (linezolid 63.0%, daptomycin 20.2%, fosfomycin 11.0%) (Figure 47).

Figure 47. Use of other antibacterials (ATC group J01X) in acute care hospitals on the day of the survey (n= 16 418 antimicrobial agents)



Out of a total of 233 different antimicrobials reported at the fifth ATC level, 20 (8.6%) accounted for 75% of the total antimicrobial use in European hospitals (Figure 48). The most frequently prescribed antibiotic, amoxicillin with enzyme inhibitor (J01CR02), accounted for 10.5% of all antimicrobial agents. The median number of different antimicrobials (ATC 5th level) reported by hospital was 20 (IQR: 12–29).

Figure 48. Antimicrobial agents accounting for 75% of antimicrobial use in European acute care hospitals (DU 75%)



DU: drug utilisation. Note: due to a global shortage of piperacillin-tazobactam during 2016-2017, some hospitals or countries (e.g. Malta) implemented a restriction policy for this antibiotic.

The type of antimicrobials used varied considerably by indication (Table 15 and Table A1.6). Combinations of penicillins, including beta-lactamase inhibitors (ATC group J01CR) were the most common group of antimicrobials in all indications except for surgical prophylaxis. Combination of penicillins with beta-lactamase inhibitors (J01CR) were the antimicrobial agents most commonly used (20.0%) for the treatment of hospital infections, followed by carbapenems (J01DH) and fluoroquinolones (J01MA) with 10.0% and 9.3%, respectively. The three antimicrobial groups most commonly prescribed for the treatment of community-acquired infections were combinations of penicillins and beta-lactamase inhibitors (J01CR: mainly amoxicillin and beta-lactamase inhibitor, J01CR02, and piperacillin and beta-lactamase inhibitor, J01CR05) followed by third-generation cephalosporins (J01DD) and fluoroquinolones (J01MA) with 23.2%, 11.7% and 11.0%, respectively. The three most common antimicrobial groups prescribed for surgical prophylaxis were first-generation cephalosporins (J01DB), second-generation cephalosporins (J01DC) and combinations of penicillins with beta-lactamase inhibitors (J01CR), with 26.6%, 17.9% and 15.2%, respectively. The most common antimicrobials prescribed for medical prophylaxis were sulfomethoxazole and trimethoprim (J01EE01, 11.0%), amoxicillin and beta-lactamase inhibitor (J01CR02, 8.0%), ciprofloxacin (J01MA02, 6.8%), ceftriaxone (J01DD04, 6.2%) and fluconazole (J02AC01, 6.0%). Within ATC group J01CR, amoxicillin and enzyme inhibitor (J01CR02) was the most frequently used drug in all indications except for the treatment intention of hospital infections, where it accounted for only 7.6% of all antimicrobials, compared with 11.9% for all other indications combined; while piperacillin and enzyme inhibitor (J01CR05) accounted for 11.4% of treatment for hospital infections compared with 6.6% for other indications ($p<0.001$).

Antimicrobial use intended to treat hospital infections was also characterised by higher (significant at $p<0.001$ level) use of intestinal anti-infectives (ATC group A07AA), in particular of oral vancomycin (A07AA09, 1.6% for hospital infection versus 0.2% for other indications combined), tetracyclines (ATC group J01AA), in particular tigecycline (J01AA12, 1.1% versus 0.2%), fourth-generation cephalosporins (ATC group J01DE, 0.8% versus 0.3%), carbapenems (ATC group J01DH, 10.0% versus 3.7%), glycopeptide antibacterials (ATC group J01XA, 7.5% versus 2.8%), polymyxins (ATC group J01XB, 1.9% versus 0.3%), other antibacterials (ATC group J01XX, 3.6% versus 1.0%), all antimycotics for systemic use (ATC group J02, 5.0% versus 2.8%) and nitroimidazole derivates (ATC group P01AB), in particular oral metronidazole (P01AB01, 2.2% versus 1.3%). The distribution of antimicrobials in the treatment of infections associated with long-term care showed a profile in between the treatment of community-acquired infections and hospital infections, with, for example, a similar use of amoxicillin and enzyme

inhibitor as for the treatment of community infections (13.9% *versus* 13.1%), but a higher use of piperacillin and enzyme inhibitor (11.3% *versus* 8.2%), oral vancomycin (0.7% *versus* 0.3%), carbapenems (8.5% *versus* 4.4%) or polymyxins (0.9% *versus* 0.3%).

Table 15. Antimicrobials (fourth ATC level*) as a percentage of the total number of antimicrobials, by indication

Antimicrobial group (ATC code)	CI	HI	LI	SP	MP	Oth	Unk	Total
Number of antimicrobials	69 067	26 877	2 624	19 788	14 960	2 414	3 861	139 591
Intestinal anti-infectives, antibiotics (A07AA)	0.7	2.8	1.0	0.1	2.9	3.6	1.5	1.3
Antifungals for systemic use (D01BA)	<0.1	0.0	0.0	0.0	<0.1	<0.1	0.1	<0.1
Tetracyclines (J01AA)	1.8	2.3	1.4	0.4	0.8	2.3	1.8	1.6
Amphenicols (J01BA)	<0.1	<0.1	0.0	<0.1	<0.1	0.0	0.0	<0.1
Penicillins, extended spectrum without anti-pseudomonal activity (J01CA)	5.8	3.5	4.1	2.6	5.3	6.6	5.4	4.8
Beta-lactamase sensitive penicillins (J01CE)	2.1	0.8	0.5	0.3	2.3	1.7	1.4	1.6
Beta-lactamase resistant penicillins (J01CF)	2.7	2.9	1.2	1.2	0.3	0.9	1.7	2.2
Beta-lactamase inhibitors (J01CG)	0.2	0.2	0.3	0.3	0.4	0.4	0.3	0.3
Combinations of penicillins, incl. beta-lactamase inhibitors (J01CR)	23.2	20.0	26.8	15.2	14.5	15.4	23.8	20.5
First-generation cephalosporins (J01DB)	1.1	0.8	0.8	26.6	2.3	1.4	2.6	4.8
Second-generation cephalosporins (J01DC)	5.2	2.9	3.5	17.9	4.4	5.4	5.8	6.5
Third-generation cephalosporins (J01DD)	11.7	6.2	11.3	9.2	9.1	8.1	9.9	9.9
Fourth-generation cephalosporins (J01DE)	0.3	0.8	0.6	0.1	0.3	0.5	0.2	0.4
Monobactams (J01DF)	0.1	0.1	0.2	<0.1	0.1	<0.1	0.1	0.1
Carbapenems (J01DH)	4.4	10.0	8.5	1.0	2.6	5.3	3.9	4. 9
Other cephalosporins and penems (J01DI)	0.0	0.1	0.0	<0.1	<0.1	0.0	0.0	<0.1
Trimethoprim and derivatives (J01EA)	0.7	1.0	0.4	0.2	1.7	0.1	1.4	0.8
Short-acting sulfonamides (J01EB)	0.0	<0.1	0.0	<0.1	<0.1	0.0	0.0	<0.1
Intermediate-acting sulfonamides (J01EC)	<0.1	0.1	0.2	<0.1	0.1	0.1	0.1	0.1
Long-acting sulfonamides (J01ED)	<0.1	<0.1	0.0	<0.1	<0.1	0.0	<0.1	<0.1
Combinations of sulfonamides and trimethoprim, incl. derivatives (J01EE)	1.3	2.2	2.4	0.7	11.8	2.3	1.9	2.6
Macrolides (J01FA)	4.5	1.2	3.6	0.4	3.4	8.4	2.9	3.1
Lincosamides (J01FF)	2.6	1.6	1.6	2.3	1.2	2.4	2.1	2.2
Streptogramins (J01FG)	<0.1	<0.1	0.1	0.0	0.0	0.1	0.0	<0.12
Streptomycins (J01GA)	<0.1	<0.1	0.0	0.0	<0.1	<0.1	0.0	<0.11
Aminoglycosides (J01GB)	4.0	4.5	3.5	4.8	4.4	6.3	3.7	4.3
First-generation quinolones (J01M1)	0.1	0.1	0.2	0.1	0.4	0.4	0.2	0.1
Second-generation quinolones (J01M2)	10.2	8.7	10.8	4.3	10.3	7.3	10.0	9.1
Third-generation quinolones (J01M3)	0.7	0.5	0.6	0.1	0.3	0.8	0.4	0.5
Combinations of antibacterials (J01RA)	0.2	0.1	0.1	0.1	0.3	0.1	0.2	0.2
Glycopeptide antibacterials (J01XA)	2.8	7.5	4.3	3.1	1.9	3.8	3.2	3.7
Polymyxins (J01XB)	0.3	1.9	0.9	0.1	0.4	0.4	0.7	0.6
Steroid antibacterials (J01XC)	0.1	0.1	0.0	<0.1	0.0	0.1	<0.1	<0.16
Imidazole derivatives (J01XD)	5.3	4.1	3.2	7.4	3.8	6.4	4.7	5.19
Nitrofuran derivatives (J01XE)	0.5	1.0	0.8	0.1	1.4	0.5	0.7	0.66
Other antibacterials (J01XX)	1.2	3.5	1.9	0.4	1.1	0.8	1.2	1.52
Antimycotics, antibiotics (J02AA)	0.1	0.4	0.3	<0.1	0.7	0.0	0.3	0.24
Imidazole derivatives (J02AB)	<0.1	<0.1	<0.1	<0.1	<0.1	0.0	<0.1	<0.11
Triazole derivatives (J02AC)	1.3	3.3	1.8	0.3	8.8	2.5	2.8	2.44
Other antimycotics for systemic use (J02AX)	0.2	1.2	0.5	<0.1	0.9	0.7	0.6	0.5
Antimycobacterials (J04)	1.4	1.1	0.3	<0.1	0.2	0.5	0.1	0.8
Nitroimidazole derivatives (P01AB)	1.5	2.3	1.6	0.6	0.9	3.1	2.1	1.5

**Fourth ATC level except for quinolone antibacterials (classified according to reference [32]) and antimycobacterials combined at second ATC level J04.*
CI: treatment intention of community-acquired infection, HI: treatment intention of hospital infection, LI: treatment intention of long-term care/other healthcare-associated infection, SP: surgical prophylaxis, MP: medical prophylaxis, Oth: other indications, Unk: Unknown indication and missing data.

Medical prophylaxis was characterised by a higher relative use of intestinal anti-infectives (ATC group A07AA, 2.9% versus 1.2% for other indications), trimethoprim including derivates and combinations (ATC groups J01EA and J01EE, 1.7% and 11.8% versus 0.7% and 1.5%, respectively) and antimycotics for systemic use (ATC group J02, 10.5% versus 2.3%). Macrolides (ATC group J01FA) were frequently used for 'other' indications (8.4% compared with 3.1% for all other indications combined).

Results by type of hospital, specialty, and patient risk factors

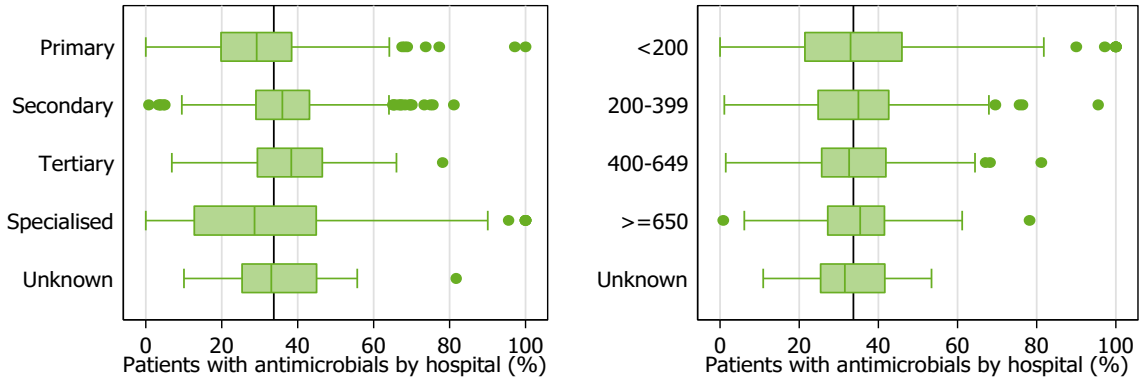
The prevalence of antimicrobial use varied significantly by type of hospital ($p<0.01$). The prevalence was the lowest in specialised and primary hospitals. Tertiary hospitals recorded the highest prevalence (Table 16). Prevalence of antimicrobial use did not vary by hospital size (Figure 49).

Table 16. Percentile distribution of the prevalence of antimicrobial use, by type of hospital

	No of hospitals	No of patients	Pts with AU	Prev AU %	P10	P25	P50	P75	P90
Primary	363	52 860	15 164	28.7	12.0	19.8	29.1	38.5	50.0
Secondary	412	109 286	36 513	33.4	20.7	29.0	36.0	43.1	54.1
Tertiary	242	122 738	43 570	35.5	23.9	29.4	38.5	46.9	53.7
Specialised	165	21 487	5 444	25.3	3.1	12.7	28.6	45.0	55.2
Unknown	27	4 384	1 398	31.9	11.7	25.3	34.5	45.7	53.4
Total	1 209	310 755	102 089	32.9	14.5	24.2	33.7	43.0	53.3

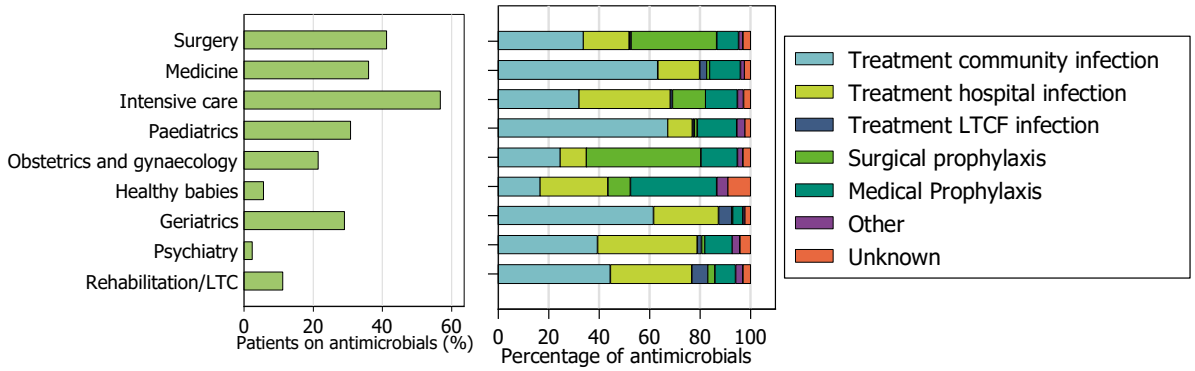
Pts with AU: patients receiving at least one antimicrobial; Prev AU: percentage patients receiving at least one antimicrobial; P: percentile.

Figure 49. Prevalence of antimicrobial use (percentage of patients on antimicrobials), by hospital type (left) and size (right), (vertical black line=overall median)



The prevalence of antimicrobial use was the lowest among psychiatric patients (2.4%) and the highest among ICU patients (55.6%) (Figure 50). The indications for antimicrobial use varied considerably by patient/consultant specialty with the highest relative use for treatment of community-acquired infections in paediatric patients (67.0% of all antimicrobials), the highest use for treatment of hospital infections in psychiatric and ICU patients (39.5% 37.0% respectively) and for treatment of infections associated with long-term care in rehabilitation and geriatric patients (6.5% and 5.1%, respectively). Surgical prophylaxis was the most common indication in obstetrics and gynaecology (42.1%); the relative frequency of medical prophylaxis varied between 4.1% in geriatrics and 15.6% in paediatrics. The percentage of patients receiving more than one antimicrobial varied between 5.9% in psychiatry and 47.7% in the ICU.

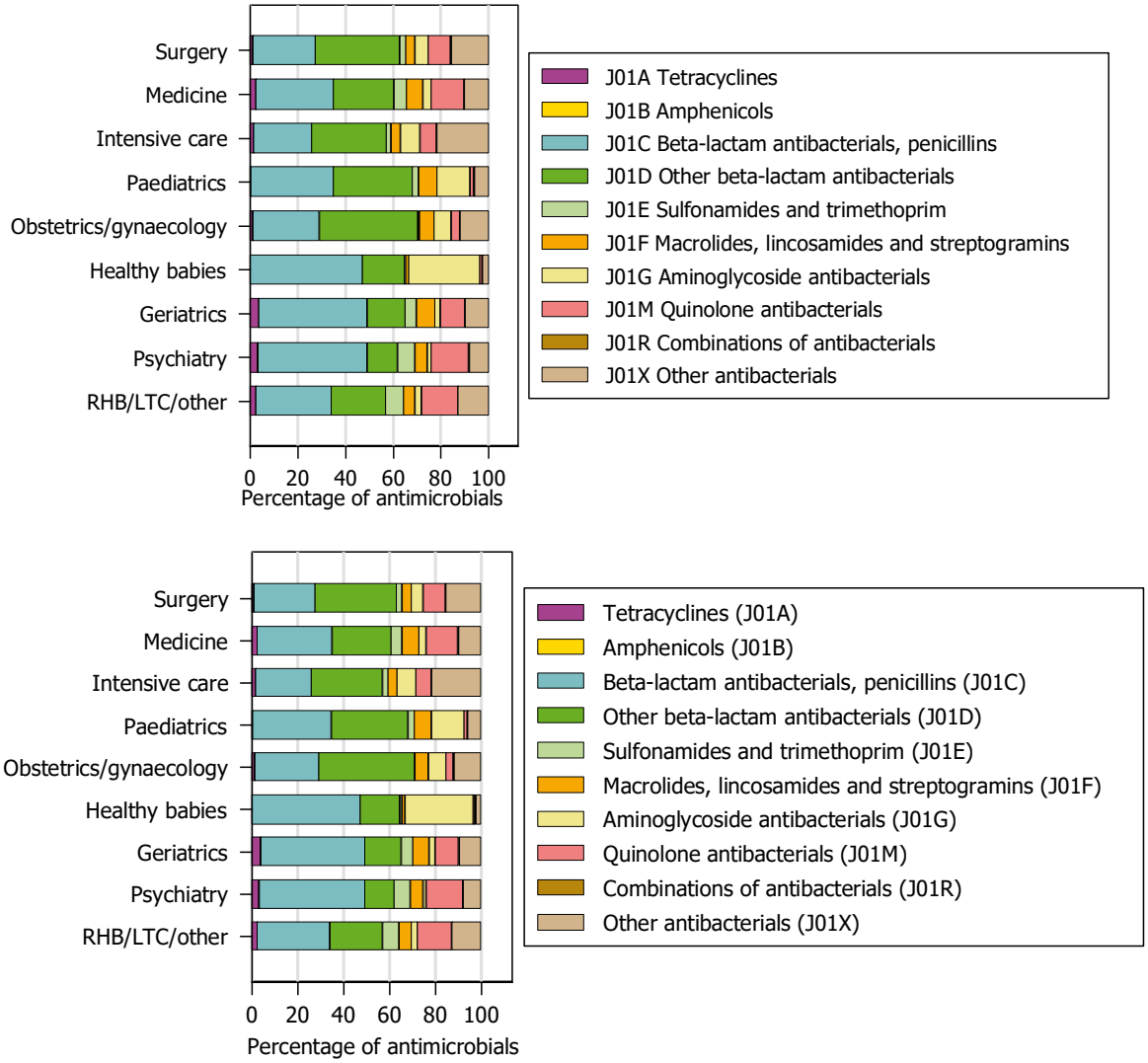
Figure 50. Prevalence of antimicrobial use (percentage of patients on antimicrobials) by patient/consultant specialty (left) and indication for antimicrobial use by patient/consultant specialty (right)



LTC=long-term care, LTCF=long-term care facility.

The distribution of antibacterials for systemic use by patient/consultant specialty showed the highest relative use of aminoglycosides among paediatric patients and the highest use of other antibacterials among ICU patients (Figure 51).

Figure 51. Distribution of antibacterials for systemic use (ATC group J01) by patient/consultant specialty



RHB=rehabilitation, LTC=long-term care

Table 17 shows the prevalence of antimicrobial use by patient risk factors for 283 055 patients in 29 countries that used the standard (patient-based) protocol. In multiple logistic regression analysis, antimicrobial use was independently associated at the p<0.001 level with all risk factors and with 105 out of 140 (75%) of the risk factor sublevels. The highest independent risk (adjusted odds ratio ≥2.0) was observed in patients with urinary catheters, in the patient/consultant specialties haematology and bone marrow transplant and in 14 surgery types, with the highest adjusted odds ratios in liver transplant surgery and appendix surgery. The lowest independent risk (adjusted odds ratio ≤0.2) was observed in healthy neonates, medical traumatology, psychiatrics, rehabilitation and long-term care. Central and peripheral vascular catheters were not included in the model because of the association with parenteral antimicrobial use. The discriminatory power of the model as measured by the area under the ROC curve was 0.7558 for the full sample.

Table 17. Patient risk factors for antimicrobial use with crude and adjusted odds ratios from multiple logistic regression model, n=283 055 patients in 29 countries, standard protocol data only

	N of patients	% of total	N of pts with AU	Pts with AU %	Crude OR	(95%	CI)	Adj OR*	(95%	CI)
All patients	283 055	100.0	95 031	33.6	-			-		
Age										
5-44 years	50 216	17.7	15 048	30.0	ref.	-		ref.	-	
<1 month	9 024	3.2	1 251	13.9	0.4	(0.4 -	0.4)	1.0	(0.8 -	1.1)
1-11 months	4 967	1.8	1 458	29.4	1.0	(0.9 -	1.0)	0.9	(0.8 -	1.0)
1-4 years	4 250	1.5	1 873	44.1	1.8	(1.7 -	2.0)	1.2	(1.1 -	1.3)
45-74 years	120 440	42.6	42 083	34.9	1.3	(1.2 -	1.3)	0.9	(0.9 -	0.9)
75-84 years	58 570	20.7	20 769	35.5	1.3	(1.3 -	1.3)	0.9	(0.9 -	0.9)
≥85 years	35 588	12.6	12 550	35.3	1.3	(1.2 -	1.3)	1.0	(0.9 -	1.0)
Gender										
Female/other/unknown	148 737	52.5	45 462	30.6	ref.	-		ref.	-	
Male	134 318	47.5	49 578	36.9	1.3	(1.3 -	1.3)	1.2	(1.2 -	1.2)
Length of stay (days)[a]										
1-3 days	85 288	30.1	25 955	30.4	ref.	-		ref.	-	
4-7 days	70 579	24.9	27 918	39.6	1.5	(1.5 -	1.5)	1.5	(1.4 -	1.5)
8-14 days	53 852	19.0	20 915	38.8	1.5	(1.4 -	1.5)	1.4	(1.4 -	1.4)
15-29 days	36 333	12.8	12 041	33.1	1.1	(1.1 -	1.2)	1.1	(1.1 -	1.1)
>=30 days	36 720	13.0	8 145	22.2	0.7	(0.6 -	0.7)	0.7	(0.7 -	0.8)
Unknown	283	0.1	57	20.1	0.6	(0.4 -	0.8)	0.6	(0.5 -	0.9)
McCabe score										
Non-fatal	188 438	66.6	58 335	31.0	ref.	-		ref.	-	
Ultimately fatal	46 012	16.3	19 082	41.5	1.6	(1.5 -	1.6)	1.2	(1.1 -	1.2)
Rapidly fatal	17 532	6.2	7 934	45.3	1.8	(1.8 -	1.9)	1.3	(1.2 -	1.3)
Unknown	31 073	11.0	9 680	31.2	1.0	(1.0 -	1.0)	1.0	(0.9 -	1.0)
Surgery since admission										
No surgery	210 400	74.3	62 926	29.9	ref.	-		ref.	-	
NHSN surgery										
NHSN surgery, not specified	25 188	8.9	10 738	42.6	1.7	(1.7 -	1.8)	1.5	(1.5 -	1.6)
AAA-Abdominal aortic aneurysm repair	205	0.1	112	54.6	2.8	(2.1 -	3.7)	1.6	(1.2 -	2.1)
AMP-Limb amputation	936	0.3	558	59.6	3.5	(3.0 -	3.9)	2.6	(2.3 -	3.0)
APPY-Appendix surgery	594	0.2	468	78.8	8.7	(7.1 -	10.6)	6.4	(5.2 -	7.8)
AVSD-Shunt for dialysis	55	0.0	26	47.3	2.1	(1.2 -	3.6)	1.4	(0.8 -	2.5)
BILI-Bile duct, liver or pancreatic surgery	646	0.2	377	58.4	3.3	(2.8 -	3.8)	1.9	(1.6 -	2.2)
BRST-Breast surgery	621	0.2	310	49.9	2.3	(2.0 -	2.7)	2.1	(1.8 -	2.4)
CARD-Cardiac surgery	1 191	0.4	563	47.3	2.1	(1.9 -	2.4)	1.7	(1.5 -	1.9)
CBGB-Coronary artery bypass graft with both chest and donor site incisions	323	0.1	140	43.3	1.8	(1.4 -	2.2)	1.4	(1.1 -	1.8)
CBGC-Coronary artery bypass graft with chest incision only	185	0.1	72	38.9	1.5	(1.1 -	2.0)	1.1	(0.8 -	1.5)
CEA-Carotid endarterectomy	95	0.0	44	46.3	2.0	(1.4 -	3.0)	1.4	(0.9 -	2.1)
CHOL-Gallbladder surgery	746	0.3	420	56.3	3.0	(2.6 -	3.5)	2.1	(1.8 -	2.4)
COLO-Colon surgery	2 022	0.7	1 125	55.6	2.9	(2.7 -	3.2)	1.5	(1.4 -	1.7)
CRAN-Craniotomy	1 262	0.4	558	44.2	1.9	(1.7 -	2.1)	1.5	(1.4 -	1.8)
CSEC-Caesarean section	1 775	0.6	601	33.9	1.2	(1.1 -	1.3)	2.6	(2.4 -	3.0)
FUSN-Spinal fusion	463	0.2	187	40.4	1.6	(1.3 -	1.9)	1.8	(1.5 -	2.2)
FX-Open reduction of fracture	2 852	1.0	1 115	39.1	1.5	(1.4 -	1.6)	1.5	(1.4 -	1.6)
GAST-Gastric surgery	647	0.2	345	53.3	2.7	(2.3 -	3.1)	1.5	(1.3 -	1.8)
HER-Herniorrhaphy	794	0.3	364	45.8	2.0	(1.7 -	2.3)	1.4	(1.2 -	1.6)
HPRO-Hip prosthesis	2 801	1.0	971	34.7	1.2	(1.1 -	1.3)	1.3	(1.2 -	1.4)
HTP-Heart transplant	31	0.0	22	71.0	5.7	(2.6 -	12.4)	4.1	(1.8 -	9.4)
HYST-Abdominal hysterectomy	409	0.1	197	48.2	2.2	(1.8 -	2.6)	2.1	(1.7 -	2.6)
KPRO-Knee prosthesis	1 569	0.6	622	39.6	1.5	(1.4 -	1.7)	1.8	(1.6 -	2.0)
KTP-Kidney transplant	177	0.1	133	75.1	7.1	(5.0 -	10.0)	2.6	(1.8 -	3.7)
LAM-Laminectomy	706	0.2	311	44.1	1.8	(1.6 -	2.1)	2.5	(2.1 -	2.9)
LTP-Liver transplant	104	0.0	87	83.7	12.0	(7.1 -	20.2)	5.7	(3.3 -	9.7)
NECK-Neck surgery	482	0.2	275	57.1	3.1	(2.6 -	3.7)	1.7	(1.4 -	2.1)
NEPH-Kidney surgery	496	0.2	315	63.5	4.1	(3.4 -	4.9)	1.5	(1.2 -	1.8)
OVRY-Ovarian surgery	297	0.1	133	44.8	1.9	(1.5 -	2.4)	2.0	(1.6 -	2.6)
PACE-Pacemaker surgery	268	0.1	130	48.5	2.2	(1.7 -	2.8)	3.3	(2.6 -	4.3)
PRST-Prostate surgery	390	0.1	241	61.8	3.8	(3.1 -	4.6)	1.1	(0.9 -	1.3)
PVBY-Peripheral vascular bypass surgery	429	0.2	237	55.2	2.9	(2.4 -	3.5)	2.3	(1.9 -	2.8)
REC-Rectal surgery	394	0.1	226	57.4	3.2	(2.6 -	3.8)	1.8	(1.5 -	2.2)
RFUSN-Refusion of spine	125	0.0	48	38.4	1.5	(1.0 -	2.1)	1.6	(1.1 -	2.3)
SB-Small bowel surgery	543	0.2	319	58.7	3.3	(2.8 -	4.0)	1.7	(1.4 -	2.1)

	N of patients	% of total	N of pts with AU	Pts with AU %	Crude OR	(95%	CI)	Adj OR*	(95%	CI)
SPLE-Spleen surgery	64	0.0	46	71.9	6.0	(3.5 -	10.3)	3.1	(1.7 -	5.5)
THOR-Thoracic surgery	635	0.2	373	58.7	3.3	(2.8 -	3.9)	2.3	(1.9 -	2.8)
THYR-Thyroid and/or parathyroid surgery	380	0.1	88	23.2	0.7	(0.6 -	0.9)	0.5	(0.4 -	0.7)
VHYS-Vaginal hysterectomy	247	0.1	122	49.4	2.3	(1.8 -	2.9)	2.3	(1.7 -	3.0)
VSHN-Ventricular shunt	169	0.1	79	46.7	2.1	(1.5 -	2.8)	2.0	(1.4 -	2.8)
XLAP-Exploratory laparotomy	739	0.3	442	59.8	3.5	(3.0 -	4.0)	2.0	(1.7 -	2.4)
Minimal/non-NSHN surgery	17 662	6.2	7 897	44.7	1.9	(1.8 -	2.0)	1.7	(1.6 -	1.8)
Unknown	2 938	1.0	668	22.7	0.7	(0.6 -	0.8)	0.8	(0.7 -	0.9)
Presence of invasive devices										
Intubation	6 177	2.2	4 251	68.8	4.5	(4.3 -	4.8)	1.9	(1.8 -	2.1)
Urinary catheter	49 929	17.6	28 569	57.2	3.4	(3.3 -	3.4)	2.5	(2.4 -	2.5)
Central vascular catheter [b]	21 225	7.5	13 894	65.5	4.2	(4.1 -	4.3)			
Peripheral vascular catheter [b]	137 396	48.5	69 443	50.5	4.8	(4.7 -	4.9)			
Patient/consultant specialty										
General surgery	18 976	6.7	8 978	47.3	ref.	-		ref.	-	
Digestive tract surgery	4 632	1.6	2 111	45.6	0.9	(0.9 -	1.0)	0.8	(0.8 -	0.9)
Orthopaedics and traumatology	8 405	3.0	2 967	35.3	0.6	(0.6 -	0.6)	0.6	(0.6 -	0.6)
Orthopaedics	9 899	3.5	3 444	34.8	0.6	(0.6 -	0.6)	0.6	(0.6 -	0.6)
Traumatology	3 871	1.4	1 234	31.9	0.5	(0.5 -	0.6)	0.5	(0.5 -	0.6)
Cardio surgery	1 955	0.7	656	33.6	0.6	(0.5 -	0.6)	0.5	(0.4 -	0.6)
Cardiovascular surgery	722	0.3	246	34.1	0.6	(0.5 -	0.7)	0.5	(0.4 -	0.6)
Vascular surgery	3 545	1.3	1 531	43.2	0.8	(0.8 -	0.9)	0.8	(0.7 -	0.8)
Thoracic surgery	1 246	0.4	517	41.5	0.8	(0.7 -	0.9)	0.7	(0.6 -	0.8)
Neurosurgery	4 887	1.7	1 492	30.5	0.5	(0.5 -	0.5)	0.4	(0.4 -	0.5)
Paediatric general surgery	1 328	0.5	582	43.8	0.9	(0.8 -	1.0)	0.8	(0.7 -	0.9)
Transplantation surgery	616	0.2	369	59.9	1.7	(1.4 -	2.0)	1.5	(1.2 -	1.8)
Surgery for cancer	1 140	0.4	463	40.6	0.8	(0.7 -	0.9)	0.7	(0.6 -	0.8)
Ear-nose-throat	3 584	1.3	1 516	42.3	0.8	(0.8 -	0.9)	1.0	(0.9 -	1.1)
Ophthalmology	1 707	0.6	286	16.8	0.2	(0.2 -	0.3)	0.3	(0.2 -	0.3)
Maxillo-facial surgery	816	0.3	496	60.8	1.7	(1.5 -	2.0)	1.9	(1.6 -	2.2)
Stomatology/ Dentistry	70	0.0	40	57.1	1.5	(0.9 -	2.4)	2.0	(1.2 -	3.2)
Burns care	260	0.1	100	38.5	0.7	(0.5 -	0.9)	0.7	(0.5 -	0.9)
Urology	6 544	2.3	3 903	59.6	1.6	(1.6 -	1.7)	1.3	(1.2 -	1.4)
Plastic and reconstructive surgery	1 567	0.6	836	53.4	1.3	(1.1 -	1.4)	1.3	(1.2 -	1.4)
Other surgery	1 016	0.4	415	40.8	0.8	(0.7 -	0.9)	0.9	(0.8 -	1.0)
General medicine	39 411	13.9	16 606	42.1	0.8	(0.8 -	0.8)	1.0	(0.9 -	1.0)
Gastro-enterology	7 049	2.5	2 591	36.8	0.6	(0.6 -	0.7)	0.9	(0.8 -	0.9)
Hepatology	476	0.2	218	45.8	0.9	(0.8 -	1.1)	1.1	(0.9 -	1.3)
Endocrinology	2 764	1.0	772	27.9	0.4	(0.4 -	0.5)	0.6	(0.5 -	0.6)
Nephrology	4 265	1.5	2 063	48.4	1.0	(1.0 -	1.1)	1.2	(1.2 -	1.3)
Cardiology	14 939	5.3	2 983	20.0	0.3	(0.3 -	0.3)	0.3	(0.3 -	0.4)
Dermatology	1 524	0.5	527	34.6	0.6	(0.5 -	0.7)	0.9	(0.8 -	1.0)
Haematology	3 334	1.2	2 100	63.0	1.9	(1.8 -	2.0)	2.6	(2.4 -	2.8)
Bone Marrow Transplantation	279	0.1	219	78.5	4.1	(3.1 -	5.4)	6.4	(4.8 -	8.6)
Haematology/BMT	768	0.3	534	69.5	2.5	(2.2 -	3.0)	3.6	(3.0 -	4.2)
Oncology	7 220	2.6	2 276	31.5	0.5	(0.5 -	0.5)	0.7	(0.6 -	0.7)
Neurology	12 854	4.5	2 032	15.8	0.2	(0.2 -	0.2)	0.3	(0.2 -	0.3)
Pneumology	9 933	3.5	5 406	54.4	1.3	(1.3 -	1.4)	1.8	(1.7 -	1.9)
Rheumatology	1 640	0.6	298	18.2	0.2	(0.2 -	0.3)	0.4	(0.3 -	0.4)
Infectious diseases	4 087	1.4	2 750	67.4	2.3	(2.1 -	2.5)	3.1	(2.8 -	3.3)
Medical traumatology	1 114	0.4	58	5.2	0.1	(0.0 -	0.1)	0.1	(0.1 -	0.1)
Other medical	3 853	1.4	984	25.5	0.4	(0.4 -	0.4)	0.6	(0.5 -	0.6)
Healthy neonates (maternity)	2 904	1.0	173	6.0	0.1	(0.1 -	0.1)	0.2	(0.1 -	0.2)
Healthy neonates (paediatrics)	1 163	0.4	33	2.8	0.0	(0.0 -	0.0)	0.1	(0.1 -	0.1)
Neonatology	3 351	1.2	521	15.5	0.2	(0.2 -	0.2)	0.6	(0.5 -	0.7)
Paediatrics general, not specialised	7 587	2.7	2 860	37.7	0.7	(0.6 -	0.7)	1.0	(0.9 -	1.1)
Medical intensive care unit (ICU)	2 625	0.9	1 490	57.0	1.5	(1.3 -	1.6)	0.9	(0.8 -	1.0)
Surgical ICU	2 359	0.8	1 646	69.8	2.6	(2.3 -	2.8)	1.1	(1.0 -	1.2)
Paediatric ICU	725	0.3	367	50.6	1.1	(1.0 -	1.3)	1.3	(1.1 -	1.5)
Neonatal ICU	2 220	0.8	673	30.3	0.5	(0.4 -	0.5)	1.1	(1.0 -	1.3)
Mixed (polyvalent) ICU	3 404	1.2	2 309	67.8	2.3	(2.2 -	2.5)	1.0	(0.9 -	1.1)
Specialised ICU	1 031	0.4	531	51.5	1.2	(1.0 -	1.3)	0.7	(0.6 -	0.8)
Other ICU	282	0.1	151	55.3	1.4	(1.1 -	1.7)	0.8	(0.6 -	1.0)
Obstetrics / Maternity	11 210	4.0	1 882	16.8	0.2	(0.2 -	0.2)	0.3	(0.2 -	0.3)
Gynaecology	4 916	1.7	1 580	32.1	0.5	(0.5 -	0.6)	0.5	(0.5 -	0.6)
Geriatrics, care for the elderly	12 203	4.3	3 594	29.5	0.5	(0.4 -	0.5)	0.6	(0.6 -	0.6)
Psychiatrics	15 126	5.3	395	2.6	0.0	(0.0 -	0.0)	0.1	(0.1 -	0.1)
Rehabilitation	8 528	3.0	721	8.5	0.1	(0.1 -	0.1)	0.2	(0.1 -	0.2)
Long-term care	6 512	2.3	425	6.5	0.1	(0.1 -	0.1)	0.1	(0.1 -	0.1)
Others not listed	3 049	1.1	615	20.2	0.3	(0.3 -	0.3)	0.4	(0.4 -	0.4)
Combination of specialties	1 271	0.4	399	31.4	0.5	(0.5 -	0.6)	0.6	(0.6 -	0.7)
Unknown	293	0.1	67	22.9	0.3	(0.3 -	0.4)	0.5	(0.3 -	0.6)
Birth weight										
>=2500g	6 595	2.3	694	10.5	ref.	-		ref.	-	
1500-<2500 (low birth weight, LBW)	1 867	0.7	294	15.7	1.6	(1.4 -	1.8)	0.8	(0.7 -	0.9)
<1500g (very low birth weight, VLBW)	1 185	0.4	309	26.1	3.0	(2.6 -	3.5)	1.3	(1.1 -	1.5)
Unknown/Not applicable	273 408	96.6	93 734	34.3	4.4	(4.1 -	4.8)	1.9	(1.6 -	2.1)
Type of hospital										
Primary	46 953	16.6	13 834	29.5	ref.	-		ref.	-	

	N of patients	% of total	N of pts with AU	Pts with AU %	Crude OR	(95%	CI)	Adj OR*	(95%	CI)
Secondary	103 141	36.4	34 890	33.8	1.2	(1.2 -	1.3)	1.1	(1.1 -	1.1)
Tertiary	112 071	39.6	40 676	36.3	1.4	(1.3 -	1.4)	1.2	(1.1 -	1.2)
Specialised	19 866	7.0	5 252	26.4	0.9	(0.8 -	0.9)	1.0	(1.0 -	1.1)
Unknown	1 024	0.4	379	37.0	1.4	(1.2 -	1.6)	1.0	(0.9 -	1.2)
Hospital specialty										
General hospital/unknown	264 339	93.4	90 133	34.1	ref.	-		ref.	-	
Paediatrics/Neonates	2 468	0.9	996	40.4	1.3	(1.2 -	1.4)	1.0	(0.9 -	1.1)
Psychiatrics	3 140	1.1	185	5.9	0.1	(0.1 -	0.1)	0.7	(0.6 -	0.9)
Surgery/Orthopaedics/Traumatology	3 186	1.1	637	20.0	0.5	(0.4 -	0.5)	0.7	(0.6 -	0.7)
Heart/Lung	1 997	0.7	597	29.9	0.8	(0.7 -	0.9)	0.6	(0.5 -	0.7)
Haematology/Oncology	2 917	1.0	975	33.4	1.0	(0.9 -	1.0)	0.7	(0.7 -	0.8)
Gynaecology/Obstetrics	1 538	0.5	243	15.8	0.4	(0.3 -	0.4)	0.9	(0.8 -	1.0)
Infectious diseases	570	0.2	407	71.4	4.8	(4.0 -	5.8)	1.4	(1.1 -	1.7)
Geriatrics/Rehabilitation/Rheumatology	950	0.3	120	12.6	0.3	(0.2 -	0.3)	0.7	(0.6 -	0.9)
Other	1 950	0.7	738	37.8	1.2	(1.1 -	1.3)	1.4	(1.2 -	1.6)
Hospital size										
<200 beds	29 702	10.5	10 197	34.3	ref.	-		ref.	-	
200-399 beds	60 490	21.4	20 476	33.9	1.0	(1.0 -	1.0)	0.9	(0.9 -	0.9)
400-649 beds	68 541	24.2	22 949	33.5	1.0	(0.9 -	1.0)	0.8	(0.8 -	0.8)
650-899 beds	42 084	14.9	14 565	34.6	1.0	(1.0 -	1.0)	0.8	(0.8 -	0.9)
>=900 beds	82 238	29.1	26 844	32.6	0.9	(0.9 -	1.0)	0.7	(0.7 -	0.8)
Hospital ownership										
Public	250 239	88.4	84 425	33.7	ref.	-		ref.	-	
Private, not-for-profit	17 895	6.3	5 349	29.9	0.8	(0.8 -	0.9)	0.9	(0.9 -	0.9)
Private, for-profit	8 719	3.1	2 932	33.6	1.0	(1.0 -	1.0)	0.9	(0.8 -	0.9)
Other/Unknown	6 202	2.2	2 325	37.5	1.2	(1.1 -	1.2)	1.2	(1.1 -	1.3)

AM: antimicrobial agent

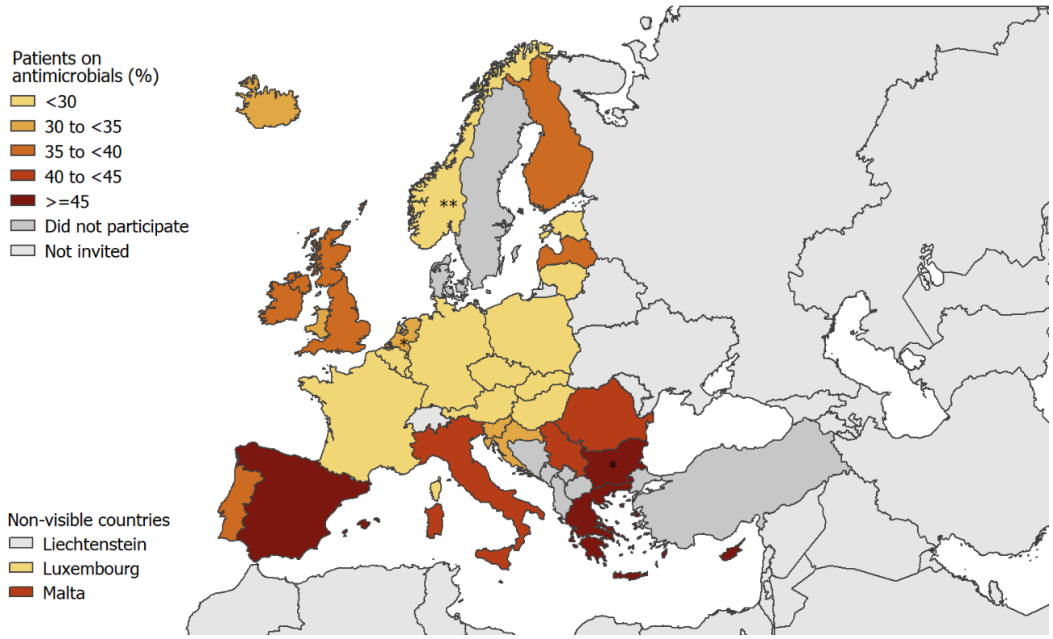
**Adj. OR: Adjusted odds ratio in final multiple logistic regression model. (a) Total length of stay (not only before HAI onset as in HAI model), total presence of intubation and urinary catheter (not only before healthcare-associated PN or urinary tract infections as in HAI model). (b) CVC and PVC: Odds ratios not calculated and variables not included in model because of strong correlation with parenteral antimicrobial treatment.*

Results by country

Prevalence of antimicrobial use, observed and predicted

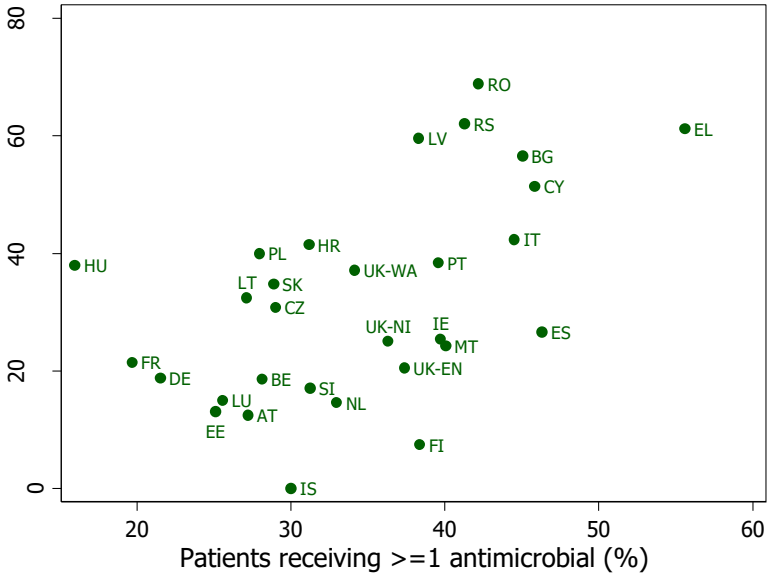
The prevalence of antimicrobial use (percentage of patients receiving at least one antimicrobial agent) in acute care hospitals ranged from 15.9% (95% CI: 13.2–18.6%) in Hungary to 55.6% (95% CI: 53.1–58.1%) in Greece (Figure 52). The weighted prevalence of antimicrobial use in Europe, accounting for the number of occupied acute care beds by country was 30.5%. At country level, the prevalence of antimicrobial use was correlated with the composite index of AMR (Spearman's rho 0.51, p<0.01, Figure 53)

Figure 52. Prevalence of antimicrobial use (percentage of patients receiving at least one antimicrobial) in acute care hospitals



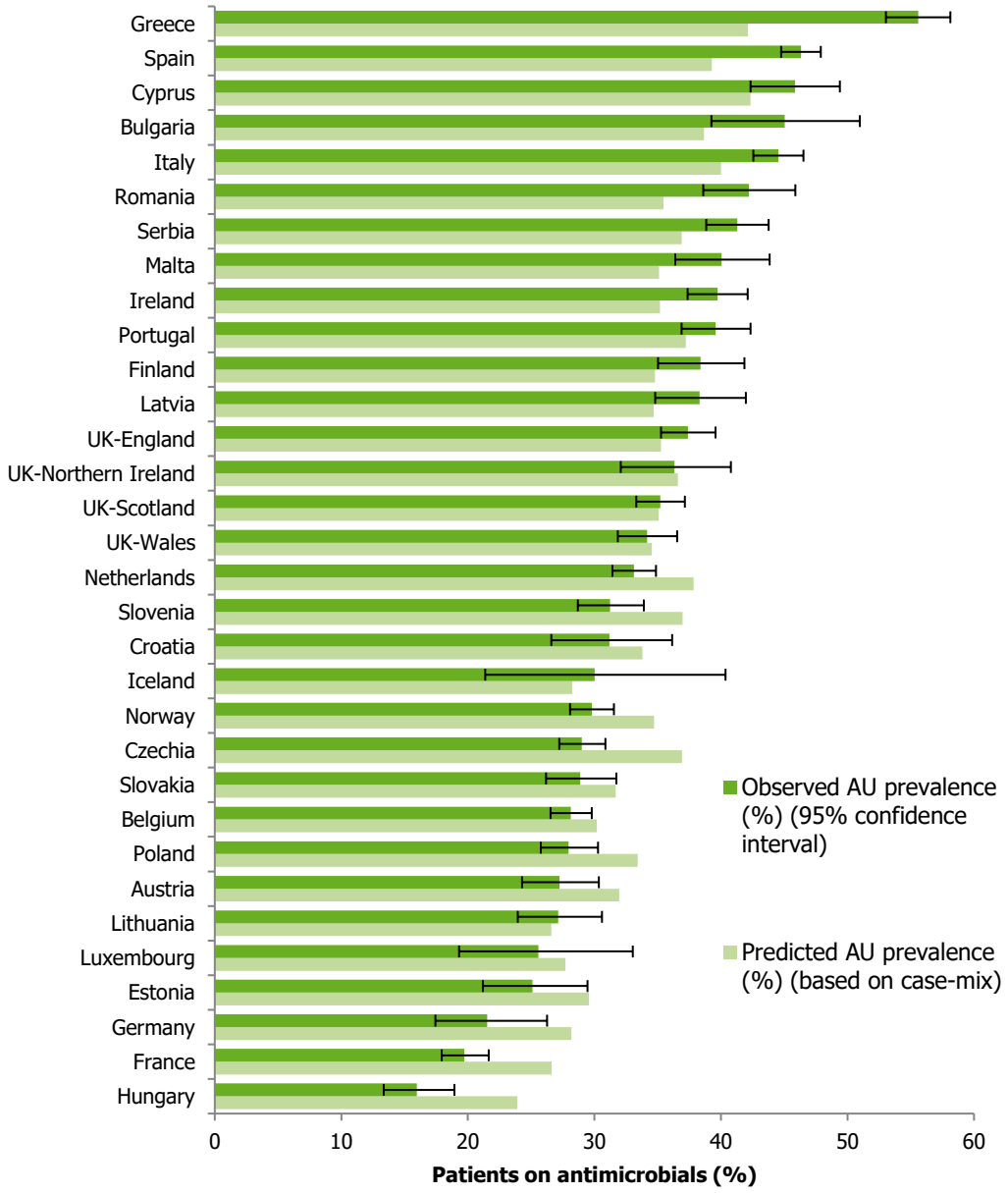
**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national PPS protocol*

Figure 53. Correlation between the prevalence of antimicrobial use and the composite index of AMR



Spearman's rho 0.51, p<0.01

Figure 54. Observed prevalence of antimicrobial use (AU) with 95% confidence intervals and predicted prevalence of antimicrobial use based on patient case mix and hospital characteristics, by country



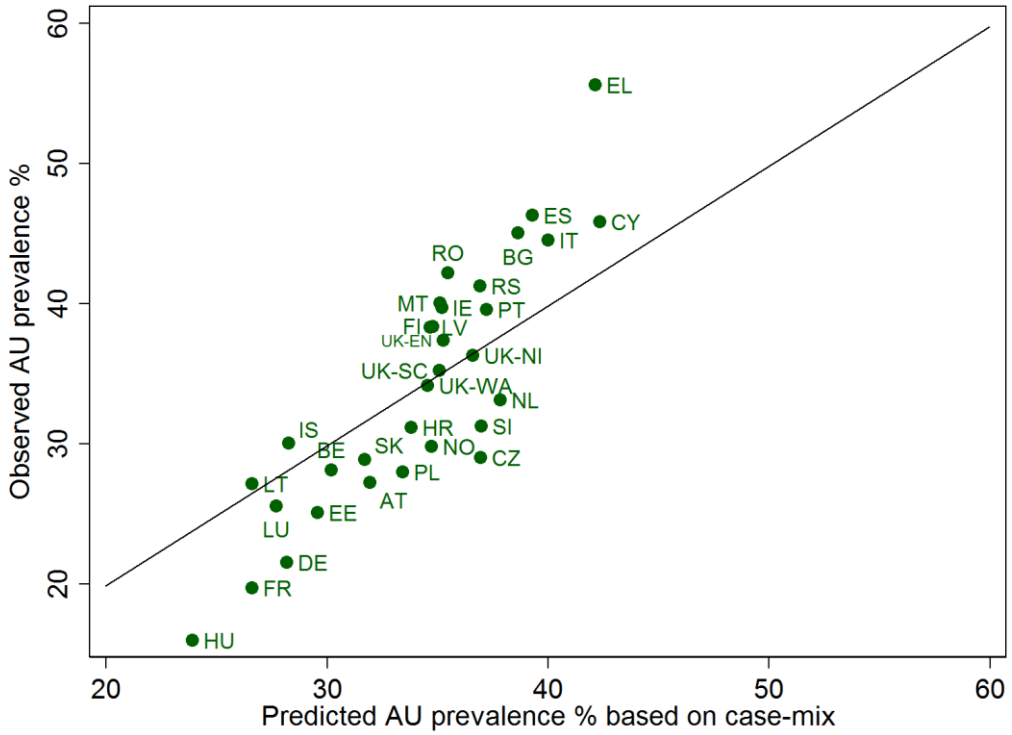
**PPS data representativeness was poor in Bulgaria and the Netherlands.*

The predicted prevalence of antimicrobial use was calculated based on patient case mix and hospital characteristics using the multiple logistic regression model in Table 17. For light protocol data (7% of the patients), a model only including patient/consultant specialty, type of hospital and hospital size was used (model not shown).

The correlation between the observed and predicted prevalence by country is shown in Figure 55 (Spearman's rho 0.86, $p<0.001$; R-squared 0.76).

The ratio of observed prevalence divided by predicted prevalence (Standardised Antimicrobial Use Ratio, SAUR) varied between less than 0.80 in Hungary (0.67), France (0.74), Germany (0.76) and Czechia (0.79) to more than 1.15 in Bulgaria (1.17), Spain (1.18), Romania (1.19) and Greece (1.31).

Figure 55. Correlation between the observed and predicted prevalence of antimicrobial use (AU) by country



Line: observed prevalence = predicted prevalence (Standardised antimicrobial use ratio (SAUR) =1). Countries below the line have a SAUR lower than 1, countries above the line have a SAUR higher than 1. The smaller the distance between the dot and the line, the closer the observed prevalence comes to the predicted prevalence based on patient case mix.

Antimicrobial use in defined daily doses (DDD) per 100 patient days

The antimicrobial use expressed in defined daily doses (DDD) in EU/EEA was 46 DDDs per 100 patient days. There was wide variability among the participating countries, ranging from 19.8 in Hungary and 26.5 in France to 69.2 in UK-Scotland and 70.6 in Cyprus (Table 18). There was a strong correlation between the antimicrobial use in DDDs and the observed prevalence of antimicrobial use (Spearman's rho 0.84, $p<0.001$). The rest of the variability was explained by the average DDDs per prescription that ranged from 1.06 in Hungary to 1.5 in UK Northern Ireland and 1.6 in Norway and the average DDDs per patient on antimicrobials that ranged from 1.4 in Hungary and 1.5 in Latvia to 2.1 in UK-Scotland and 2.2 in UK-Northern Ireland. The number of DDDs per patient was related both to the average DDDs per patient and to the number of patients receiving more than one antimicrobial that ranged from 19.8% in Austria to 38.5% in UK-Northern Ireland, 39.6% in Cyprus and 43.6% in Greece. Antimicrobial use in DDDs in the PPS was correlated with the consumption of antibacterials for systemic use (J01) in the hospital sector in the EU/EEA in 2017 (ESAC-Net) (Pearson's correlation coefficient 0.44, $p<0.05$).

Table 18. Antimicrobial use by country expressed as Defined Daily Doses*

Country	DDDs per 1 000 population per day[1]	DDDs per 100 patient days	Average DDDs per prescription	Average DDDs per patient receiving antimicrobials	Patients receiving more than one antimicrobial (%)
Austria	*NA*	40.3	1.3	1.6	19.8
Belgium	1.6	45.5	1.4	1.7	20.2
Bulgaria	1.5	54.3	1.2	1.5	21.9
Croatia	1.7	42.0	1.2	1.7	35.1
Cyprus	*NA*	70.6	1.3	1.8	39.6
Czechia	*NA*	48.1	1.4	1.9	26.8
Estonia	1.7	38.0	1.3	1.6	20.6
Finland	2.1	49.8	1.2	1.6	27.4
France	2.1	26.5	1.1	1.5	30.7
Germany	*NA*	31.8	1.2	1.5	24.7
Hungary	1.2	19.8	1.1	1.4	24.5
Iceland	*NA*	35.4	1.2	1.5	20.5
Ireland	1.6	68.2	1.3	1.8	32.5
Italy	1.9	64.6	1.2	1.6	30.4
Latvia	1.9	51.0	1.1	1.5	29.1
Lithuania	2.1	37.9	1.2	1.7	23.7
Luxembourg	1.8	39.8	1.3	1.7	24.8
Malta	3.1	64.8	1.2	1.8	35.3
Netherlands	0.9	49.7	1.4	1.7	24.8
Norway	1.4	55.0	1.6	2.0	22.8
Poland	1.8	36.7	1.1	1.5	28.2
Portugal	1.4	51.7	1.1	1.5	26.4
Romania	*NA*	53.7	1.1	1.5	31.5
Slovakia	*NA*	42.6	1.2	1.6	28.3
Slovenia	1.5	45.3	1.3	1.6	22.9
Spain	1.8	66.4	1.2	1.6	28.6
UK – England	2.6	64.2	1.4	1.9	35.0
UK – Northern Ireland		68.8	1.5	2.2	38.5
UK – Scotland		69.2	1.5	2.1	37.9
UK – Wales		56.9	1.3	1.8	30.5

[1] *Antimicrobial consumption in the hospital sector reported to ESAC-Net, 2017 data*

NA: Not available. Greece did not collect data on dosage. Denmark, Liechtenstein and Sweden did not participate.

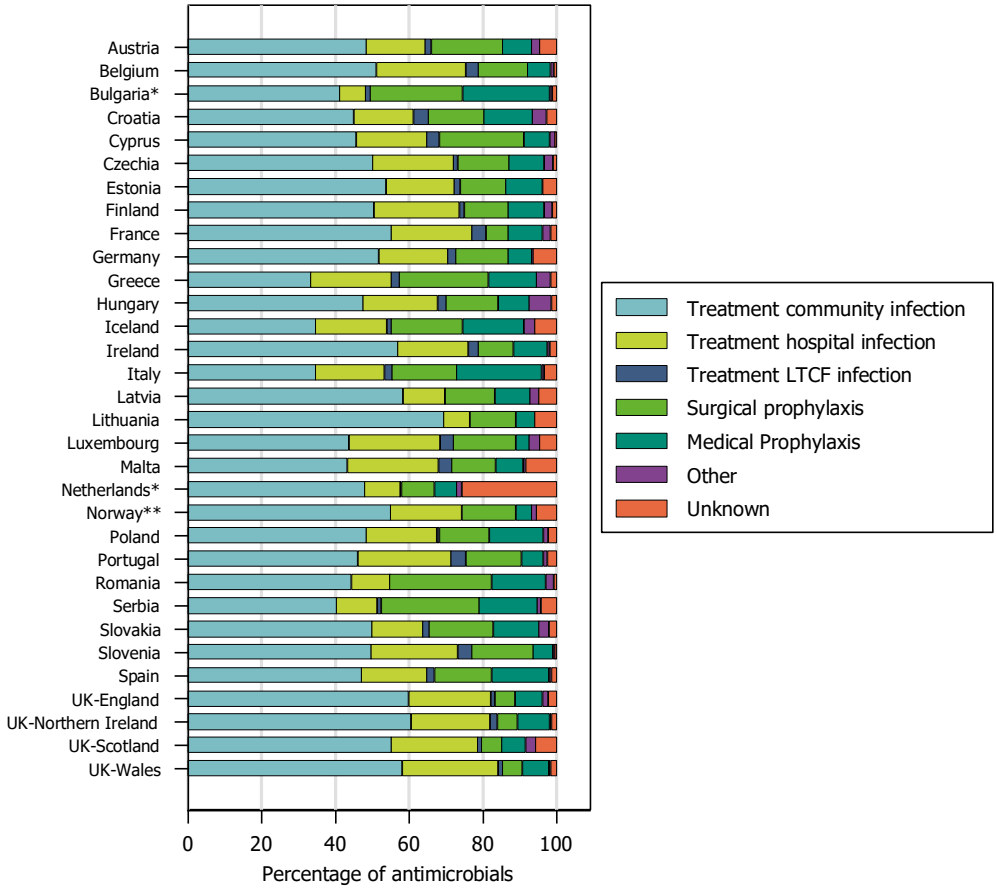
**2018 ATC/DDD index applied.*

For ATC groups A07AA, D01BA, J01, J02, J04 (as second-line treatment of e.g. meticillin-resistant Staphylococcus aureus *(MRSA) infections (rifampicin) or for treatment of mycobacteria other than tuberculosis) and P01AB*

Indications for antimicrobial use

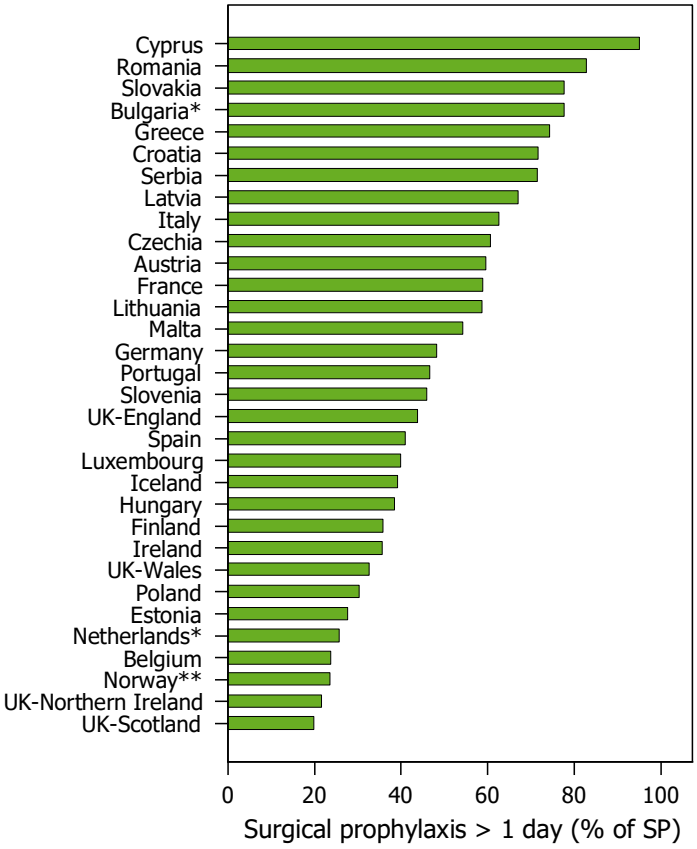
Indications for antimicrobial use varied considerably by country (Figure 56). The percentage of antimicrobials prescribed for treatment of a community-acquired infection was the lowest in Greece (33.3%) and the highest in Lithuania (69.4%). Treatment of a hospital infection was closely correlated with the prevalence of HAIs as per case the definition (see Figure 16), with a relative frequency varying from 6.9% of antimicrobials in Bulgaria to 26.2% of antimicrobials in the UK-Wales. The percentage of antimicrobials prescribed for treatment of an infection associated with long-term care varied from 0% in Lithuania to 4.1% in Croatia. Surgical prophylaxis accounted for less than 10% of antimicrobials in UK-Wales (5.3%), UK-Northern Ireland (5.4%), UK-Scotland (5.5%), UK-England (5.5%), France (6.0%), the Netherlands (8.9%) and Ireland (9.5%), but for more than 20% of antimicrobials in Cyprus (23.0%), Greece (24.2%), Bulgaria (25.3%), Serbia (26.4%) and Romania (27.7%). The percentage of surgical prophylaxis prescribed for more than one day was the lowest in UK-Scotland (10.7%) and the highest in Cyprus (92.3%) (Figure 57). Medical prophylaxis accounted for less than 5% of antimicrobials in Luxembourg (3.4%) and Norway (4.2%) but for more than 20% in Italy (23.3%) and Bulgaria (23.4%) (Figure 58). Other indications for antimicrobial use were most common in Hungary (6.5% of all antimicrobials). Documented antimicrobial use for an `unknown indication' was most frequent in Malta (7.6%), followed by Germany (6.3%).

Figure 56. Indications for antimicrobial use by country



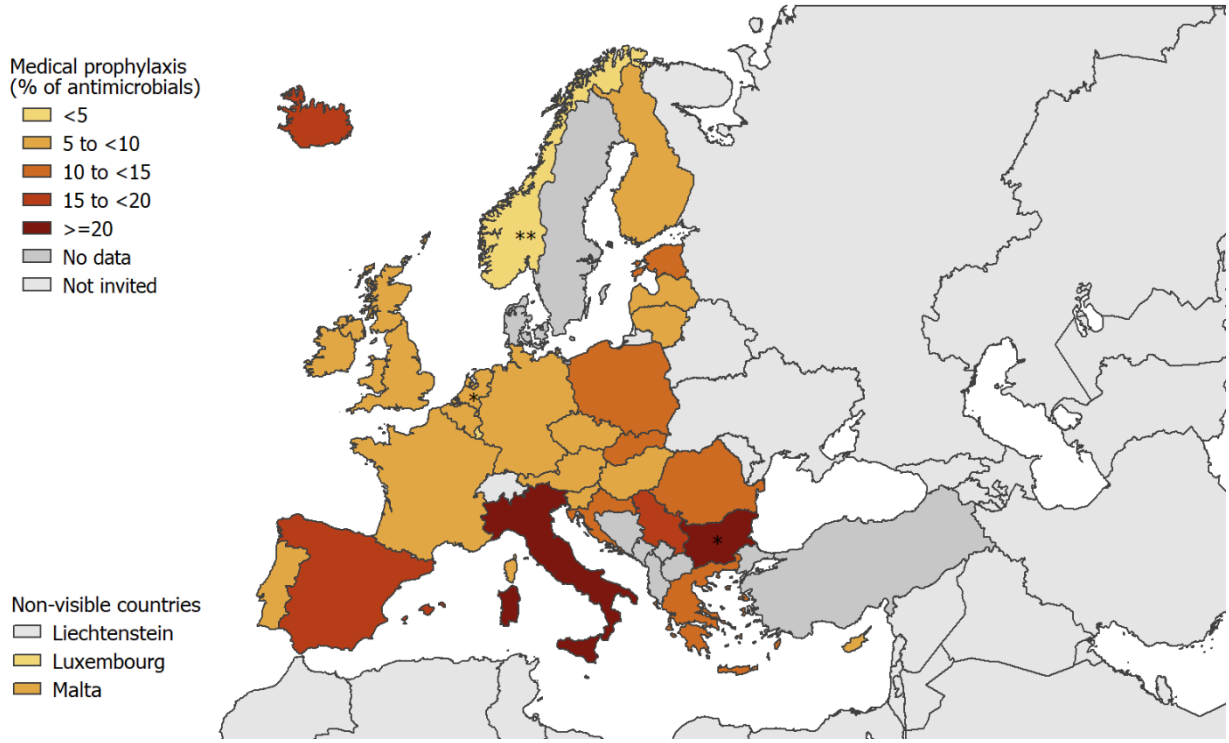
**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national PPS protocol*

Figure 57. Surgical prophylaxis given for more than one day as a percentage of the total antimicrobials prescribed for surgical prophylaxis, by country



SP=surgical prophylaxis.
**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national PPS protocol*

Figure 58. Percentage of antimicrobials prescribed for medical prophylaxis

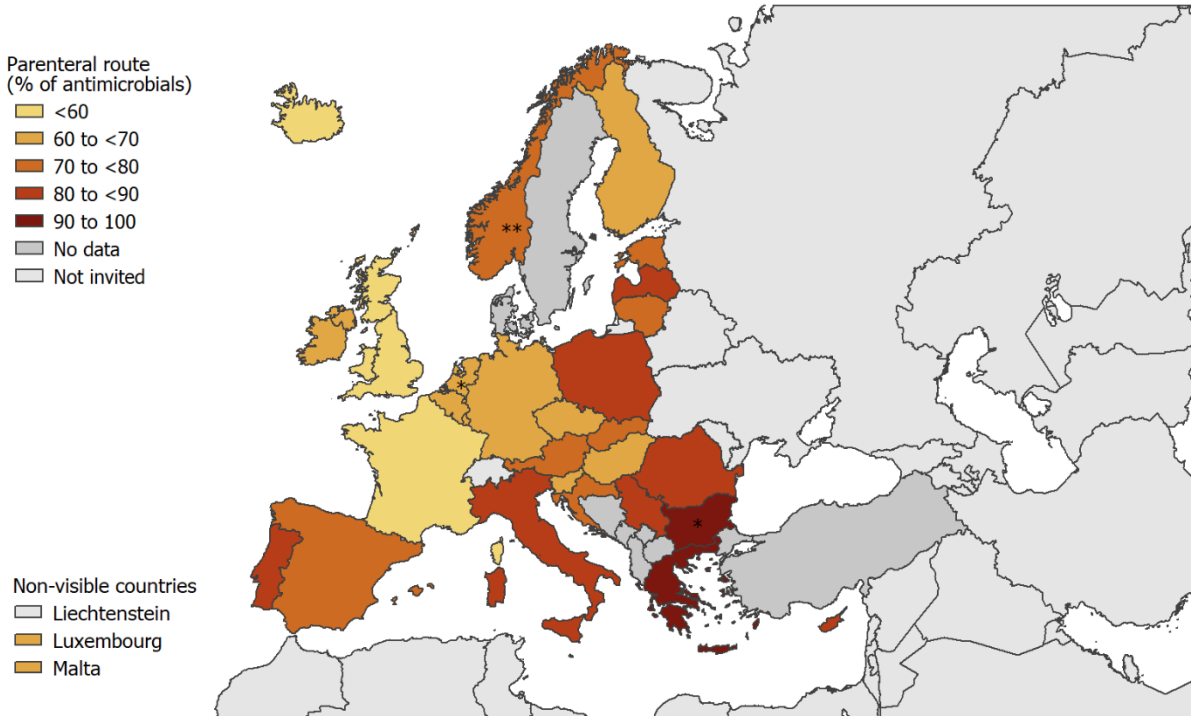


**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national PPS protocol*

Route of administration and documentation of the reason for antimicrobial use

The route of administration of antimicrobials was parenteral in 72.8% of cases (country median 69.6%) and varied from 51% in UK-Scotland to more than 90% in Bulgaria and Greece (Figure 59).

Figure 59. Percentage of antimicrobials for which the route of administration was parenteral



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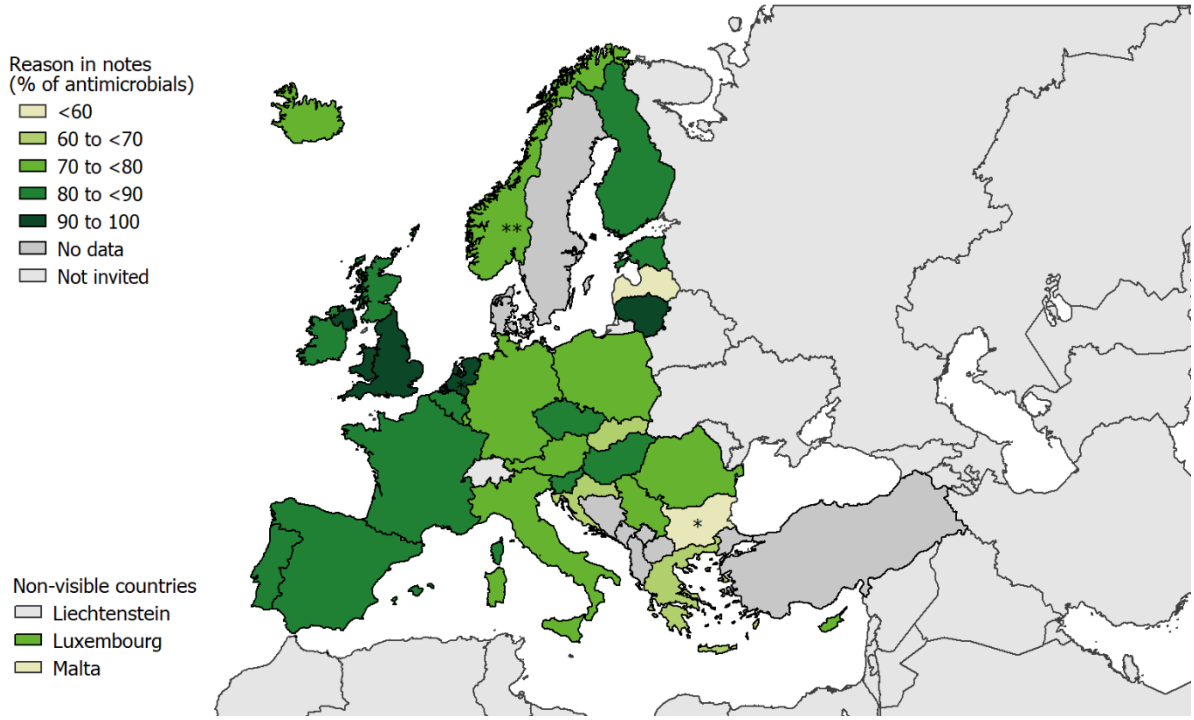
The reason for antimicrobial use was documented in the patient's medical records for 80.2% of prescriptions (country median: 80.8%) and ranged from 44.0% in Latvia to 93.6% in UK-Northern Ireland (Figure 60).

Figure 60. Percentage of antimicrobials for which the reason for use was documented in the patient's records

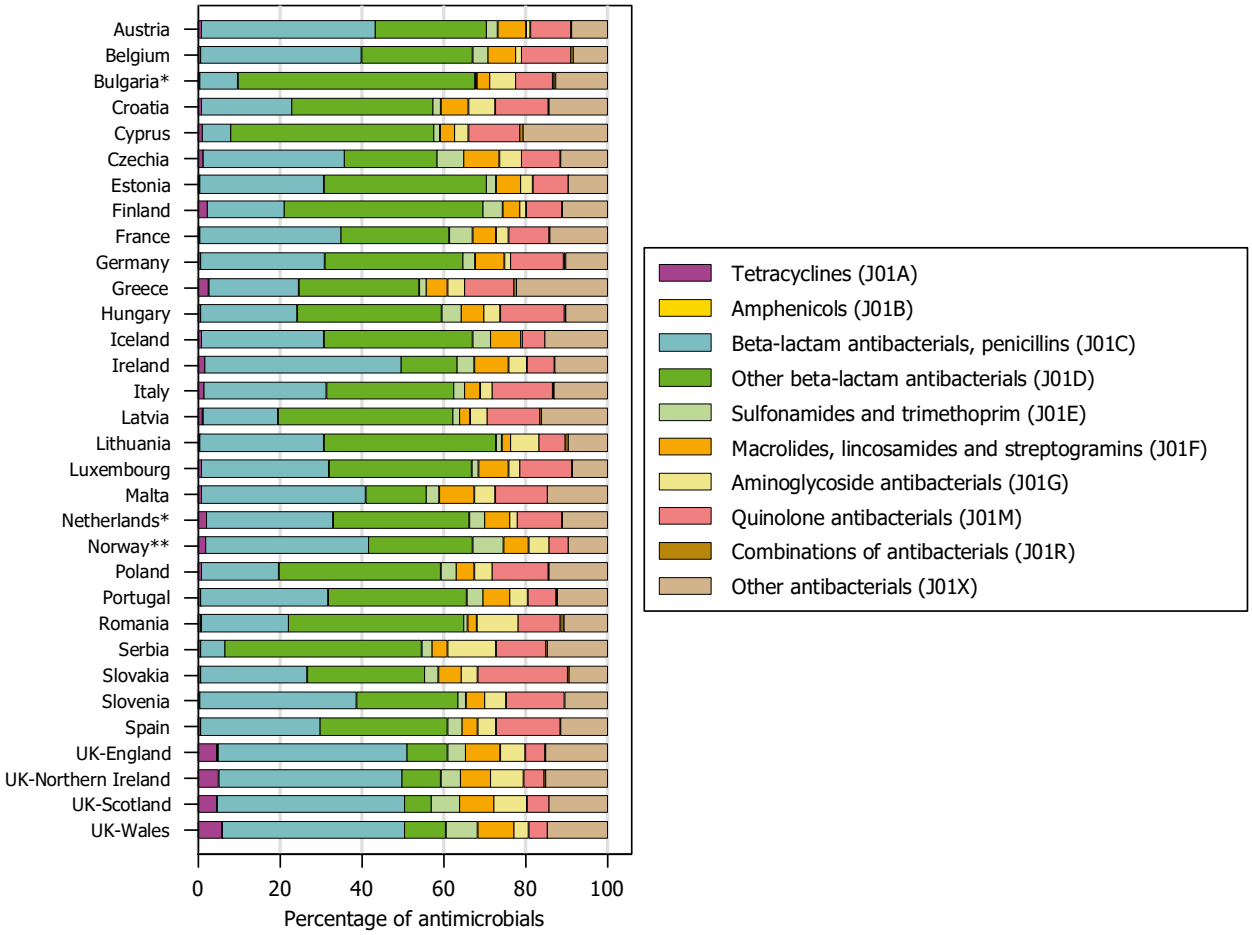


**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national PPS protocol*

Distribution of antimicrobial agents

Within ATC group J01 (antibacterials for systemic use), the percentage of penicillins (ATC group J01C) varied between 7.0% in Cyprus and 48.1% in Ireland (Figure 61). Other beta-lactam antibacterials (ATC Group J01D) varied between 6.5% in UK-Scotland and 57.9% in Bulgaria. The percentage of ATC group J01E (sulfonamides and trimethoprim) within ATC group J01 ranged from 0.4% in Bulgaria to 7.7% in UK-Wales. The percentage of ATC group J01F (macrolides, lincosamides and streptogramins) ranged from 2.0% in Lithuania to 8.7% in Czechia, UK-England and UK-Wales, the percentage of aminoglycosides (ATC group J01G) from 0.5% in Iceland to 10.0% in Romania, the percentage of quinolone antibacterials (ATC group J01M) from 4.4% in UK-Wales to 21.9% in Slovakia and the percentage of other antibacterials (ATC group J01X) from 8.4% in Luxembourg to 22.3% in Greece.

Figure 61. Distribution of antimicrobial groups by ATC third level and by country, (antibacterials for systemic use, ATC group J01)

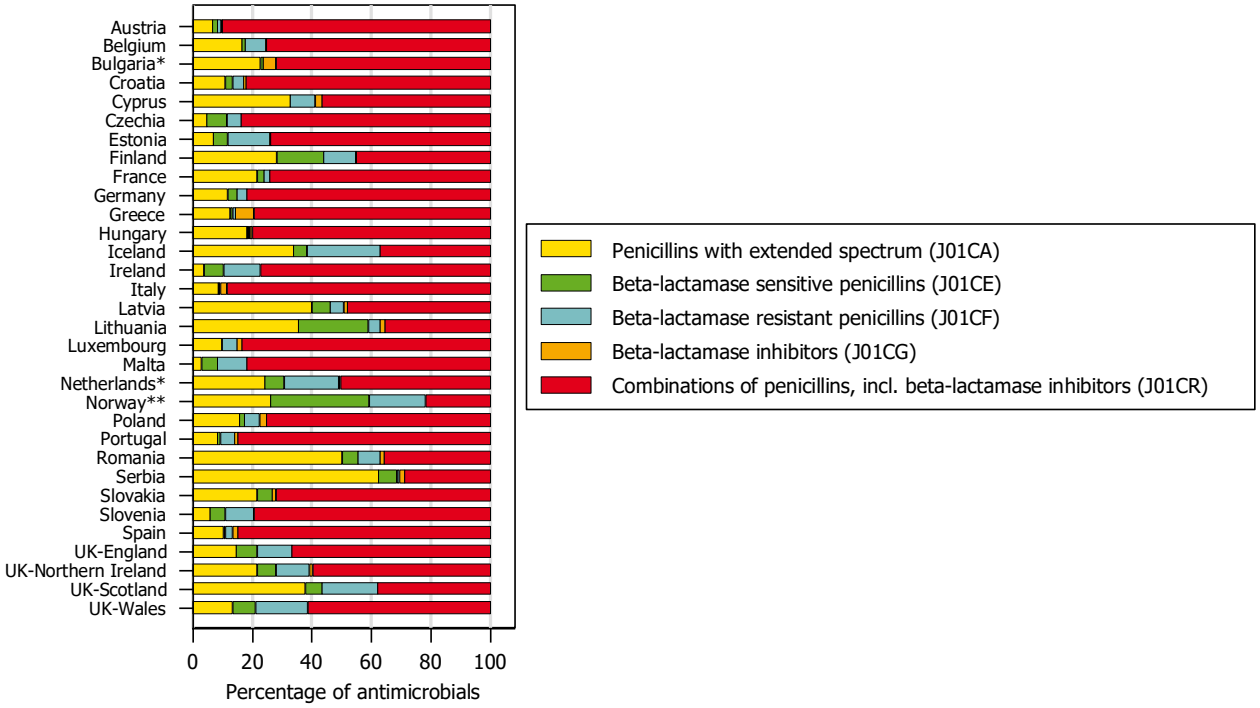


**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national PPS protocol*

Within ATC group J01C (penicillins), the percentage of penicillins with extended spectrum (ATC group J01CA) varied between 2.9% in Malta and 50.3% in Romania (Figure 62). Beta-lactamase-sensitive penicillins (ATC group J01CE) accounted for 0.0% of penicillins in Luxembourg and Cyprus and 33.1% in Norway. Beta-lactamase-resistant penicillins (ATC group J01CF) accounted for 0.0% of penicillins in Bulgaria and Slovakia and 24.6% in Iceland. ATC group J01CR (combinations of penicillins, including beta-lactamase inhibitors) were the most frequently used penicillins in all countries except Lithuania, Norway, Romania and UK-Scotland.

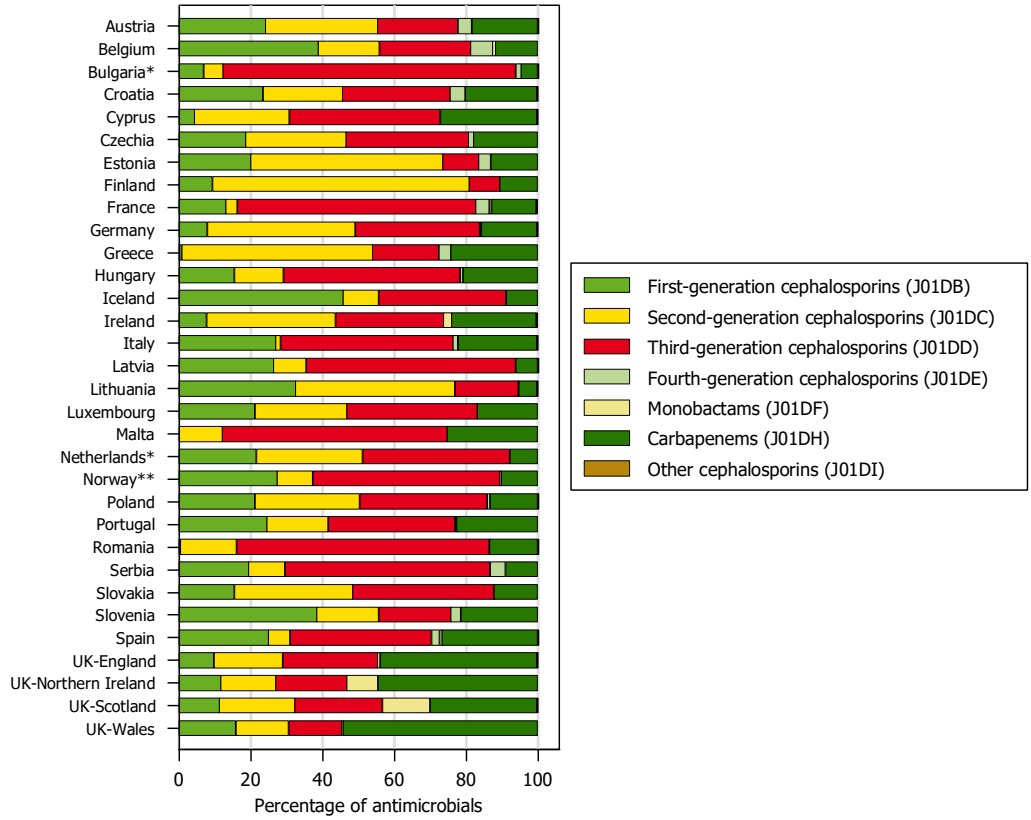
The percentage of first-generation cephalosporins within ATC group J01D (other beta-lactam antibacterials) varied from 0.0% in Malta to 45.6% in Iceland (Figure 63). Second-generation cephalosporins accounted for more than half of J01D use in Greece (52.9%), Estonia (53.5%) and Finland (71.5.7%). The percentage of third-generation cephalosporins within ATC group J01D varied from 8.6% in Finland to more than 70% in Romania (70.4%) and Bulgaria (81.5%), and the percentage of fourth-generation cephalosporins ranged from 0.0% in 14 countries to 6.1% in Belgium. Use of monobactams was the highest in UK-Scotland (13.1% of ATC group J01D). The percentage of carbapenems within ATC group J01D ranged from 4.7% in Bulgaria to more than 30% in UK-England, UK-Northern Ireland and UK-Scotland.

Figure 62. Antimicrobial use by country: Beta-lactam antibacterials, penicillins (ATC group J01C)



**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national PPS protocol*

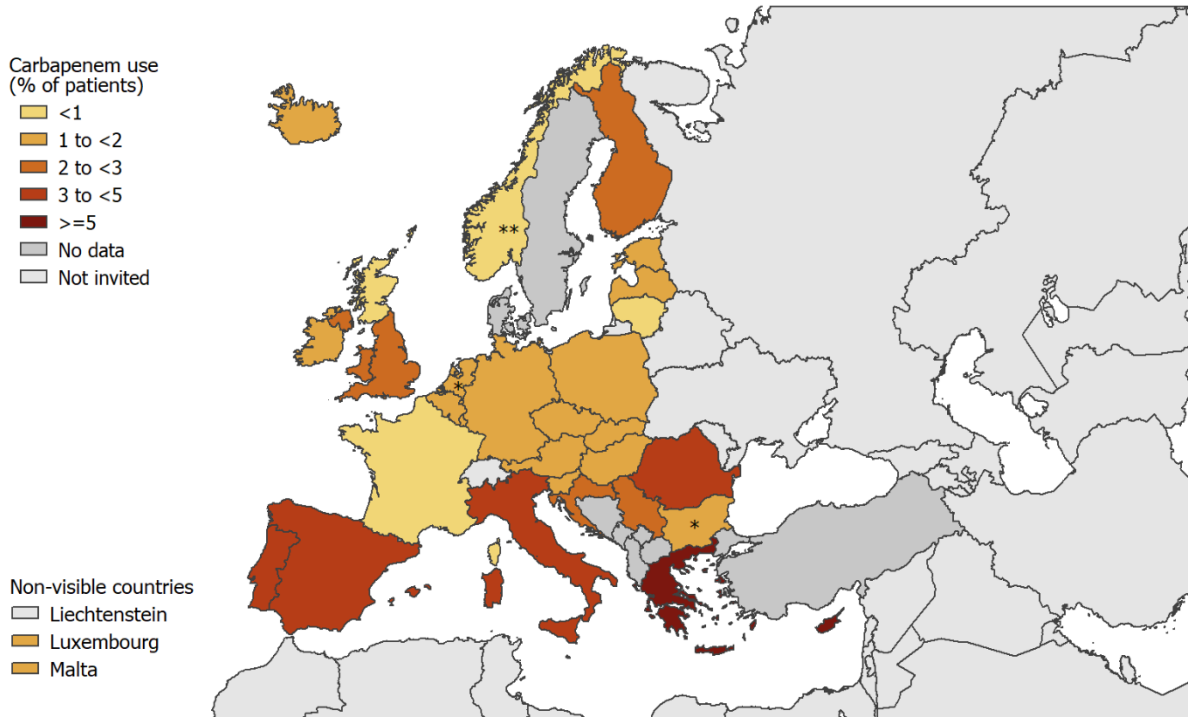
Figure 63. Antimicrobial use by country: other beta-lactam antibacterials (ATC group J01D)



**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national PPS protocol*

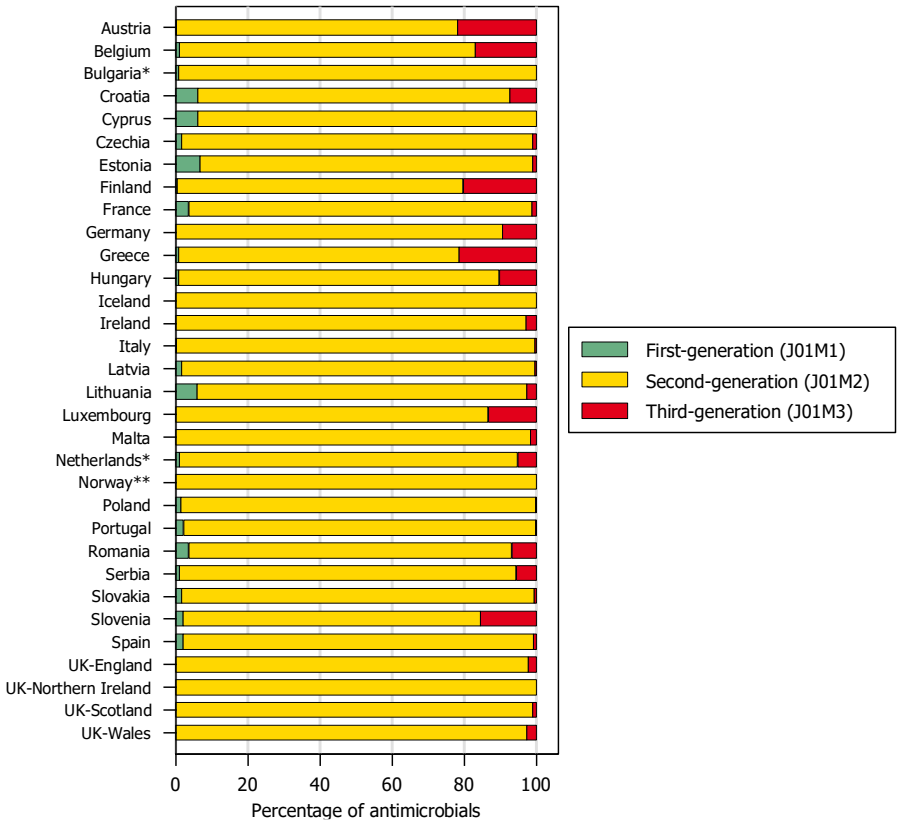
The percentage of patients receiving carbapenems ranged from less than 1% of hospitalised patients in France, Lithuania, Norway and UK-Scotland to more than 5% in Greece and Cyprus (Figure 46).

Figure 64. Prevalence of carbapenem (J01DH) use (percentage of hospitalised patients receiving carbapenems)



**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national PPS protocol*

Figure 65. Antimicrobial use by country: Quinolone antibacterials (J01M)



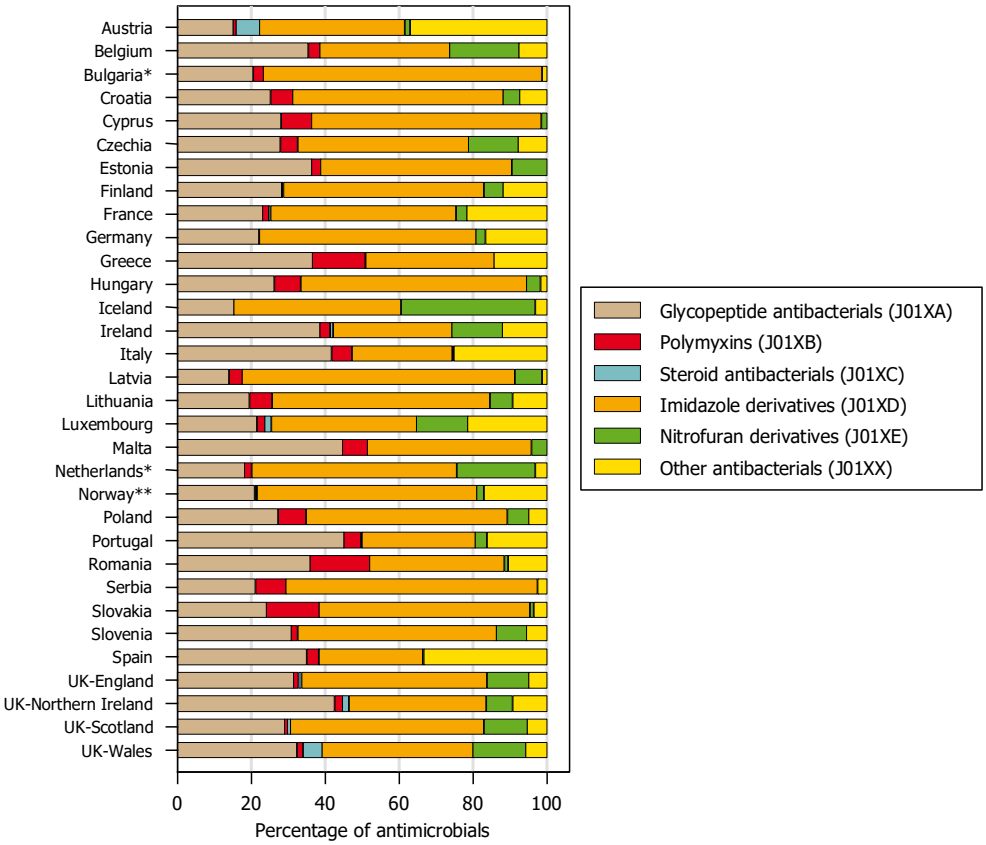
Quinolone antibacterials (ATC group J01M) were classified according to reference [32] as in ESAC-Net [33].
**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national PPS protocol*

The large majority (92.7%) of quinolone antibacterials (ATC group J01M) used in European hospitals were second-generation quinolones. First-generation quinolones were not reported by 10 countries but accounted for more than 5% of ATC group J01M in Croatia (6.2%) and Estonia (6.7%). Third-generation quinolones were not reported by five countries but represented more than 20% of ATC group J01M in Finland (20.2%%), Greece (21.3%) and Austria (21.8%) (Figure 65).

Within ATC group J01X (other antibacterials), the most frequently used antibacterials were imidazole derivates (ATC group J01XD), representing from 27.3% of J01X antibacterials in Italy to 75.5% in Bulgaria (Figure 66).

The second most important group within ATC group J01X were glycopeptide antibacterials (ATC group J01XA), the lowest in Latvia (14.0%) and the highest in Portugal (45.0%).

Figure 66. Antimicrobial use by country: other antibacterials (J01X)

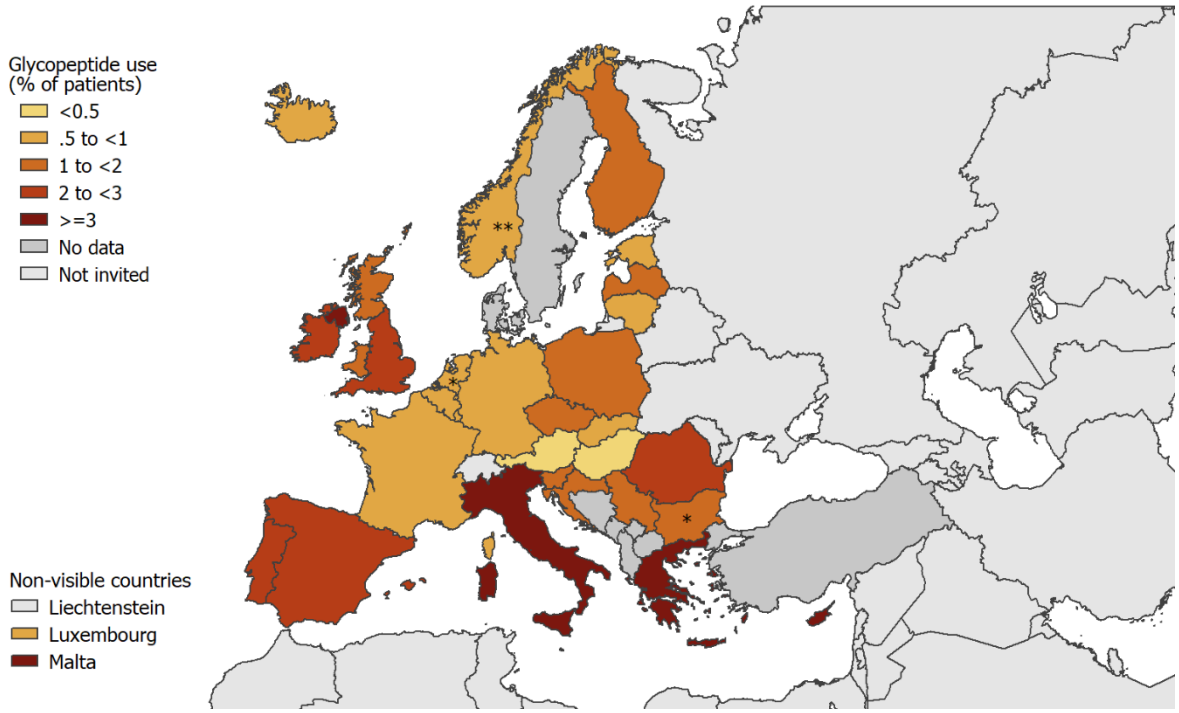


**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national PPS protocol*

The prevalence of glycopeptide use (percentage of hospitalised patients receiving glycopeptides) ranged from 0.4% of patients in Austria to more than 3% in Italy (3.1%), UK-Northern Ireland (3.1%), Malta (3.4%), Cyprus (3.7%) and Greece (6.7%) (Figure 67). At country level, the prevalence of glycopeptide use was associated with the percentage of meticillin resistance in *S. aureus* (MRSA) from HAIs (Spearman's rho 0.51, p<0.01).

Polymyxins (ATC group J01XB) represented less than 1% of ATC group J01X in six countries but more than 10% in Slovakia (14.3%), Greece (14.3%) and Romania (16.0%). Steroid antibacterials (ATC group J01XC) were not reported by 18 countries and accounted for 6.4% of ATC group J01X in Austria (8.4%). Nitrofuran derivates (ATC group J01XE) accounted for less than 1% of ATC group J01X in six countries and ranged up to 36.4% in Iceland. ATC group J01XX (other antibacterials including linezolid, daptomycin and fosfomycin) represented less than 1% of ATC group J01X in Hungary, Iceland and Sweden and more than 20% in Luxembourg (21.6%), France (21.7%), Italy (25.1%), Spain (33.4%) and Austria (36.9%).

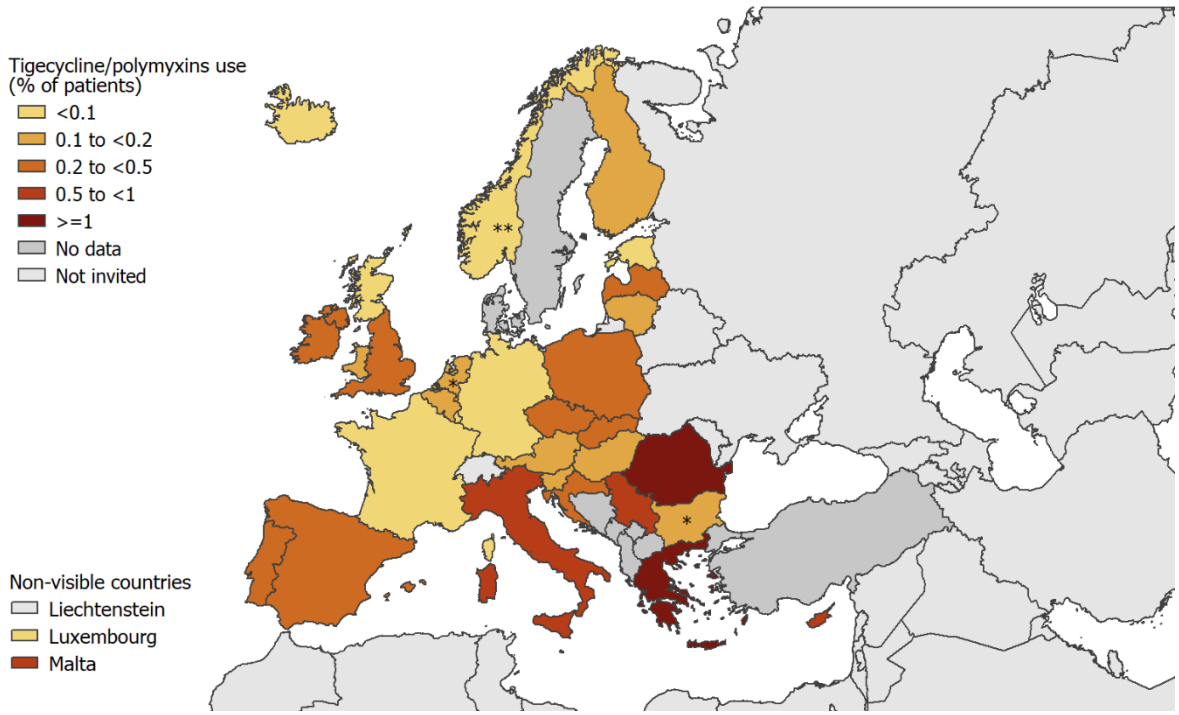
Figure 67. Prevalence of glycopeptide (J01XA) use (percentage of hospitalised patients receiving glycopeptide antibacterials)



**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national PPS protocol*

The prevalence of the use of polymyxins (ATC group J01XB) and/or tigecycline (ATC J01AA12) as an indicator of empirical or documented treatment of infections with carbapenem-resistant gram-negatives [35] varied from less than 1 per 1 000 patients (0.1%) in 7 countries to approximately 1.0% of patients in Cyprus, Italy and Romania and 3.8% of patients in Greece (Figure 68). At country level, the indicator was strongly associated with the percentage of Enterobacterales resistant to carbapenems reported for HAIs (Spearman's rho 0.68, p<0.001).

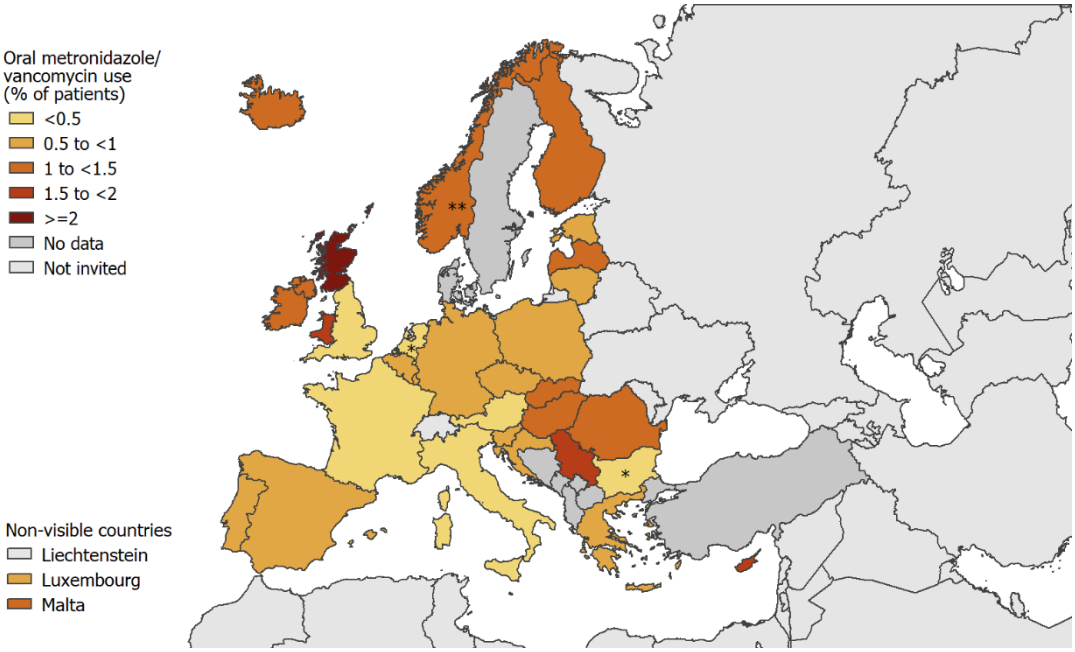
Figure 68. Prevalence of use of polymyxins (ATC group J01XB) and/or tigecycline (percentage of hospitalised patients receiving any of these antibacterials)



**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national PPS protocol*

The prevalence of the use of oral metronidazole (P01AB01) and/or oral vancomycin (A07AA09) as an indicator of the oral treatment of *C. difficile* infections, varied from 0% France to 2.1% of patients in UK-Scotland (Figure 69). The indicator was correlated at country level with the relative frequency of healthcare-associated *C. difficile* infections and of healthcare-associated gastro-intestinal infections (both Spearman's rho 0.50, p<0.01).

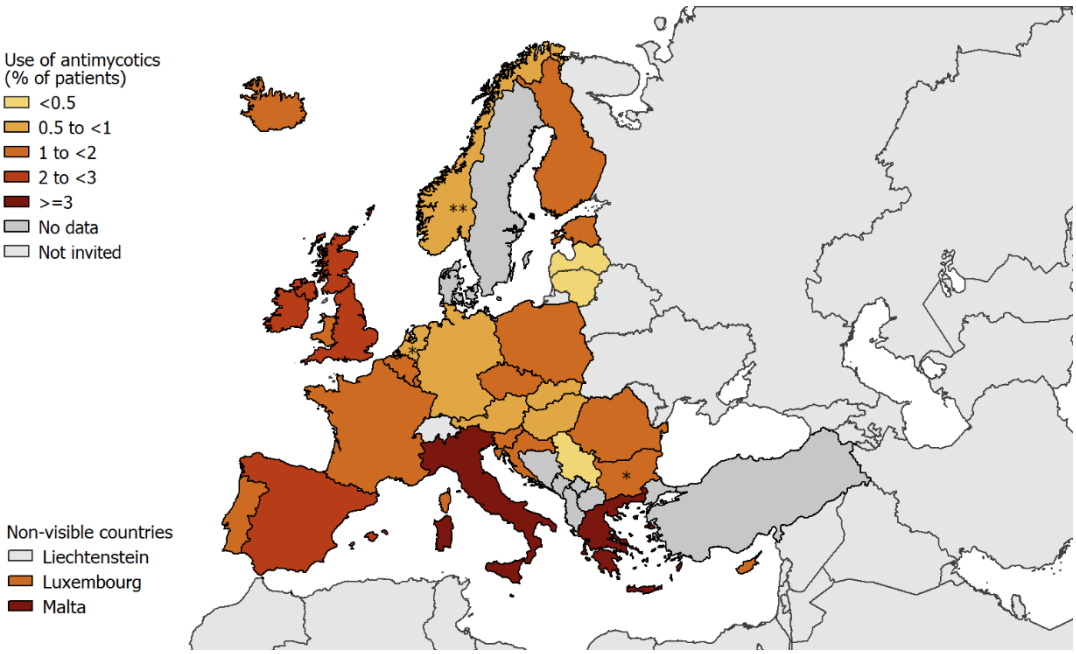
Figure 69. Prevalence of use of oral metronidazole (P01AB01) and/or oral vancomycin (A07AA09) (percentage of hospitalised patients receiving any of these antimicrobials)



**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national PPS protocol*

Finally, an important variation between countries was also observed for the prevalence of the use of antimycotics, including antimycotics for systemic use (ATC group J02) and nystatin (A07AA02), which together accounted for 3.6% of all antimicrobials, varying from less than 1% in Lithuania (0.7%) to 7.3% in Malta. Nystatin accounted for 11.9% within this group overall, varying between 0.0% in ten countries to 53.1% in UK-Northern Ireland. The prevalence of antimycotics ranged from 0.3% of patients in Lithuania to 3% or more in Greece (3.1%), Italy (3.6%) and Malta (4.2%) (Figure 70).

Figure 70. Prevalence of use of antimycotics (ATC group J02 and nystatin) (percentage of hospitalised patients receiving any antimycotic for systemic use)

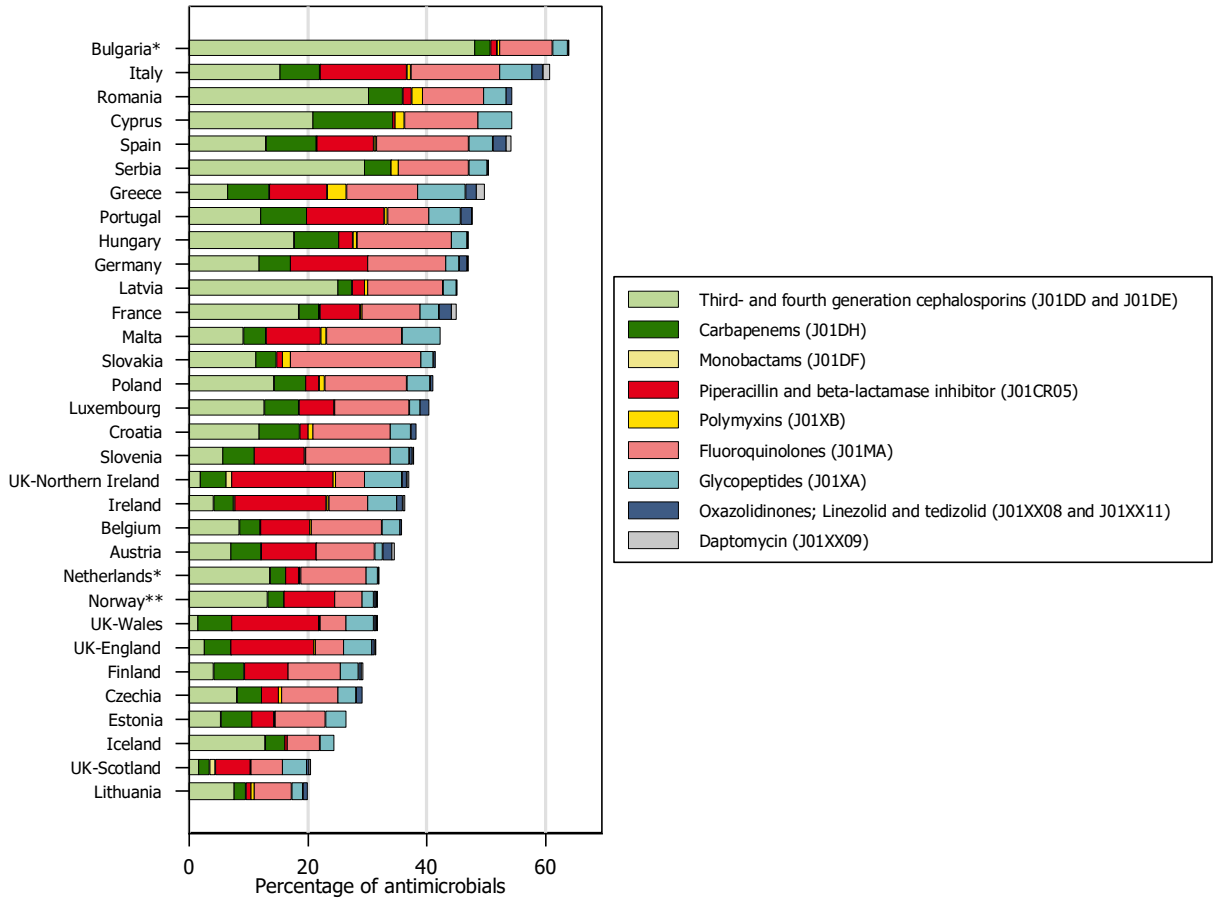


**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national PPS protocol*

Broad-spectrum antibacterials

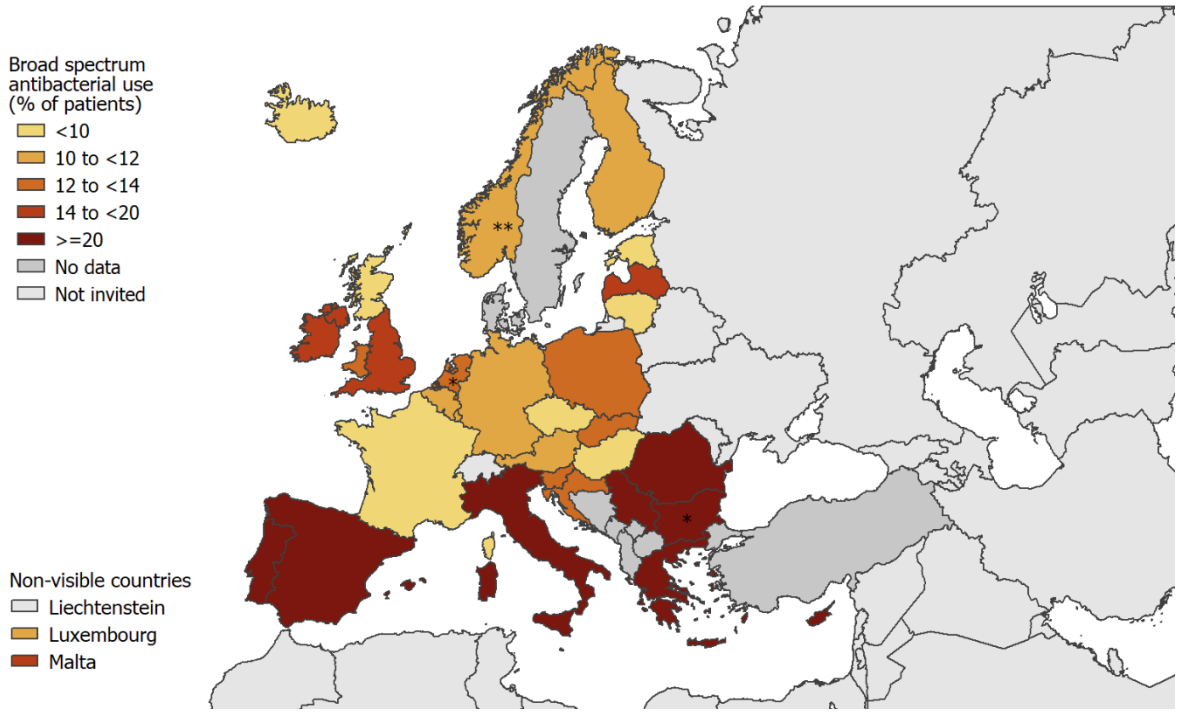
The percentage of broad-spectrum antibacterials as defined in the European Centre for Disease Prevention and Control, European Food Safety Authority and European Medicines Agency Joint Scientific Opinion [34] among antibacterials for systemic use (J01) was 41.3%. There was wide variability across EU/EEA countries and the UK from 20.0% in Lithuania and 20.5 % in UK-Scotland to 60.8% in Italy and 64.0% in Bulgaria (Figure 71). The prevalence of patients receiving at least one broad-spectrum bacterial varied from 5.4% of patients in Lithuania to 33.1% of patients in Bulgaria (Figure 72), with a country median of 12.6%.

Figure 71. Distribution of broad-spectrum antibacterials among all antibacterials for systemic use (J01)



At country level, the percentage of broad-spectrum antibacterials was significantly associated with the prevalence of antimicrobial use (Spearman's rho 0.48, $p<0.01$), the percentage of antimicrobials administered via parenteral route (Spearman's rho 0.65, $p<0.001$), the percentage of prolonged surgical prophylaxis (Spearman's rho 0.62, $p<0.001$), the percentage of antimicrobials prescribed for medical prophylaxis (Spearman's rho 0.38, $p<0.05$) and the composite index of AMR (Spearman's rho 0.68, $p<0.001$).

Figure 72. Prevalence of use of broad-spectrum antibacterials (% of patients receiving at least one broad-spectrum antibacterial)

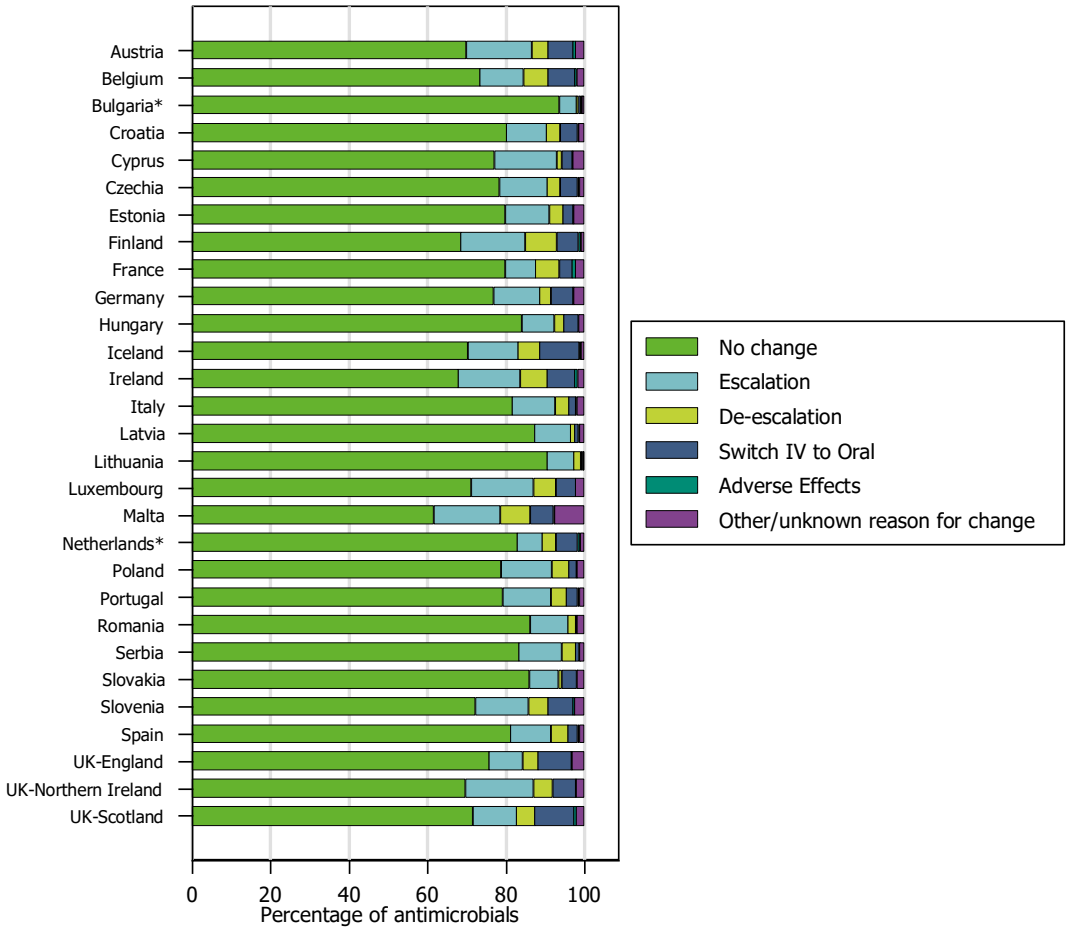


**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national PPS protocol*

Change of antimicrobial agent

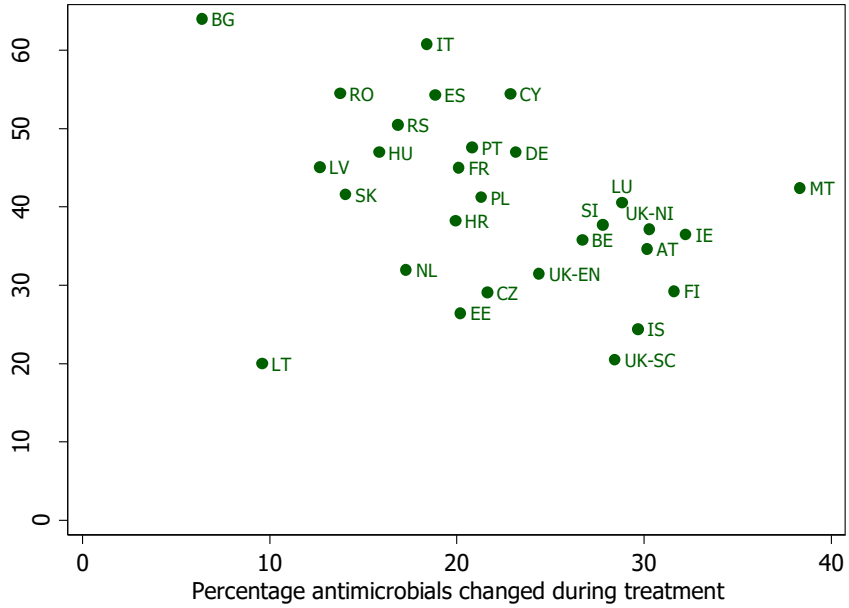
In total, information about change of the antimicrobial during the infection episode was reported for 76.8% of antimicrobial prescriptions. For antimicrobial prescriptions where the information was reported, most (79.0%, country range: 61.5–93.6%) had not been changed since the initiation of the treatment (Figure 73). Escalation, de-escalation and switch from intravenous to oral use were reported for 10.9%, 3.9%, and 4.0% antimicrobial prescriptions, respectively. The change was due to adverse effects for 0.4% and to other reasons for 1.8% prescriptions. The proportion of prescriptions with a change during treatment was negatively correlated with the percentage of broad spectrum antibacterials among all antibacterials used (Spearman's rho -0.40, $p<0.05$, (Figure 74)), the percentage of perioperative prophylaxis prescriptions lasting longer than one day (Spearman's rho -0.46, $p<0.01$,Figure 75) and the composite index of AMR (Spearman's rho -0.63, $p<0.001$, Figure 76), but not with the prevalence of antimicrobial use.

Figure 73. Change of antimicrobial agent during the infection episode and reported reason for change



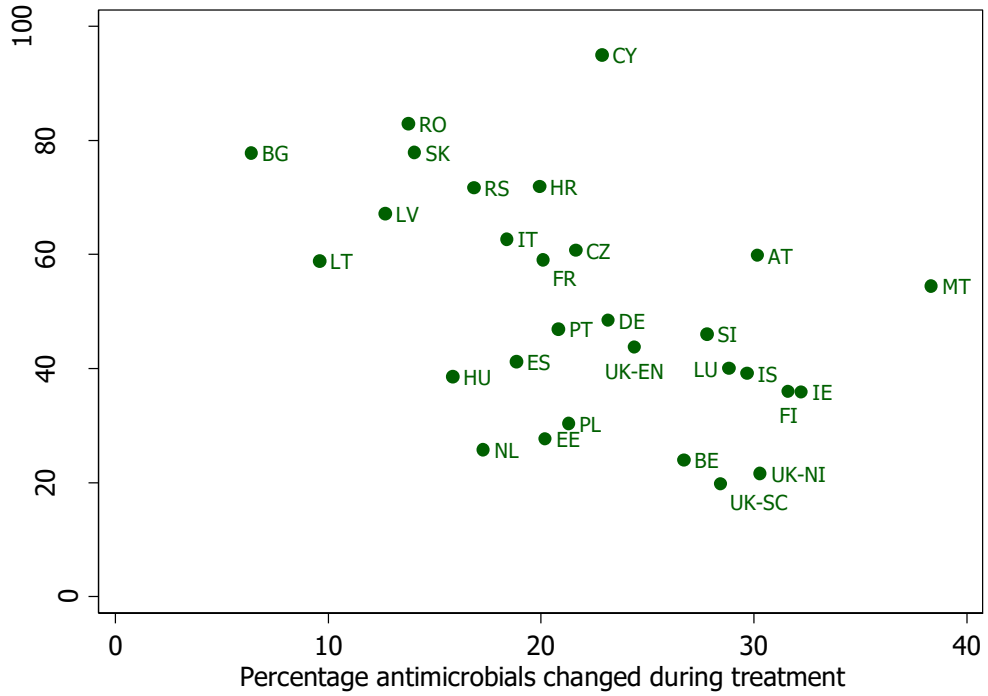
**PPS data representativeness was poor in Bulgaria and the Netherlands. Greece, Norway and UK-Wales did not collect information on change of antimicrobials.*

Figure 74. Correlation of the percentage of prescriptions that were changed during treatment and the percentage of broad-spectrum antimicrobials



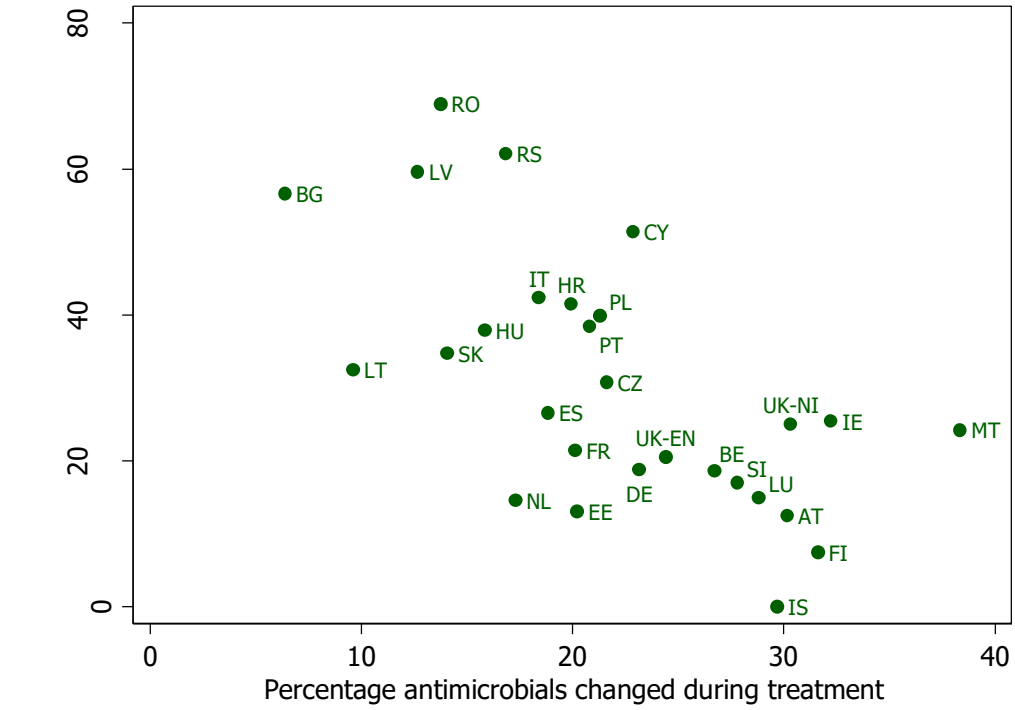
Spearman's rho -0.40, p<0.05

Figure 75. Correlation of the percentage of prescriptions that were changed during treatment and the percentage of surgical prophylaxis prescribed for more than one day



Spearman's rho -0.46, p<0.01

Figure 76. Correlation between the percentage of prescriptions that were changed during treatment and the composite index of AMR



Spearman's rho -0.63, p<0.001

Validation of antimicrobial use data

National validation studies

In the twenty-four EU/EEA countries and the four UK administrations that validated their PPS data, 3.2% of patients not receiving antimicrobials according to the primary PPS teams, did receive an antimicrobial according to the national validators (false negatives). On the other hand, 4.4% patients reported with antimicrobials were found to be false positives. When applying the percentages false negatives and false positives to the (primary) antimicrobial use prevalence results in these countries, the sensitivity of the primary PPS data collectors for detecting and reporting a patient receiving antimicrobials was on average 93.8% and varied between 81.8% in Estonia to 100% in Croatia (Table 19). The specificity for detecting and reporting a patient receiving antimicrobials was high in all countries and 97.7% on average, being the lowest in Italy (87.9%) and the highest in Croatia and UK-Wales (100%).

Table 19. Results of national PPS validation surveys: prevalence of antimicrobial use

Country	N of hos	N of pts	FN %	FP %	Se % (95%CI)	Sp % (95%CI)	pPPS AU%	Corrected AU% (95%CI)	Kappa
Austria	5	254	0.6	4.8	98.4 (91.1-100%)	98.2 (95.7-99.5%)	27.2	26.4 (24.2-30.3%)	0.96
Belgium	5	260	3.5	3.5	91.6 (82.8-96.8%)	98.6 (96.0-99.7%)	28.1	29.6 (26.3-33.2%)	0.92
Bulgaria*	7	384	1.0	3.4	98.8 (95.7-99.9%)	97.3 (94.2-99.0%)	44.9	43.9 (41.9-46.4%)	0.96
Croatia	5	261	0.0	0.0	100 (94.0-100%)	100 (98.7-100%)	31.2	31.2 (98.7-100%)	1.00
Czechia	6	285	2.1	2.9	95.1 (86.5-99.0%)	98.8 (97.0-99.7%)	29.1	29.7 (27.3-33.0%)	0.95
Estonia	5	251	7.3	2.0	81.8 (71.1-90.1%)	99.3 (97.4-99.9%)	25.1	30.0 (26.1-34.5%)	0.89
Finland	5	250	3.0	0.9	95.4 (88.8-98.7%)	99.5 (96.9-100%)	38.4	39.9 (37.1-43.0%)	0.96
France	5	272	2.4	7.8	89.8 (77.5-96.6%)	98.2 (96.0-99.4%)	18.6	19.1 (16.0-22.6%)	0.89
Germany	10	432	0.5	1.7	98.0 (92.8-99.8%)	99.5 (97.5-100%)	21.5	21.6 (19.6-23.0%)	0.97
Greece	8	353	6.0	0.9	95.4 (91.0-98.1%)	98.9 (95.9-99.9%)	55.6	57.8 (55.0-60.8%)	0.94
Hungary	5	252	2.7	11.4	86.3 (69.7-96.1%)	97.8 (96.2-98.8%)	16.2	16.7 (13.8-21.0%)	0.87
Iceland	*2*	*262*	*3.3*	*8.3*	*92.3 (83.0-97.5%)*	*96.5 (93.5-98.4%)*	*30.0*	*29.8 (26.2-34.1%)*	*0.89*
Ireland	6	317	9.8	5.2	86.4 (79.6-91.6%)	96.3 (92.5-98.5%)	39.7	43.6 (39.1-48.0%)	0.84
Italy	5	254	4.2	16.4	94.2 (87.2-97.9%)	87.9 (82.2-92.5%)	44.5	39.6 (34.4-45.0%)	0.81
Latvia	*11*	*457*	*5.6*	*3.1*	*91.5 (85.6-95.6%)*	*98 (96.1-99.2%)*	*38.3*	*40.6 (37.8-43.9%)*	*0.91*
Lithuania	*21*	*606*	*3.8*	*6.1*	*90.2 (84.3-94.4%)*	*97.7 (96.1-98.8%)*	*27.1*	*28.3 (25.9-30.8%)*	*0.90*
Luxembourg	*12*	*432*	*1.7*	*2.9*	*95.2 (89.1-98.4%)*	*99.0 (97.4-99.7%)*	*25.6*	*26.1 (24.1-28.3%)*	*0.95*
Malta	*4*	*233*	*2.6*	*8.6*	*95.9 (88.5-99.2%)*	*94.5 (90.1-97.3%)*	*40.1*	*38.2 (34.3-42.8%)*	*0.89*
Netherlands*	4	178	3.0	1.3	94.2 (84.3-98.7%)	99.4 (96.4-100%)	33.1	34.7 (31.3-38.9%)	0.95
Poland	*19*	*682*	*0.8*	*4.9*	*97.9 (93.8-99.6%)*	*98.2 (97.1-99.0%)*	*26.6*	*25.9 (24.6-27.5%)*	*0.95*
Portugal	*26*	*2172*	*4.6*	*8.6*	*92.7 (90.5-94.4%)*	*94.6 (93.3-95.6%)*	*38.8*	*38.3 (36.9-39.8%)*	*0.87*
Romania	*8*	*721*	*1.6*	*1.7*	*97.6 (95.3-99.2%)*	*98.7 (97.3-99.5%)*	*42.5*	*42.8 (41.2-44.2%)*	*0.97*
Slovakia	5	250	1.6	0.7	96.2 (89.6-99.2%)	99.7 (98.4-100%)	28.9	29.8 (28.0-32.1%)	0.98
Spain	10	335	7.0	8.2	91.9 (84.8-96.4%)	93.0 (87.7-96.4%)	46.3	46.3 (41.4-51.5%)	0.85
UK-England	13	521	2.3	2.5	96.2 (90.6-98.9%)	98.5 (96.2-99.6%)	37.5	38.1 (35.7-41.0%)	0.95
UK-Northern Ireland	*9*	*255*	*1.0*	*1.8*	*98.2 (94.9-99.6%)*	*99.0 (97.4-99.7%)*	*36.3*	*36.3 (34.8-38.0%)*	*0.97*
UK-Scotland	10	969	8.1	3.0	86.7 (78.4-92.7%)	98.3 (94.9-99.6%)	35.2	39.4 (35.0-43.9%)	0.88
UK-Wales	*5*	*254*	*0.8*	*0.0*	*98.6 (96.7-99.5%)*	*100 (99.4-100%)*	*34.2*	*34.7 (33.9-35.3%)*	*0.99*
EU/EEA mean	**8**	**437**	**3.2**	**4.4**	**93.8 (92.0-95.6)**	**97.7 (96.7-98.7)**	**33.9**	**34.5 (30.8-37.7)**	**0.92**
Serbia	5	249	2.6	3.0	96.3 (89.7-99.2%)	97.9 (94.7-99.4%)	41.3	41.6 (38.5-45.3%)	0.94

*N of hos: number of validated hospitals; N of pts: number of validated patients; FN: false negatives; FP: false positives; Se: sensitivity; Sp: specificity; CI: confidence interval; pPPS AU %: AU prevalence (% of patients receiving at least one antimicrobial) of the primary national PPS (see Table 20 for confidence intervals); Corr AU %: corrected AU prevalence after adjustment for validation results. Kappa: kappa statistic for the presence of at least one antimicrobial; *Poor country representativeness in Bulgaria and the Netherlands. Results in italics were considered representative validation results at country level; Cyprus, Norway and Slovenia did not perform a validation survey.*

The mean corrected prevalence of antimicrobial use in countries performing a validation study was on average 34.5% compared with an average observed prevalence of 33.6% patients with at least one antimicrobial. The estimated country-weighted corrected prevalence of antimicrobial use, calculated by applying the mean percentages false negatives and false positives to the country-weighted EU/EEA prevalence, was 31.4% (95%CI 27.7-35.3), compared to 30.5% (95%cCI 27.7-33.5) before correction (see section `Burden estimates').

Expressing the results of the validation studies as inter-rater reliability between the primary PPS data collectors and the national validators - whereby the latter are not considered as the gold standard –, the mean kappa for the presence of at least one antimicrobial was 0.92 (95% confidence interval 0.90-0.94), ranging from less than 0.85 in Ireland and Italy to 1.00 in Croatia.

External validation

External validation teams identified difficulties with other variables of the antimicrobial use section of the protocol: the indication for antimicrobial use was often not well recorded in the patient files, and the clinical staff could not always be contacted to confirm; the reason for change, especially escalation, was difficult to interpret e.g. when a different antibiotic was added to a previous one given for the same indication; and start dates of antimicrobials frequently did not agree with other information being presented.

Burden estimates

Prevalence burden estimates: number of patients with an HAI or antimicrobials on any given day

Estimates of the total number of patients with an HAI or antimicrobials for EU/EEA were calculated correcting for non-participating EU/EEA countries (Denmark and Sweden) and for the average results of the national validation studies. After these corrections, the number of patients with at least one HAI on any given day in acute care hospitals in EU/EEA Member States was estimated at 98 166 patients with a 95% confidence interval ranging from 81 022 to 117 484 patients. The number of patients receiving antimicrobials in acute care hospitals on any given day was estimated at 472 497 patients (95% CI: 416 721–531 504).

Table 20. Estimation of the number of patients with at least one HAI and the number of patients with antimicrobial use on any day in acute care hospitals

	Occupied beds in country (average per day)	Pts with HAI %	(95%CI)	Pts with HAI N	(95%CI)	Pts with AU %	(95% CI)	Pts with AU N	(95%CI)
Austria	36 351	4.0	(3.4-4.7)	1 461	(1 243-1 716)	27.2	(24.3-30.4)	9 892	(8 827-11 033)
Belgium	37 651	7.3	(6.4-8.3)	2 731	(2 397-3 109)	28.1	(26.5-29.8)	10 593	(9 991-11 217)
Bulgaria*	25 324	3.5	(1.7-6.8)	875	(434-1 733)	45	(39.2-51.0)	11 407	(9 939-12 910)
Croatia	11 047	5.3	(4.5-6.2)	581	(495-683)	31.2	(26.6-36.1)	3 443	(2 938-3 993)
Cyprus	1 437	8.2	(5.4-12.4)	118	(77-178)	45.8	(42.3-49.4)	659	(609-710)
Czechia	40 691	6.7	(5.9-7.6)	2 732	(2 413-3 090)	29	(27.2-30.9)	11 806	(11 078-12 562)
Estonia	4 582	4.2	(2.4-7.3)	193	(111-332)	25.1	(21.2-29.5)	1 150	(971-1 350)
Finland	15 894	8.8	(7.5-10.4)	1 406	(1 187-1 660)	38.4	(35.0-41.9)	6 101	(5 567-6 653)
France	159 810	5.8	(4.9-7.0)	9 334	(7 823-11 116)	19.7	(17.9-21.6)	31 523	(28 660-34 597)
Germany	400 132	3.6	(2.8-4.7)	14 452	(11 087-18 789)	21.5	(17.4-26.3)	86 111	(69 756-105 081)
Greece	18 252	10.0	(8.5-11.6)	1 821	(1 559-2 121)	55.6	(53.0-58.1)	10 148	(9 680-10 610)
Hungary	46 134	4.0	(3.3-4.8)	1 833	(1 516-2 212)	15.9	(13.4-18.9)	7 357	(6 159-8 736)
Iceland	642	6.3	(0.8-36.9)	41	(5-237)	30	(21.4-40.4)	193	(137-259)
Ireland	10 932	6.1	(5.0-7.5)	670	(546-820)	39.7	(37.4-42.1)	4 342	(4 085-4 604)
Italy	167 619	8.0	(6.8-9.5)	13 457	(11 362-15 899)	44.5	(42.6-46.5)	74 647	(71 341-77 983)
Latvia	5 127	3.7	(2.6-5.2)	189	(132-268)	38.3	(34.8-42.0)	1 965	(1 785-2 152)
Lithuania	14 613	2.9	(2.1-4.0)	423	(301-590)	27.1	(23.9-30.6)	3 967	(3 499-4 472)
Luxembourg	1 860	5.1	(4.0-6.5)	95	(75-120)	25.6	(19.3-33.0)	476	(359-615)
Malta	972	6.2	(5.2-7.4)	61	(51-72)	40.1	(36.4-43.8)	389	(354-426)
Netherlands*	24 167	3.8	(3.4-4.3)	925	(826-1 036)	33.0	(31.2-34.8)	7 975	(7 540-8 410)
Norway**	10 505	5.1	(4.1-6.4)	540	(430-677)	29.8	(28.1-31.5)	3 129	(2 950-3 314)
Poland	120 492	5.8	(4.8-6.9)	6 931	(5 764-8 317)	28	(25.8-30.3)	33 702	(31 045-36 494)
Portugal	27 907	9.1	(8.1-10.2)	2 537	(2 263-2 841)	39.6	(36.9-42.3)	11 046	(10 295-11 816)
Romania	61 931	3.6	(2.8-4.7)	2 257	(1 747-2 909)	42.2	(38.6-45.9)	26 135	(23 907-28 415)
Slovakia	20 279	4.0	(3.1-5.3)	820	(630-1 066)	28.9	(26.2-31.7)	5 857	(5 309-6 436)
Slovenia	5 581	6.5	(5.8-7.3)	363	(322-409)	31.2	(28.7-33.9)	1 744	(1 601-1 892)
Spain	84 908	7.8	(7.0-8.5)	6 586	(5 983-7 243)	46.3	(44.8-47.9)	39 331	(38 003-40 665)
UK-England	96 774	6.4	(5.4-7.6)	6 230	(5 264-7 358)	37.4	(35.3-39.6)	36 187	(34 127-38 295)
UK-N. Ireland	4 965	6.1	(4.8-7.9)	305	(236-392)	36.3	(32.1-40.8)	1 803	(1 593-2 025)
UK-Scotland	11 448	4.3	(3.5-5.3)	496	(406-606)	35.2	(33.3-37.2)	4 031	(3 813-4 253)
UK-Wales	6 715	5.7	(4.7-6.7)	380	(318-453)	34.2	(31.9-36.5)	2 294	(2 139-2 454)
EU/EEA	1 474 742	5.5	(4.5-6.6)	80 842	(67 001-98 051)	30.5	(27.7-33.5)	449 401	(408 058-494 431)
EU/EEA, corrected[a]	1 503 881	5.5	(4.5-6.6)	82 713	(67 675-99 256)	30.5	(27.7-33.5)[a]	458 654	(416 521-503 783)
EU/EEA, corrected after validation	1 503 881	**6.5**	**(5.4-7.8)**	**98 166**	**(81 022-117 484)**	**31.4**	**(27.7-35.3)**	**472 497**	**(416 721-531 504)**
Serbia	18 920	4.3	(3.5-5.4)	821	(656-1 024)	41.3	(38.8-43.8)	7 811	(7 348-8 281)

Mean number of occupied beds: number of patient-days/365; patient-days for all beds in acute care hospitals were used or for acute care beds if the former was unknown, for the year preceding the survey; Pts: patients; 95% CI: 95% confidence interval, adjusted for design effect.
*[a]Cumulative 95% CI for the EU/EEA, wider than the design effect-adjusted 95% CI of [29.2–31.9%] reported in reference [2]. *PPS data*

*representativeness was poor in Bulgaria and the Netherlands. **Norway used a national PPS protocol. [a]Corrected for non-participating EU countries with estimation for Denmark and Sweden combined.*

After applying the country-specific prevalence percentages to the number of occupied acute care hospital beds per country, the country-weighted prevalence of patients with HAIs in the EU/EEA was 5.5% (cumulative 95% CI: 4.5–6.6%) before validation and 6.5% (cumulative 95% CI: 5.4-7.8%) corrected after validation. The country-weighted prevalence of patients receiving antimicrobials in the EU/EEA was 30.5% (cumulative 95% CI: 27.7–33.5%) before validation and 31.4% (cumulative 95% CI: 28.4-34.7%) corrected after validation.

The country-weighted prevalence and estimated numbers of patients with an HAI on a given day, by type of HAI, is given in Table 21. After weighting for the number of occupied beds in each country, the prevalence of patients with pneumonia (1.26%) was the highest, followed by urinary tract infections (1.10%) and surgical site infections (1.08%). The total number of HAIs on any given day in the EU/EEA was estimated at 104 177 HAIs.

Table 21. Estimated number of (patients with) a HAI on any given day, by type of HAI

Type of HAI	HAI in PPS sample		Country-weighted HAI prevalence		Estimated HAI on a given day, EU/EEA	
	N	% total	%	95% cCI[a]	N	95% cCI[a]
Pneumonia	4 200	21.4	1.26	0.96–1.68	18 935	14 398–25 265
Other lower respiratory tract infection[b]	838	4.3	0.24	0.15–0.41	3 568	2 208–6 192
Urinary tract infection	3 710	18.9	1.10	0.85–1.43	16 491	12 822–21 455
Surgical site infection	3 601	18.3	1.08	0.81–1.44	16 130	12 185–21 715
Bloodstream infection	2 116	10.8	0.69	0.48–1.00	10 294	7 241–15 097
Clostridioides difficile infection	951	4.8	0.32	0.21–0.51	4 786	3 105–7 721
Other gastrointestinal infection	792	4.0	0.24	0.14–0.41	3 549	2 108–6 166
Skin and soft tissue infection	823	4.2	0.21	0.13–0.36	3 146	1 900–5 451
Eye, ear, nose or mouth infection	557	2.8	0.16	0.09–0.35	2 400	1 278–5 194
Systemic infection	1 069	5.4	0.29	0.17–0.52	4 388	2 586–7 799
Other infection	969	4.9	0.30	0.19–0.50	4 518	2 867–7 574
All types of HAI EU/EEA	19 626	100	NA	NA	88 204	62 697–129 630
All types of HAI, EU/EEA, corrected after validation	NA	NA	NA	NA	**104 177**	**74 743–152 575**

[a]95% cCI: cumulative 95% confidence interval - country-specific estimates of the numbers of each type of HAI were summed up to obtain the total number for Europe, and applied to the total number of occupied beds to obtain the prevalence and confidence intervals by type of HAI. [b]Other lower respiratory tract infections included bronchitis, tracheobronchitis, bronchiolitis, tracheitis, lung abscess or empyema, without evidence of pneumonia.

Estimates of the annual number of patients acquiring an HAI, by country

The incidence of patients acquiring at least one HAI per year in the period 2016-2017 estimated using the Rhame and Sudderth formula is given by country in Table 22. The estimated incidence and 95% confidence interval were applied to the annual number of discharges from acute care hospitals to estimate the total number of patients with HAIs per country and per year and summed up to obtain the total number for Europe. Because of the uncertainty inherent in the Rhame and Sudderth formula, two estimates were calculated for each country, one using the country mean number of days from HAI onset until the day of the PPS (LN-INT) and one using the country median time from HAI onset until the day of the PPS. The median was chosen because the median time from admission to the day of the PPS for all patients in the PPS was similar to the overall length of stay in participating hospitals (Figure 7). However, since this relationship is not necessarily true for patients with HAIs, we also used the mean time from HAI onset until the day of the PPS to obtain a lower estimate of the incidence. The point estimate per country was calculated as the mean of the two estimates. The lower 95% confidence interval limit is given as the lower limit of the lowest estimate, the upper 95% confidence interval limit as the upper limit of the highest estimate.

After correction for non-participating EU countries and validation, the total annual number of patients with HAI in the EU/EEA was estimated to be between 3.1 million and 4.5 million patients, with a point estimate of 3.8 million patients with at least one HAI per year in acute care hospitals. The country-weighted European HAI incidence estimate was 3.7% (95% CI: 2.4-5.3%) before validation and 4.1% (95% CI 3.4-4.9%) after validation (Table 22).

Table 22. Estimation of the annual number of patients acquiring at least one HAI in acute care hospitals

Country	N of discharges	LOS	Mean LN-INT	P50 (LN-INT)	Estimated HAI incidence %	(95% CI)	N patients with HAI/year	(95% CI)
Austria	2 707 753	4.9	11.1	7	2.3	(1.5-3.3)	62 306	(40 978-89 762)
Belgium	1 858 726	6.5	11.2	7	5.4	(3.7-7.6)	101 110	(68 186-141 713)
Bulgaria*	1 632 089	4.1	8.3	7.5	1.8	(0.9-3.8)	29 572	(13 909-61 597)
Croatia	667 849	6.4	10.1	7	4.1	(2.8-5.6)	27 129	(18 937-37 561)
Cyprus	166 295	5.7	12.2	8	4.8	(2.5-8.7)	8 010	(4 158-14 541)
Czechia	2 260 239	6.7	10.4	7	5.4	(3.9-7.3)	122 313	(87 039-165 208)
Estonia	222 363	7.3	11.1	8	3.3	(1.6-6.6)	7 393	(3 558-14 761)
Finland	915 892	3.6	8.1	5	5.1	(3.3-7.5)	46 735	(30 053-68 350)
France	11 330 996	6.8	12.1	8	4.1	(2.8-5.9)	467 961	(311 830-671 498)
Germany	19 480 504	7.2	10.4	7	3.1	(1.9-4.8)	604 495	(373 766-938 383)
Greece	1 562 761	3.9	10.8	8	4.3	(3.1-5.7)	66 487	(48 386-89 068)
Hungary	2 226 485	7.9	12.3	7	3.5	(2.1-5.4)	78 095	(46 906-120 082)
Iceland	39 198	7.9	10	6	6.7	(0.6-48.6)	2 609	(239-19 038)
Ireland	705 000	5.9	11	7	4.2	(2.7-6.3)	29 671	(18 846-44 323)
Italy	8 930 979	7	11.3	8	6	(4.2-8.3)	534 709	(373 705-740 544)
Latvia	300 575	6.3	11.3	8	2.5	(1.4-4.1)	7 447	(4 322-12 399)
Lithuania	705 224	7.9	12.3	7	2.6	(1.3-4.6)	18 046	(9 322-32 167)
Luxembourg	74 782	6.6	12.8	8	3.4	(2.1-5.3)	2 569	(1 560- 3 995)
Malta	72 909	4.9	13.5	10.5	2.6	(1.9-3.4)	1 877	(1 380- 2 507)
Netherlands*	1 700 000	3.7	7.8	5	2.3	(1.6-3.2)	39 585	(27 525-54 115)
Norway**	776 203	3.7	10	6.6	2.4	(1.5-3.7)	18 767	(11 873-28 340)
Poland	8 254 611	5.1	10.4	7	3.5	(2.3-5.0)	289 602	(193 881-415 274)
Portugal	1 128 245	6.1	11.2	8	5.9	(4.4-7.8)	66 860	(49 568-87 500)
Romania	3 674 275	6	9.9	7	2.6	(1.7-4.0)	97 257	(62 340-146 893)
Slovakia	1 005 003	6.2	9.2	7	3.1	(2.1-4.6)	31 519	(20 848-46 607)
Slovenia	380 077	5.4	9.3	7	4.4	(3.3-5.6)	16 635	(12 630-21 441)
Spain	5 247 215	6	11.9	8	4.9	(3.6-6.4)	255 169	(186 398-335 644)
UK-England	9 450 142	2.5	10	6	2.2	(1.4-3.2)	205 722	(130 191-303 990)
UK-Northern Ireland	302 008	4.5	11.6	6	3.5	(1.8-5.9)	10 527	(5 559-17 841)
UK-Scotland	1 156 473	3.6	8.8	6	2.2	(1.5-3.2)	25 539	(16 992-36 977)
UK-Wales	827 634	3	11	6	2.2	(1.3-3.3)	17 880	(10 595-27 545)
EU/EEA	**89 762 505**	**5.6**	**10.7**	**7.1**	**3.7**	**(2.4-5.3)**	**3 293 595**	**(2 185 484-4 789 661)**
EU/EEA, corrected[a]	91 885 503	5.6	10.7	7.1	3.7	(2.4-5.3)	3 372 146	(2 220 554-4 854 535)
EU/EEA, corrected after validation	**91 885 503**	**5.6**	**10.7**	**7.1**	**4.1**	**(3.4-4.9)**	**3 758 014**	**(3 122 074 – 4 509 617)**
Serbia	988 383	6.8	10.2	8	3.3	(2.3-4.6)	32 337	(22 714-45 256)

***Number of discharges**: source national denominator data reported in TESSy (national denominator data) or Eurostat, see Annex 1 Table A1.7. **LOS**: average length of hospital stay from PPS hospital data, previous year (=LA in Rhame and Sudderth formula); **LN**= length of stay in patients with HAI; **INT**: number of days from hospital admission to onset of HAI (onset of first HAI if more than one HAI in single patient); **LN-INT**: number of days from onset of HAI until discharge in incidence series (if hospital-wide HAI surveillance had been performed in the same period), approached by PPS survey date – date of HAI onset +1 (see text); for HAI present on admission, the date of onset was replaced by the date of admission; P50=percentile 50 or median; **Estimated HAI incidence %:** percentage of hospitalised patients with at least one HAI per year, estimated using formula by Rhame and Sudderth [38] $I=P \times LA/(LN-INT)$, where P is the prevalence of patients with at least one HAI with 95% confidence intervals corrected for the PPS country-specific design effect, LA is the length of stay for all patients and (LN-INT) is the length of stay until survey date from onset of infection in patients with an HAI. Two estimates were calculated per country, one based on the mean and one based on the median time from HAI onset to the day of the PPS, see text. **Estimated number of patients per year with HAI**: number of discharges multiplied by estimated HAI incidence and 95% confidence interval. The HAI incidence and 95% CI for the EU/EEA was calculated as the sum of the estimated country-specific numbers of patients with HAI × 100 /total number of discharges.*
**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national PPS protocol. [a]Corrected for non-participating EU countries with estimation for Denmark and Sweden combined.*

Estimates of the annual number of HAIs, by type of HAI

The country-weighted estimated incidence and total numbers of patients with HAIs, by type of HAI and per year and corrected for non-participating EU countries is given in Table 23. The most common types of HAI in terms of number of HAIs per year was urinary tract infections with an estimated number of 888 106 HAIs per year, closely followed by pneumonia with 860 938 HAIs per year. Both types of HAI were estimated to affect about 1% of hospitalised patients per year in Europe. The 95% confidence interval of the total number of HAIs per year ranged from 2.6 million HAIs to 7.6 million HAIs per year, a wider range than around the estimated total of patients with at least one HAI because of the cumulative uncertainty around each of the site-specific incidence estimates.

Table 23. Estimation of the number of HAIs by type of HAI per year in acute care hospitals

Type of HAI	Mean (LN-INT)	P50 (LN- INT)	Country-weighted HAI incidence (estimated)		Estimated HAIs per year, EU/EEA	
			%	95% cCI[a]	N	95% cCI[a]
Pneumonia	8.9	6.7	0.94	(0.62-1.40)	862 084	(567 728-1 283 203)
Other lower respiratory tract infection[b]	7.9	6.4	0.20	(0.10-0.41)	183 232	(91 731-376 990)
Urinary tract infection	7.8	6.2	0.95	(0.62-1.39)	869 941	(572 105-1 278 951)
Surgical site infection	14.3	9.0	0.56	(0.32-0.93)	518 182	(293 036-858 222)
Bloodstream infection	11.6	8.7	0.41	(0.25-0.67)	375 050	(227 552-613 624)
Clostridioides difficile infection	11.5	8.8	0.21	(0.11-0.37)	189 526	(105 154-340 978)
Other gastrointestinal infection	13.0	8.0	0.16	(0.07-0.34)	144 926	(64 880-312 212)
Skin and soft tissue infection	15.5	10.9	0.12	(0.05-0.26)	108 269	(45 149-242 816)
Eye, ear, nose or mouth infection	8.5	6.9	0.13	(0.06-0.33)	123 091	(54 155-303 206)
Systemic infection	7.7	5.6	0.27	(0.12-0.60)	251 237	(110 732-549 877)
Other infection	17.8	10.9	0.17	(0.07-0.36)	154 138	(65 647-332 357)
All types of HAI EU/EEA	10.9	7.0			3 779 677	(2 197 869-6 492 437)
All types of HAI, EU/EEA, corrected after validation					**4 464 159**	**(2 620 139-7 641 606)**

Estimated HAI incidence %: *percentage of hospitalised patients with at least one HAI per year, estimated using formula by Rhame and Sudderth [38] I=P × LA/(LN-INT), where P is the prevalence of patients with at least one HAI with 95% confidence intervals corrected for the PPS country-specific design effect. Two estimates were calculated per country, one based on the mean and one based on the median time from HAI onset to the day of the PPS (LN-INT), see text.*

Estimated number of patients per year with HAI*: number of discharges multiplied by estimated HAI incidence and 95% confidence interval. The HAI incidence and 95% CI for the EU/EEA was calculated as the sum of the estimated country-specific numbers of patients with HAI x100 /total number of discharges, with a correction for non-participating countries Sweden and Denmark. Correction for validation results (last line) was done by applying the ratio of the corrected HAI prevalence over the primary PPS HAI prevalence from Table 20. [b]Other lower respiratory tract infections included bronchitis, tracheobronchitis, bronchiolitis, tracheitis, lung abscess or empyema, without evidence of pneumonia.*

The total annual number of patients with intubation-associated pneumonia in the EU/EEA was estimated at 259 972 (95% CI: 143 543–457 223) and patients with catheter-related bloodstream infections at 184 132 (95% CI: 102 021–334 963).

Estimates of the annual number of HAIs with antimicrobial-resistant bacteria

The annual number of patients with HAIs involving resistant bacteria was estimated without corrections nor imputations, assuming that resistant pathogens were not present in HAIs for which microbiological data were not available, which certainly resulted in an underestimation. In other words, we assumed that there were no HAIs with resistant bacteria in countries that did not participate in the PPS (Denmark and Sweden), nor in countries that did not report AMR data in 2016-2017 (Norway, and UK-Scotland), nor in 45.9% of HAIs in other countries (because samples were not taken or because microbiological results were not yet available or negative). Results of these estimates (based on Rhame and Sudderth conversions for HAIs with antimicrobial-resistant bacteria) are given in Table 24. Details for the incidence estimates by country were published earlier for the composite index of AMR and for carbapenem-resistant Enterobacterales [1]. The total number of patients acquiring an HAI with at least one antimicrobial-resistant bacterium included in the composite index of AMR was estimated at 291 067 (95% cCI: 162 417–504 270) patients for the composite index of AMR and 31 696 (95% cCI: 14 611–78 205) patients for carbapenem-resistant Enterobacterales. The total for the main microorganism contributing to the latter, carbapenem-resistant *K. pneumoniae,* estimated using Rhame and Sudderth conversion from the PPS 2016-2017 data (23 701 HAIs) was similar to the number published by Cassini et al. using a different methodology based on EARS-Net data (23 397 infections) [41].

Table 24. Estimation of the number of HAIs with antimicrobial-resistant bacteria per year in acute care hospitals

Antimicrobial-resistant bacteria	Mean (LN-INT)	P50 (LN- INT)	Country-weighted HAI incidence (estimated)[a]		Estimated HAIs per year, EU/EEA (uncorrected)	
			%	95% cCI	N	95% cCI
Composite index of AMR	17.0	10.5	0.32	(0.18-0.56)	291 067	(162 417-504 270)
Meticillin-resistant *Staphylococcus aureus*	17.5	14.3	0.05	(0.03-0.12)	49 095	(23 932-104 308)
Vancomycin-resistant *Enterococcus faecalis*	18.7	18.1	<0.01	(0.00-0.01)	2 530	(512-13 456)
Vancomycin-resistant *Enterococcus faecium*	18.9	14.5	0.02	(0.00-0.08)	15 529	(4 149-69 715)
Enterobacterales resistant to third-generation cephalosporins[c]	15.7	9.8	0.21	(0.11-0.39)	190 321	(99 746-351 906)
Third-generation cephalosporin-resistant *Escherichia coli*	14.0	9.6	0.08	(0.04-0.16)	71 936	(35 652-146 930)
Third-generation cephalosporin-resistant *Klebsiella pneumoniae*	18.7	15.0	0.08	(0.04-0.17)	71 644	(35 519-151 586)
Carbapenem-resistant *Pseudomonas aeruginosa*	19.3	14.9	0.04	(0.02-0.09)	34 609	(14 923-82 910)
Carbapenem-resistant *Acinetobacter baumannii*	29.8	44.0	0.03	(0.01-0.07)	26 924	(13 122-65 067)
Carbapenem-resistant Enterobacterales[c]	21.9	20.5	0.04	(0.02-0.09)	31 696	(14 611-78 205)
Carbapenem-resistant *Escherichia coli*	11.0	10.5	0.01	(0.00-0.03)	4 780	(1 179-23 000)
Carbapenem-resistant *Klebsiella pneumoniae*	19.5	17.3	0.03	(0.01-0.06)	23 701	(11 058-57 817)

[a] ***Country-weighted HAI incidence (estimated):*** *the incidence % by country was defined as the percentage of hospitalised patients acquiring at least one HAI per year, estimated using formula by Rhame and Sudderth [38] I=P × LA/(LN-INT), where P is the prevalence of patients with at least one HAI with a resistant pathogen. The estimates by country were summed up to obtain the EU/EEA estimate. Point estimates by country were calculated as the average of two estimates, one based on the mean and one based on the median time from HAI onset to the day of the PPS(LN-INT).* [b] ***Uncorrected EU/EEA estimates****: in this table, EU/EEA totals were not corrected for 1) non-participating countries Denmark and Sweden; 2) countries not providing antimicrobial susceptibility data (Norway and UK-Scotland); 3) HAIs without microbiological results (45.9% of all HAIs, Norway excluded) and 4) HAIs with microbiological results for which antimicrobial susceptibility results were not yet available on the survey date (11.9% of 9 034 microorganisms included in the composite index of AMR).*

[c] ***Composite index of antimicrobial resistance (AMR)****: Staphylococcus aureus resistant to meticillin, Enterococcus faecium and Enterococcus faecalis resistant to vancomycin, Enterobacterales resistant to third-generation cephalosporins, Pseudomonas aeruginosa and Acinetobacter baumannii resistant to carbapenems. The sum of the estimated number of HAIs per resistant microorganism differs from the estimated total for the composite index because each calculation (each line) in the table uses a specific mean and median time from infection onset until the day of the PPS (LN-INT). In addition, in the first line (composite index of AMR), a patient with an HAI involving more than one resistant microorganism is only counted once.*

[d] ***Enterobacterales****: including Escherichia coli, Klebsiella spp., Enterobacter spp., Proteus spp., Citrobacter spp., Serratia spp. and Morganella spp. Details are only shown for Escherichia coli and Klebsiella pneumoniae.*

Structure and process indicators

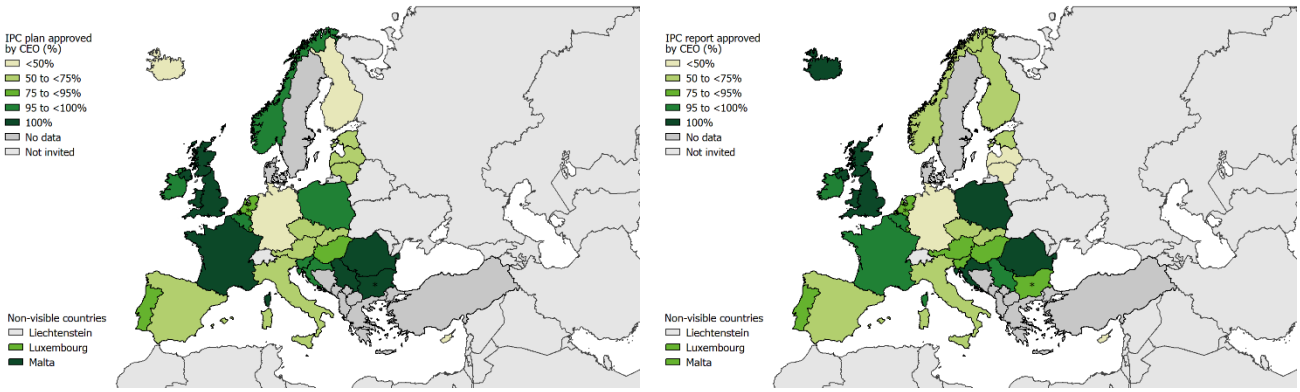
The number of hospitals reporting structure and process indicators varied according to the indicator and the level at which the data were collected (hospital or ward level). Denominators (number of responding hospitals) by indicator and by country are given in the annex (Table A.I.8).

Core component 1. Infection prevention and control (IPC) programme

Infection prevention and control (IPC) plan and report, approved by the hospital CEO or a senior executive officer

Overall, 78.7% of EU/EEA hospitals reported having an annual IPC plan and 77.4% an annual IPC report that were approved by the hospital CEO or a senior executive officer. The existence of both an approved plan and an approved report was reported by 72.9% (773/1061) hospitals, and 16.5% (175/1061) hospitals had neither an approved plan nor an approved report. The latter percentage was the highest in Cyprus (100%), followed by Germany (56.3%), Latvia (50.0%), Lithuania (39.3%), Slovakia (36.2%), Spain (36.1%) and Finland (35.4%) (Figure 77). There was no association between having an approved plan or an approved report and the composite index of AMR, or the prevalence of HAIs.

Figure 77. Percentage of hospitals reporting the presence of an annual infection prevention and control (IPC) plan (left) and annual IPC report (right), approved by the hospital chief executive officer (CEO) or a senior executive officer



**PPS data representativeness was poor in Bulgaria and the Netherlands.*

Infection prevention and control (IPC) staffing levels

Infection prevention and control nurses (IPCNs)

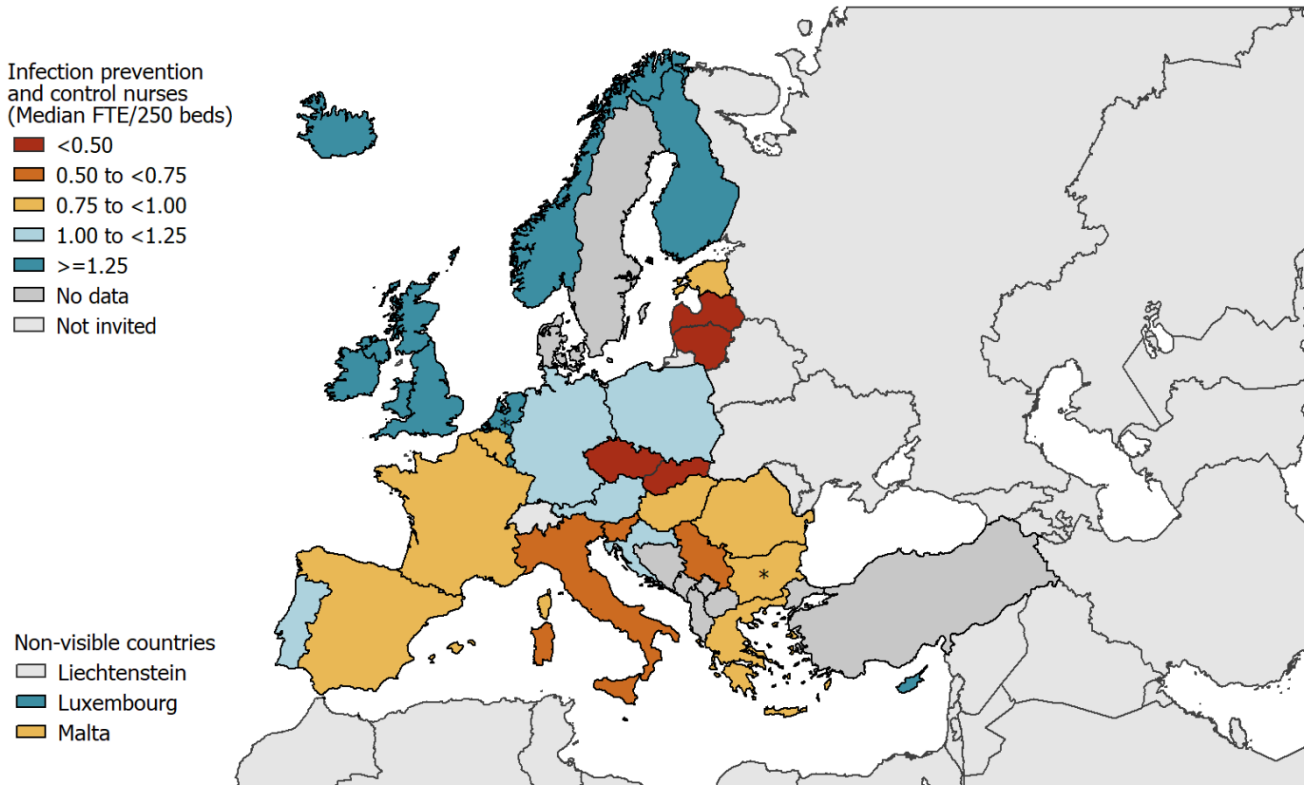
The number of infection prevention and control nurse (IPCN) full-time equivalents (FTEs) was provided by 1 141 hospitals. Data from eight hospitals were discarded as outliers. The median number of IPCN FTEs per 250 beds was 1.04 (IQR: 0.58–1.56) and ranged from 0.0 in Lithuania and Slovakia to 2.22 IPCN FTEs per 250 beds in the Netherlands (Figure 78, Figure 79). The median number of IPCN FTEs per 250 beds decreased significantly with increasing hospital size ($p<0.001$, (Table 25) but did not vary significantly according to the type of hospital (Table 26).

In 169 (14.9%) hospitals from 18 countries, IPCN FTEs were not reported. The percentage of hospitals without reported IPCN worktime was 50% or higher in Latvia, Lithuania and Slovakia, and was the highest in small hospitals (p-value adjusted for country <0.001). It was also higher in private for-profit hospitals than in private not-for-profit and public hospitals (25.5% *vs* 14.1%) and lower in tertiary hospitals than in primary, secondary and specialised hospitals, but these differences were not statistically significant after adjustment for hospital size and country. Hospitals without IPCN worktime less frequently reported having an approved annual IPC plan (59.1% *vs* 84.4%, $p<0.001$) or an annual IPC report (51.9% *vs* 84.2%, $p<0.001$) than hospitals that did report IPC FTEs.

The number of IPCN FTEs in the hospital was significantly associated with the composite index of AMR (p for trend <0.001). The median composite index of AMR was the highest in hospitals without reported IPCN worktime (45.7%) and 6.4 times lower in hospitals with at least 2.00 IPCN FTEs per 250 beds (7.1%) than in other hospitals (Figure 80). The association remained statistically significant after adjustment for type of hospital and hospital size.

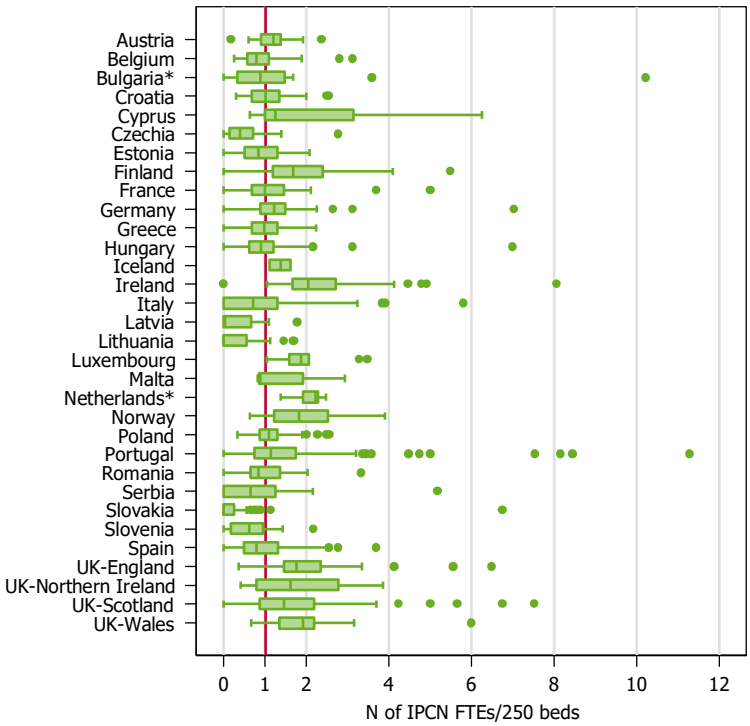
The number of IPCN FTEs in the hospital was also significantly associated with HAI prevalence, but in the opposite direction. Hospitals without reported IPCN worktime had a significantly lower HAI prevalence than hospitals with IPCN FTEs (median 3.0% *vs* 5.0%, $p<0.001$), but there was no significant difference in HAI prevalence between the IPCN staffing levels above zero FTE. The association of IPCN staffing levels with HAI prevalence did not remain statistically significant after adjustment for the number of blood cultures per 1 000 patient-days (see below).

Figure 78. Median number of infection prevention and control nurse FTEs per 250 hospital beds (n=1 196 hospitals)



**PPS data representativeness was poor in Bulgaria and the Netherlands.*

Figure 79. Number of infection prevention and control nurse FTEs per 250 hospital beds by country (n=1 196 hospitals)



**PPS data representativeness was poor in Bulgaria and the Netherlands. Red vertical line=median.*

Table 25. Infection prevention and control nurse FTEs per 250 hospital beds by hospital size

N of beds	N of hospitals	IPCN FTEs per 250 hospital beds						% hospitals without IPCN
		Mean	P10	P25	P50	P75	P90	
<200	428	1.50	0.00	0.00	1.30	2.08	3.37	26.2
200-399	304	1.11	0.14	0.74	1.07	1.42	1.94	9.2
400-649	205	1.07	0.29	0.58	0.93	1.23	1.80	7.8
≥650	196	0.98	0.23	0.59	0.81	1.27	1.74	6.6
Total	**1 133**	**1.23**	**0.00**	**0.58**	**1.04**	**1.56**	**2.35**	**14.9**

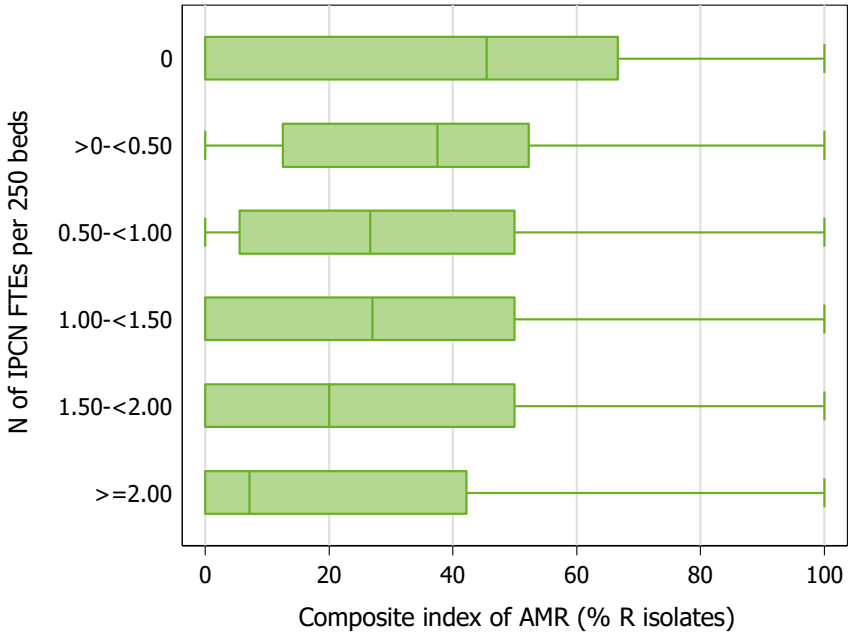
P: percentile. IPCN: infection prevention and control nurse.

Table 26. Infection prevention and control nurse FTEs per 250 hospital beds by type of hospital

Type of hospital	N of hospitals	IPCN FTEs per 250 hospital beds						% hospitals without IPCN
		Mean	P10	P25	P50	P75	P90	
Primary	348	1.31	0.00	0.58	1.04	1.66	2.66	17.8
Secondary	397	1.13	0.00	0.55	0.99	1.52	2.16	15.6
Tertiary	228	1.11	0.28	0.64	1.01	1.33	1.83	5.7
Specialised	155	1.44	0.00	0.56	1.20	1.91	3.22	20.0
Unknown	5	1.59	0.00	1.14	1.42	2.08	3.29	20.0
Total	**1 133**	**1.23**	**0.00**	**0.58**	**1.04**	**1.56**	**2.35**	**14.9**

P: percentile. IPCN: infection prevention and control nurse

Figure 80. Composite index of AMR by levels of infection prevention and control nurse FTE per 250 beds



FTE: full-time equivalent. IPCN: infection prevention and control nurse. The analysis only includes hospitals with at least one HAI with microbiological documentation of a microorganism included in the composite index of AMR with known antimicrobial susceptibility results (n=827 hospitals). Composite index of AMR: Staphylococcus aureus *resistant to meticillin,* Enterococcus faecium *and* Enterococcus faecalis *resistant to vancomycin, Enterobacterales resistant to third-generation cephalosporins,* Pseudomonas aeruginosa *and* Acinetobacter baumannii *resistant to carbapenems.*

Infection prevention and control doctors (IPCDs)

The number of infection prevention and control doctor (IPCD) FTE was provided by 1 136 hospitals from 27 EU/EEA countries and the four UK administrations. Data from seven hospitals were discarded as outliers. The median number of IPCD FTE per 250 beds was 0.28 (IQR: 0.04–0.64) and ranged from 0 in Greece and Slovakia to 0.60 FTE/250 beds in Romania (Figure 81, Figure 82). The median number of FTE IPCD per 250 beds did not vary significantly according to the type of hospital (Table 27) or hospital size (Table 28).

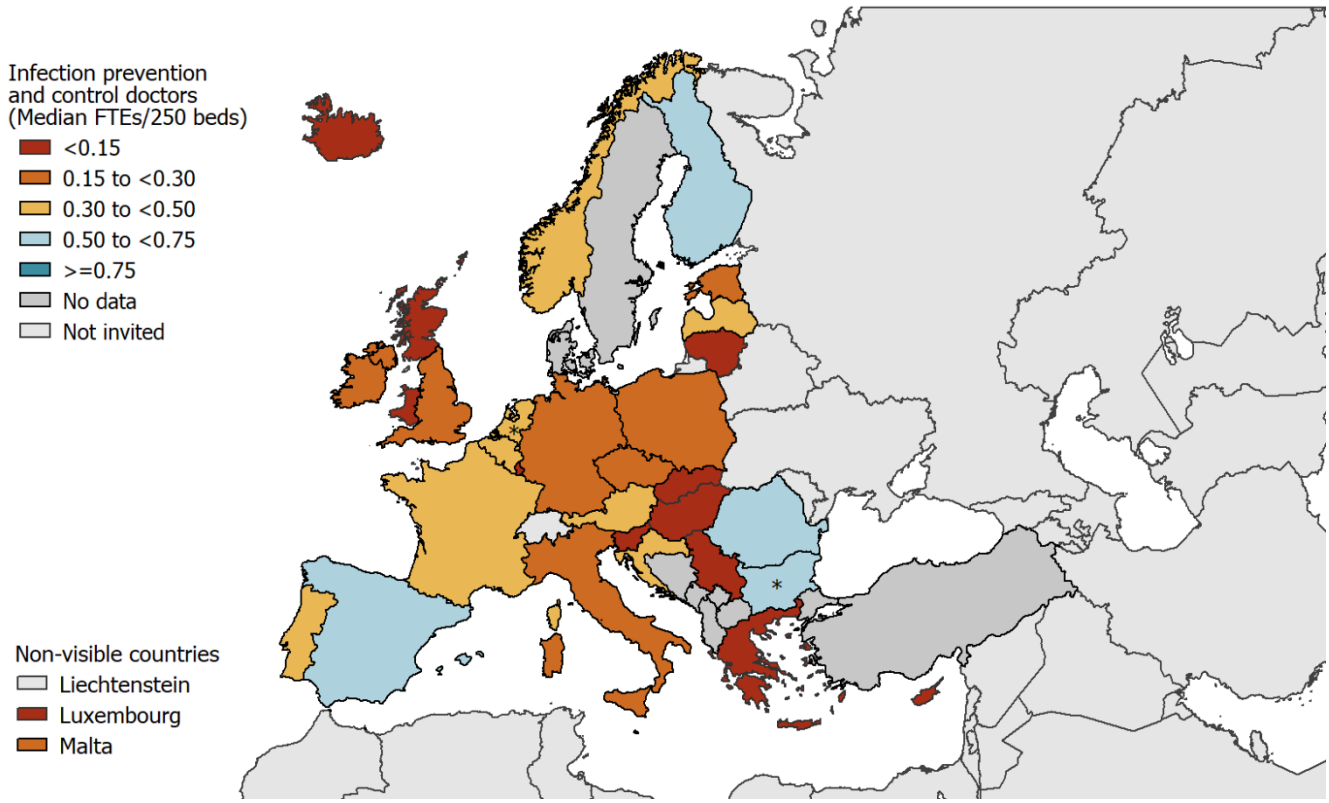
In 24.1% (n=272) hospitals from 22 EU/EEA countries and the four UK administrations, IPCD worktime was not reported. This percentage was 50% or higher in Cyprus, Greece, Iceland, Lithuania, Malta and Slovakia and was the highest in small hospitals (Table 28, p-value adjusted for country < 0.001). The percentage of hospitals without IPCD was also higher in private for-profit hospitals (36.9% *vs* 21.2%) but this difference was not significant after adjustment for hospital size and country. However, the

higher percentage of hospitals without IPCD in primary hospitals (Table 27) remained significant after adjustment for hospital size and country.

Hospitals without an IPCD reported having an approved annual IPC plan (65.5% *vs* 85.1%, p<0.001) or an annual IPC report (61.0% *vs* 84.8%, p<0.001) less frequently. Hospitals without an IPCD were also more likely to have no IPCN (110/273 or 40.3% without IPCN) than hospitals with an IPCD (59/860 or 6.9% without IPCN) (p<0.001). The median prevalence of HAIs was lower in hospitals with neither an IPCD nor an IPCN (2.2%) than in hospitals with either an IPCD or an IPCN (4.1%) and in hospitals with both in place (5.1%) (p<0.001). The composite index of AMR was slightly higher in hospitals without IPCD (33.3% *vs* 25.0%, p<0.05) but unlike for IPCNs, it did not vary significantly according to IPCD staffing levels above zero FTE.

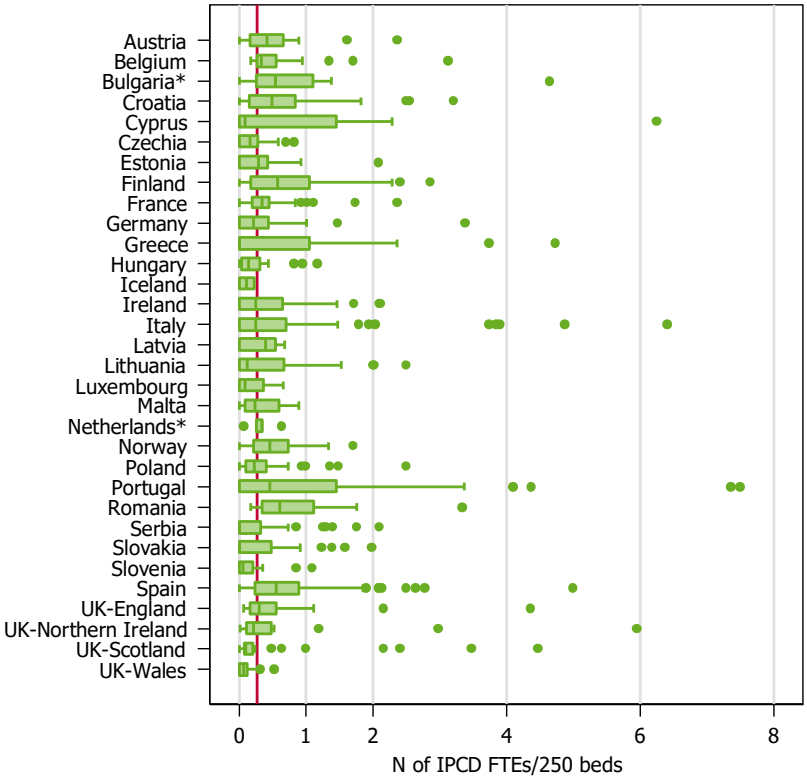
It should be noted that the definition of IPCD in 2016-2017 differed from the definition in 2011-2012. In the second ECDC PPS, FTE spent on antimicrobial stewardship activities mentioned as part of the job description had to be reported separately.

Figure 81. Median number of infection prevention and control doctor FTEs per 250 hospital beds (n=1 182 hospitals)



**PPS data representativeness was poor in Bulgaria and the Netherlands.*

Figure 82. Number of infection prevention and control doctor FTEs per 250 hospital beds, by country (n=1 182 hospitals)



**PPS data representativeness was poor in Bulgaria and the Netherlands.*

Table 27. Number of infection prevention and control doctor FTEs per 250 hospital beds by type of hospital

Type of hospital	N of hospitals	IPCD FTEs per 250 hospital beds						% hospitals without IPCD
		Mean	P10	P25	P50	P75	P90	
Primary	345	0.53	0.00	0.00	0.27	0.65	1.33	31.0
Secondary	396	0.45	0.00	0.00	0.22	0.55	1.00	26.0
Tertiary	225	0.56	0.03	0.14	0.36	0.61	1.16	9.3
Specialised	158	0.65	0.00	0.00	0.34	0.94	1.71	25.3
Unknown	5	0.73	0.00	0.36	0.57	0.66	2.08	20.0
Total	**1 129**	**0.53**	**0.00**	**0.04**	**0.28**	**0.64**	**1.28**	**24.1**

P: percentile.

Table 28. Number of infection prevention and control doctor FTEs per 250 hospital beds by hospital size,

N of beds	N of hospitals	IPCD FTEs per 250 hospital beds						% hospitals without IPCD
		Mean	P10	P25	P50	P75	P90	
<200	426	0.71	0.00	0.00	0.32	0.89	2.02	35.9
200-399	303	0.44	0.00	0.05	0.30	0.68	1.01	23.4
400-649	206	0.38	0.00	0.08	0.22	0.47	0.62	18.0
≥650	194	0.40	0.07	0.14	0.28	0.48	0.68	5.7
Total	**1 129**	**0.53**	**0.00**	**0.04**	**0.28**	**0.64**	**1.28**	**24.1**

P: percentile.

Microbiological laboratory support

Microbiological laboratory support during weekends

Hospitals were asked whether clinicians could request routine clinical and screening microbiological tests and receive back results within the standard turnaround time during weekends. France and Greece did not include this question in their national protocol. In the Netherlands and in Norway, only 31.6% (n=6) and 51.2% (n=22) of the hospitals respectively replied to the hospital indicator questionnaire. In Lithuania, only one question per weekend day was reported, which was considered as valid for the clinical tests. For hospitals in other countries however, it was unclear whether no answer meant a missing (unknown) or a negative reply. In those countries, we assumed that 'unknown' signified 'service not available' for hospitals that had replied at least once `yes' or 'no' to one of the four questions. This approach resulted in 1 008 EU/EEA hospitals replying for clinical tests and 946 hospitals (excluding Lithuania) for screening tests. Clinical tests would be reported by 782 (77.6%) hospitals on Saturdays and by 570 (56.6%) hospitals on Sundays. Screening tests would be reported by 670 (70.8%) hospitals on Saturdays and by 484 (51.2%) hospitals on Sundays. Full availability of clinical and screening tests on both Saturday and Sunday was reported by 442 (46.7%) hospitals, ranging from 0% in Latvia to 100% hospitals in Malta and UK-Northern Ireland (Table 29). Full availability of microbiological laboratory support during weekends was not significantly associated with the prevalence of HAI nor with the composite index of AMR.

Table 29. Availability of microbiological laboratory support during weekends

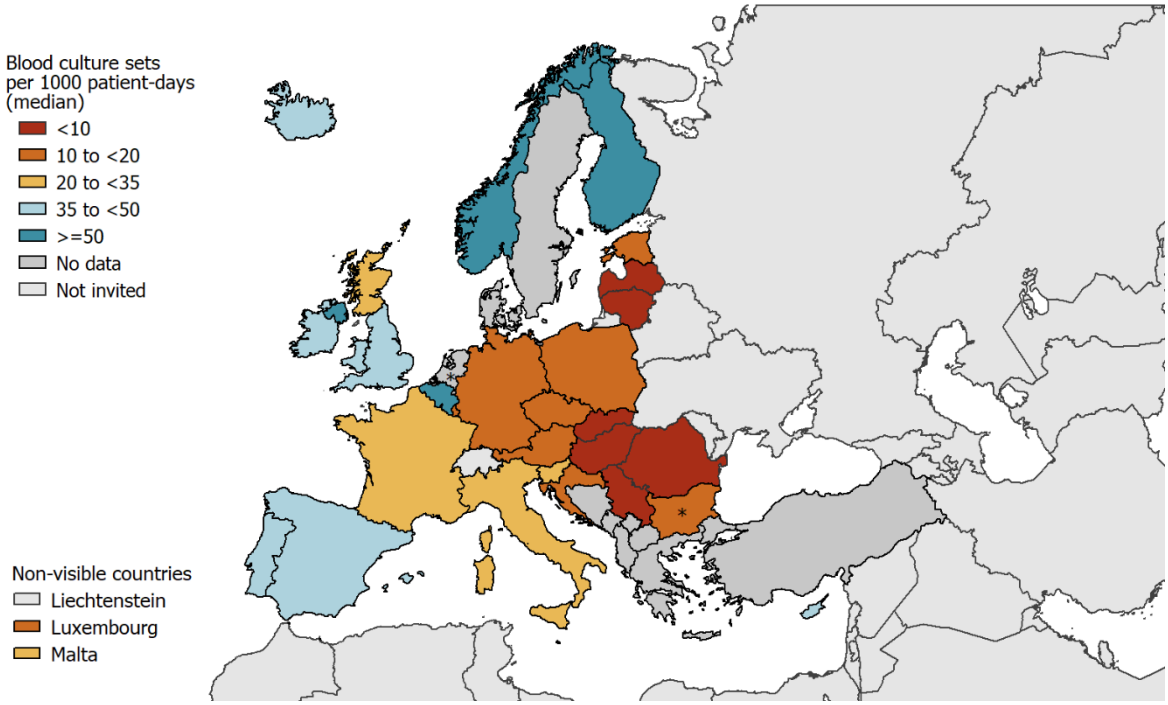
Country	Responding hospitals		Clinical tests available		Screening test available		All four tests available
			Saturday	Sunday	Saturday	Sunday	
	N	%	%	%	%	%	%
Austria	48	98.0	75.0	41.7	62.5	37.5	31.3
Belgium	29	67.4	100.0	96.6	89.7	79.3	75.9
Bulgaria*	12	100.0	100.0	58.3	75.0	33.3	33.3
Croatia	31	91.2	83.9	38.7	67.7	29.0	25.8
Cyprus	7	87.5	28.6	28.6	28.6	28.6	28.6
Czechia	45	100.0	93.3	66.7	88.9	55.6	55.6
Estonia	20	87.0	75.0	45.0	75.0	50.0	40.0
Finland	42	82.4	97.6	95.2	50.0	45.2	42.9
France	0	0.0	-	-	-	-	-
Germany	49	100.0	85.7	57.1	81.6	53.1	42.9
Greece	0	0.0	-	-	-	-	-
Hungary	33	86.8	69.7	18.2	57.6	12.1	12.1
Iceland	2	100.0	100.0	100.0	100.0	50.0	50.0
Ireland	60	100.0	75.0	51.7	60.0	33.3	31.7
Italy	56	100.0	87.5	55.4	71.4	39.3	35.7
Latvia	14	100.0	71.4	0.0	35.7	0.0	0.0
Lithuania	62	100.0	45.2	32.3	-	-	-
Luxembourg	11	91.7	90.9	90.9	90.9	90.9	90.9
Malta	4	100.0	100.0	100.0	100.0	100.0	100.0
Netherlands*	6	31.6	50.0	50.0	50.0	50.0	50.0
Norway	22	51.2	81.8	50.0	81.8	54.5	45.5
Poland	77	96.3	96.1	80.5	92.2	77.9	76.6
Portugal	71	76.3	70.4	49.3	81.7	76.1	47.9
Romania	34	85.0	67.6	52.9	47.1	35.3	35.3
Slovakia	45	90.0	84.4	77.8	73.3	66.7	64.4
Slovenia	19	95.0	94.7	68.4	89.5	47.4	47.4
Spain	96	100.0	42.7	15.6	37.5	13.5	11.5
UK-England	31	96.9	87.1	83.9	77.4	74.2	74.2
UK-Northern Ireland	16	100.0	100.0	100.0	100.0	100.0	100.0
UK-Scotland	45	100.0	82.2	77.8	82.2	77.8	77.8
UK-Wales	21	100.0	100.0	100.0	100.0	95.2	95.2
EU/EEA	**1 008**	**83.4**	**77.6**	**56.6**	**70.8**	**51.2**	**46.7**
Serbia	63	95.5	100.0	31.7	46.0	14.3	14.3

**PPS data representativeness was poor in Bulgaria and the Netherlands.*

Number of blood culture sets per year

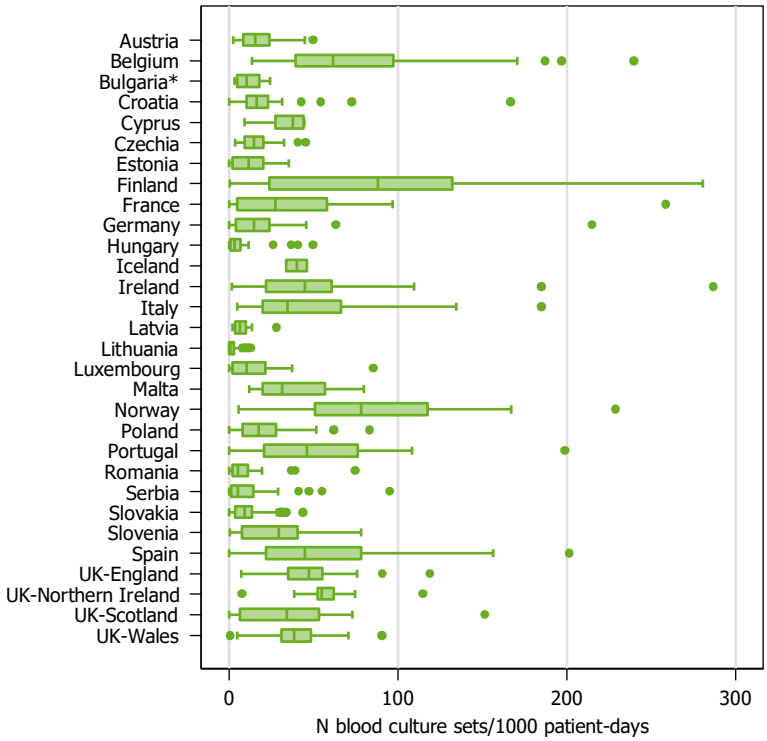
The number of blood culture sets received and processed by the laboratory over a one-year period was provided by 1 065 (88.1%) hospitals from all EU/EEA countries and the UK except Greece and the Netherlands, mostly (93.8%) for the year preceding the survey. Five observations were considered as outliers.

Figure 83. Median number of blood culture sets per 1 000 patient-days (n=1 124 hospitals)



**PPS data representativeness was poor in Bulgaria and the Netherlands.*

Figure 84. Number of blood culture sets per 1 000 patient-days (n=1124 hospitals), by country



**PPS data representativeness was poor in Bulgaria. The number of blood cultures was not reported by Greece and the Netherlands.*

The median number of blood culture sets per 1 000 patient-days was 22.8 [IQR 6.6 – 49.5] and varied between less than 10 in Lithuania, Hungary, Serbia, Romania, Latvia and Slovakia and more than 50 in UK-Northern Ireland, Belgium, Norway and Finland (Figure 83, Figure 84). The median was significantly associated with the type of hospital (p<0.001,Table 30) and increased significanty with hospital size (p<0.001,Table 31).

Table 30. Number of blood culture sets per 1 000 patient-days by type of hospital

Type of hospital	N of hospitals	Blood culture sets per 1000 patient-days					
		Mean	P10	P25	P50	P75	P90
Primary	328	26.6	0.5	3.2	13.5	35.6	68.4
Secondary	365	37.8	2.7	10.7	28.2	51.8	80.1
Tertiary	213	44.9	6.4	15.2	35.5	59.2	91.0
Specialised	149	29.9	0.0	3.2	12.1	38.1	86.8
Unknown	5	55.8	0.7	1.6	7.5	85.2	184.1
Total	**1 060**	**34.7**	**1.2**	**6.6**	**22.7**	**49.3**	**81.3**

P: percentile.

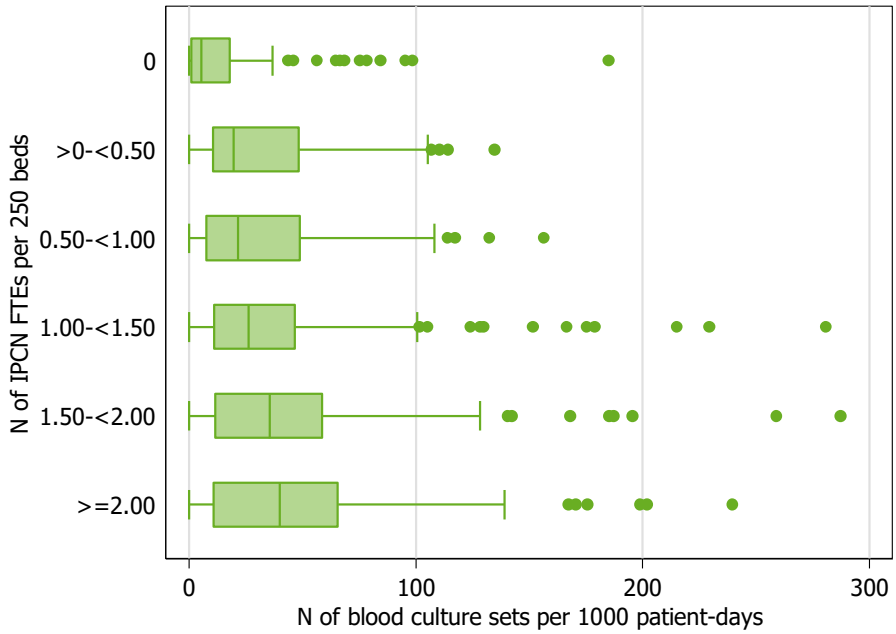
Table 31. Number of blood culture sets per 1 000 patient-days by hospital size

N of beds	N of hospitals	Blood culture sets per 1000 patient-days					
		Mean	P10	P25	P50	P75	P90
<200	409	31.2	0.2	2.7	14.8	43.6	85.2
200-399	284	36.9	3.5	9.9	26.3	49.5	82.1
400-649	185	37.6	4.7	13.4	27.6	50.9	77.0
≥650	182	37.3	2.8	8.0	30.6	55.6	81.3
Total	**1060**	**34.9**	**1.2**	**6.6**	**22.8**	**49.5**	**81.7**

P: percentile.

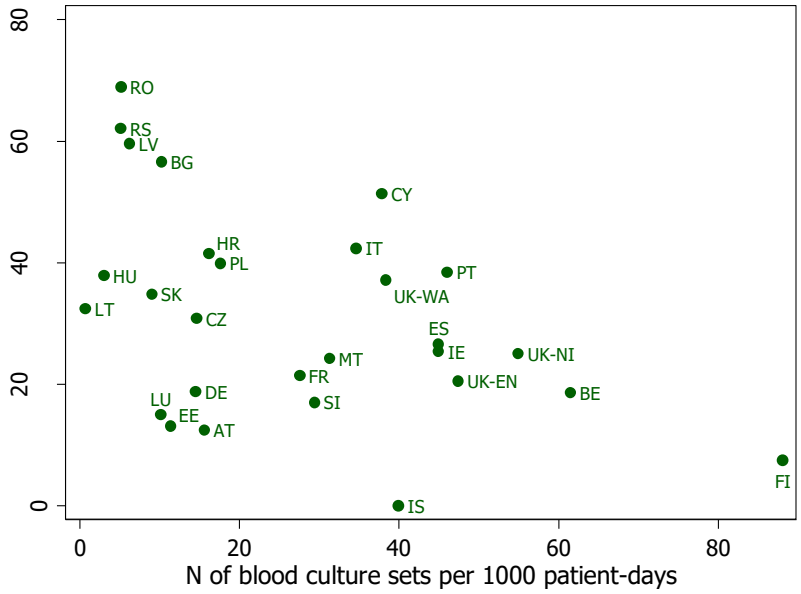
The median number of blood culture sets per 1 000 patient-days was 11.7 when clinical tests were not available during weekends, 15.9 when they were available on only one weekend day and 26.3 when clinical tests were available on both Saturdays and Sundays (p<0.001). The median also increased significantly with increasing staffing levels of IPCN, from 5.3 blood cultures per 1 000 patient-days in hospitals without IPCN to 40.0 in hospitals with at least two IPCN FTE per 250 beds (p<0.001, Figure 85). It was lower in hospitals without IPCD (12.0 per 1 000 patient-days) than in hospitals with an IPCD (25.9 per 1 000 patient-days, p<0.001), but without a trend across IPCD staffing levels above zero FTE, and also after adjustment for hospital size.

Figure 85. Number of blood culture sets per 1 000 patient-days by levels of infection prevention and control nurse FTEs per 250 beds



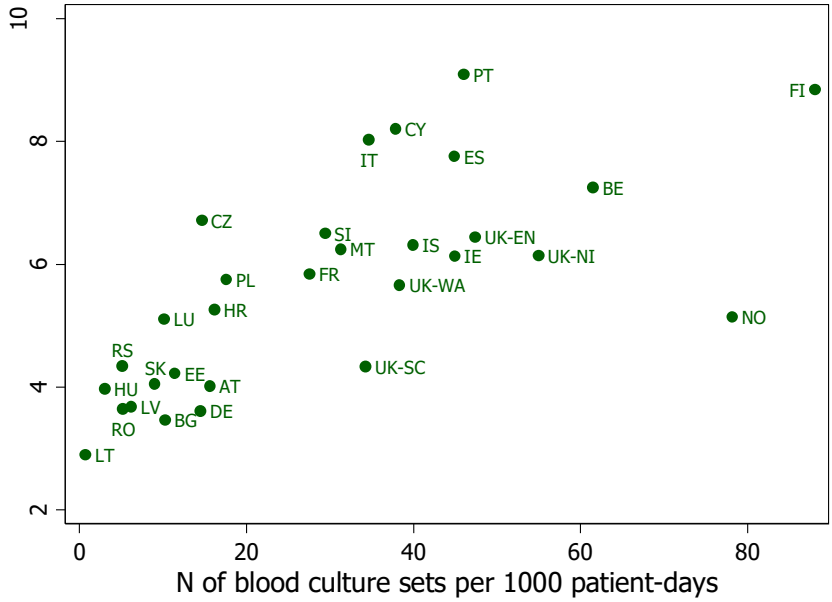
The number of blood culture sets per 1 000 patient-days was negatively correlated with the composite index of AMR at country level (Spearman's rho -0.40, p=0.04; Figure 86). However, it was positively correlated with the prevalence of patients with at least one HAI, both at hospital (Spearman's rho 0.43, p<0.001) and at country level, where the frequency of blood culture testing explained 49% of the inter-country variation of the HAI prevalence (Spearman's rho 0.75, p<0.001; R^2=0.487; Figure 87).

Figure 86. Correlation of the number of blood culture sets per 1 000 patient-days with the composite index of AMR



Spearman's rho -0.40, p=0.04. The number of blood culture sets was reported for the year preceding the survey and was not reported by Greece and the Netherlands.

Figure 87. Correlation of the number of blood culture sets per 1 000 patient-days with the prevalence of patients with at least one HAI



Spearman's rho 0.75, p<0.001. The number of blood cultures was reported for the year preceding the survey and was not reported by Greece and the Netherlands. Norway used a national protocol requiring imputation of non-included types of HAI in 24/43 hospitals (see methods).

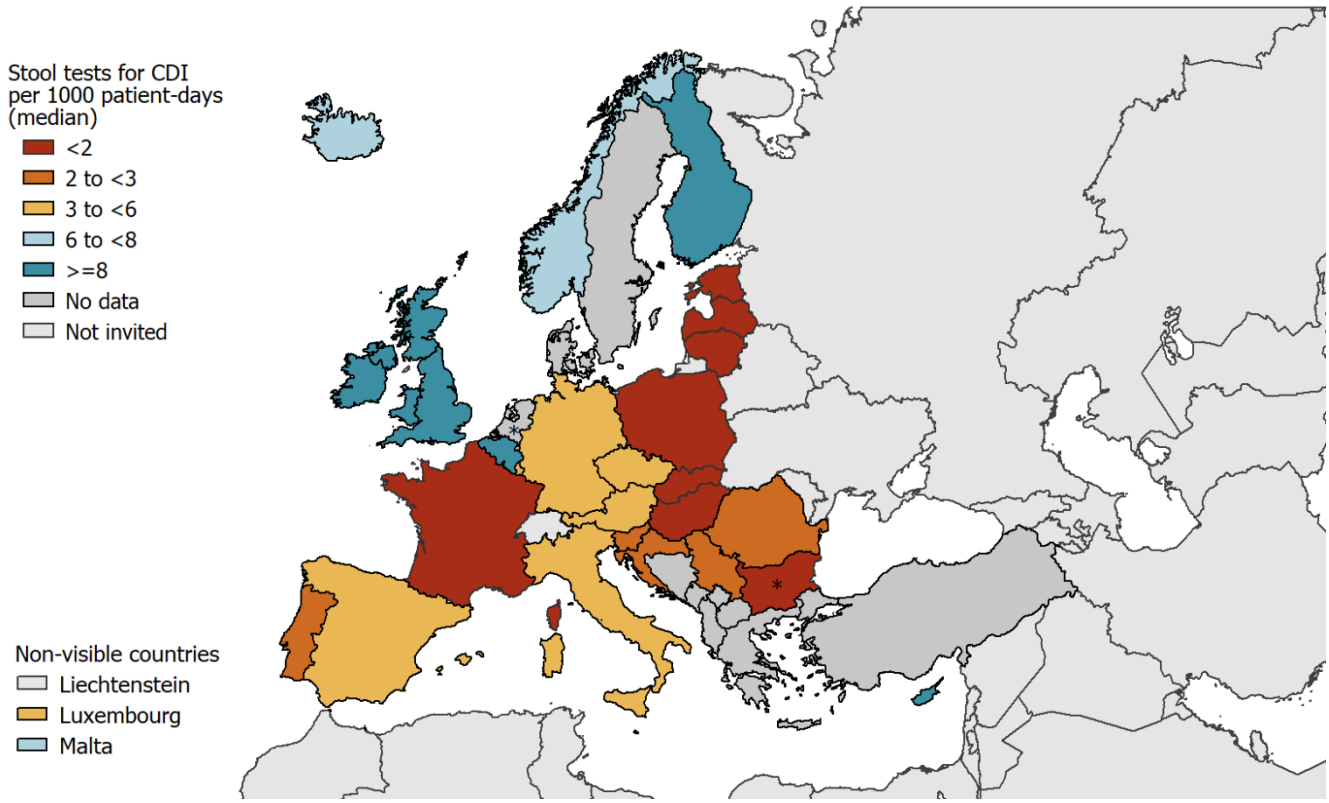
Number of stool tests for diagnosis of *C. difficile* infections per year

The number of inpatient stool tests peformed by the laboratory for the diagnosis of *Clostridioides difficile* infections (CDIs) over a one-year period was provided by 1 036 (86.0%) hospitals from all EU/EEA countries and the UK except Greece and the Netherlands. Four observations were discarded as outliers. In 95% hospitals, data for the year preceding the survey were reported. The median number of stool tests for CDI per 1 000 patient-days was 3.4 (IQR: 1.3–7.7) and varied between 0 in Lithuania and 14.1 in UK-England (Figure 88, Figure 89).

The median number of stool tests for CDI was 2.2 per 1 000 patient-days in hospitals where clinical tests could not be requested at weekends, 3.1 when they could be requested on only one weekend day and 4.5 when clinical tests were available on both Saturdays and Sundays (p<0.001). The median was significantly lower in specialised and primary hospitals (p<0.001,Table 32) and increased significanty with hospital size (p for trend<0.001,Table 33). The number of stool tests for CDI per 1 000 patient-days was correlated with the number of blood culture sets per 1 000 patient-days both at hospital-level (Spearman's rho 0.67, p<0.001) and at country-level (Spearman's rho 0.76, p<0.001) (Figure 90), it was positively correlated with the number of IPCN FTEs per 250 beds (p for trend <0.001) and it was significantly lower in hospitals without IPCD worktime (2.0 stool samples per 1 000 patient-days) than in hospitals with reported IPCD FTEs (3.8 per 1 000 patient-days, p<0.001), again (as for the number of blood cultures) without a trend across IPCD staffing levels above zero FTE.

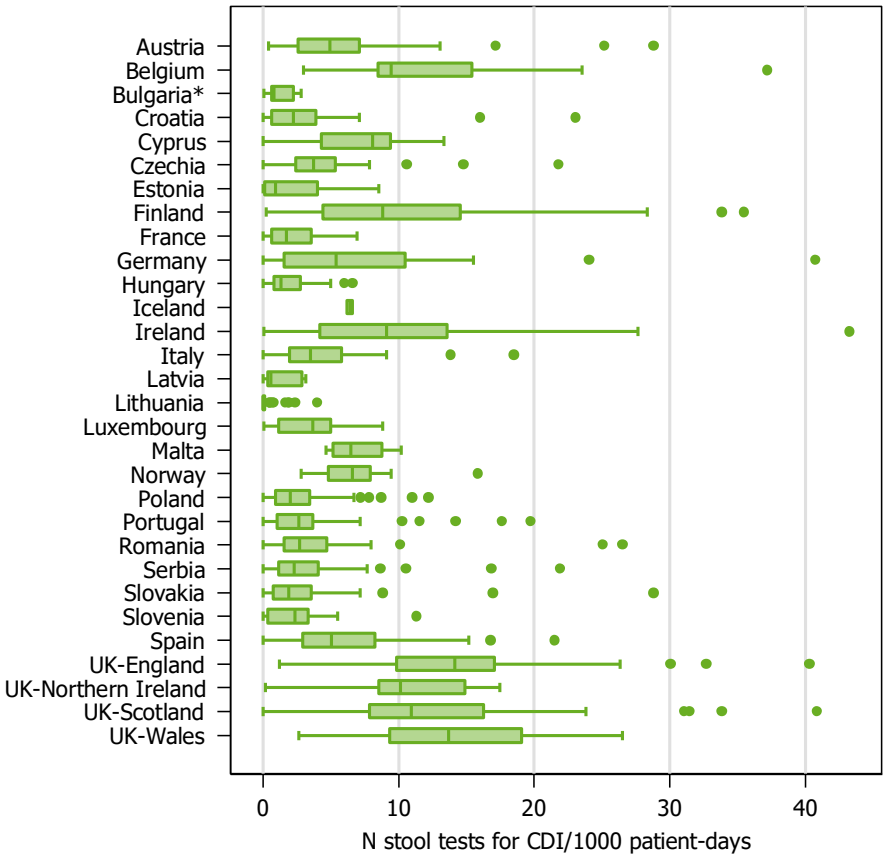
Similar to the number of blood cultures, the number of stool tests for CDI per 1 000 patient-days was associated with the HAI prevalence, both at hospital level (Spearman's rho 0.31, p<0.001) and at country level (Spearman's rho 0.49, p<0.01), but in multivariable analysis with both indicators included, only the number of blood cultures per 1 000 patient-days remained significant. Surprisingly however, at the country-level the number of stool tests for CDI per 1 000 patient-days was not associated with the prevalence of CDI (percentage of patients with CDI) nor with the relative percentage of CDI (CDI as a percentage of all HAIs).

Figure 88. Median number of stool tests for CDI per 1 000 patient-days (n=1 097 hospitals)



**PPS data representativeness was poor in Bulgaria and the Netherlands.*

Figure 89. Number of stool tests for CDI per 1 000 patient-days (n=1 097 hospitals), by country



*The number of cultures was reported for the year preceding the survey and was not reported by Greece and the Netherlands. *Poor data representativeness.*

Table 32. Number of stool tests for CDI diagnosis per 1 000 patient-days by type of hospital

Type of hospital	N of hospitals	Stool tests for CDI diagnosis per 1000 patient-days					
		Mean	P10	P25	P50	P75	P90
Primary	310	4.6	0.0	0.8	2.8	6.6	11.1
Secondary	361	6.2	0.3	1.9	4.0	8.7	14.8
Tertiary	212	6.9	1.3	2.4	4.5	8.8	16.3
Specialised	143	4.3	0.0	0.4	1.5	4.7	12.5
Unknown	6	3.2	0.0	0.0	2.0	4.8	10.1
Total	**1032**	**5.6**	**0.1**	**1.3**	**3.4**	**7.7**	**13.7**

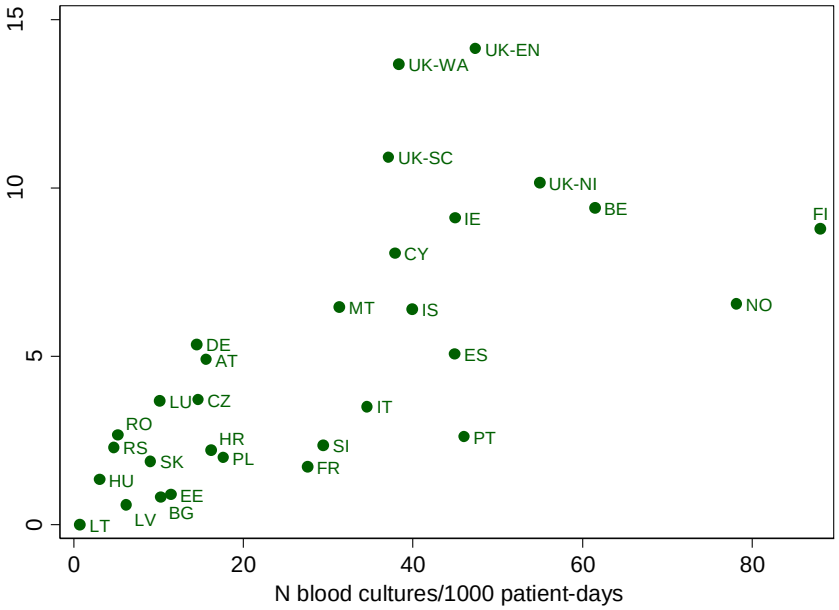
P: percentile.

Table 33. Number of stool tests for CDI diagnosis per 1 000 patient-days by hospital size

N of beds	N of hospitals	Stool tests for CDI diagnosis per 1000 patient-days					
		Mean	P10	P25	P50	P75	P90
<200	393	4.8	0.0	0.4	2.3	6.6	12.5
200-399	277	5.7	0.4	1.6	3.8	7.6	13.7
400-649	183	6.5	0.8	2.0	4.0	8.8	15.5
≥650	179	6.3	0.9	2.2	4.1	7.8	14.1
Total	**1032**	**5.6**	**0.1**	**1.3**	**3.4**	**7.7**	**13.7**

P: percentile.

Figure 90. Microbiology laboratory support: correlation between the annual numbers of stool tests for CDI diagnosis and blood culture sets, per 1 000 patient-days



Spearman's rho 0.76, p<0.001

Core component 2. Infection prevention and control guidelines

The presence of guidelines was collected as part of the multimodal strategies for the prevention of the major types of HAI, both at hospital-wide level and specifically for intensive care units. Hospitals that reported `yes' or `no' to at least one of the questions were included in the denominator, resulting in 777 hospitals with ICU beds for the ICU-specific strategies and 993 hospitals for the hospital-wide strategies. France and Greece did not include the question on multimodal strategies. UK-England only included questions at the hospital-wide level. The presence of guidelines for the prevention of healthcare-associated or device-associated pneumonia, bloodstream infections and urinary tract infections in ICUs was reported by respectively 70.0%, 74.3% and 71.0% hospitals, with 61.4% hospitals reporting guidelines for all three types of infection. The presence of guidelines for the prevention of healthcare-associated or device-associated pneumonia, bloodstream infections, urinary tract infections and surgical site infections at the hospital-wide level was reported by respectively 56.3%, 65.2%, 69.6% and 64.0% hospitals, with 45.8% hospitals reporting guidelines for all four types of infection (Table 34). There was no correlation at country-level between the presence of guidelines and neither the prevalence of HAIs nor the composite index of AMR.

Table 34. Hospitals reporting the presence of guidelines as part of multimodal strategies for the prevention of HAIs

Country	Intensive care units						Hospital-wide						
	N	%	PN	BSI	UTI	All	N	%	PN	BSI	SSI	UTI	All
Austria	38	77.6	76.3	81.6	86.8	71.1	47	95.9	66.0	74.5	76.6	83.0	59.6
Belgium	30	69.8	76.7	80.0	80.0	63.3	30	69.8	53.3	76.7	66.7	83.3	43.3
Bulgaria*	12	100.0	91.7	100.0	100.0	91.7	12	100.0	75.0	83.3	83.3	83.3	75.0
Croatia	30	88.2	90.0	83.3	93.3	83.3	30	88.2	80.0	80.0	70.0	90.0	56.7
Cyprus	6	75.0	83.3	100.0	100.0	83.3	8	100.0	37.5	87.5	87.5	87.5	37.5
Czechia	45	100.0	68.9	77.8	64.4	57.8	45	100.0	53.3	73.3	62.2	62.2	44.4
Estonia	14	60.9	42.9	50.0	28.6	14.3	19	82.6	36.8	52.6	47.4	63.2	26.3
Finland	26	51.0	88.5	92.3	80.8	76.9	48	94.1	64.6	81.3	91.7	91.7	60.4
France	0	0.0	-	-	-	-	0	0.0	-	-	-	-	-
Germany	35	71.4	65.7	65.7	62.9	48.6	49	100.0	49.0	42.9	46.9	57.1	36.7
Greece	0	0.0	-	-	-	-	0	0.0	-	-	-	-	-
Hungary	29	76.3	58.6	65.5	65.5	55.2	38	100.0	47.4	55.3	44.7	57.9	31.6
Iceland	2	100.0	100.0	100.0	100.0	100.0	2	100.0	50.0	100.0	50.0	100.0	50.0
Ireland	36	60.0	52.8	52.8	61.1	33.3	57	95.0	22.8	52.6	47.4	66.7	17.5
Italy	41	73.2	73.2	85.4	87.8	73.2	55	98.2	65.5	87.3	67.3	85.5	56.4
Latvia	13	92.9	38.5	46.2	53.8	38.5	14	100.0	35.7	42.9	50.0	42.9	35.7
Lithuania	54	87.1	48.1	50.0	48.1	40.7	57	91.9	43.9	45.6	49.1	38.6	35.1
Luxembourg	7	58.3	100.0	100.0	100.0	100.0	11	91.7	54.5	63.6	54.5	63.6	45.5
Malta	3	75.0	33.3	66.7	66.7	33.3	4	100.0	25.0	75.0	75.0	75.0	25.0
Netherlands*	19	100.0	10.5	10.5	10.5	10.5	19	100.0	5.3	10.5	0.0	10.5	0.0
Norway	23	53.5	95.7	100.0	100.0	95.7	24	55.8	95.8	100.0	100.0	100.0	95.8
Poland	73	91.3	79.5	84.9	83.6	76.7	79	98.8	75.9	79.7	74.7	82.3	72.2
Portugal	49	52.7	83.7	81.6	85.7	79.6	79	84.9	63.3	73.4	82.3	82.3	55.7

Country	Intensive care units						Hospital-wide						
	N	%	PN	BSI	UTI	All	N	%	PN	BSI	SSI	UTI	All
Romania	37	92.5	86.5	86.5	86.5	83.8	36	90.0	86.1	86.1	83.3	86.1	83.3
Slovakia	39	78.0	53.8	59.0	59.0	53.8	44	88.0	43.2	45.5	45.5	47.7	43.2
Slovenia	16	80.0	37.5	31.3	25.0	25.0	20	100.0	35.0	30.0	30.0	30.0	20.0
Spain	53	55.2	81.1	81.1	43.4	43.4	59	61.5	33.9	47.5	57.6	37.3	16.9
UK-England	0	0.0	-	-	-	-	32	100.0	71.9	18.8	62.5	71.9	15.6
UK-Northern Ireland	11	68.8	90.9	100.0	100.0	90.9	16	100.0	100.0	100.0	93.8	100.0	93.8
UK-Scotland	25	55.6	60.0	88.0	84.0	52.0	45	100.0	55.6	80.0	80.0	82.2	42.2
UK-Wales	11	52.4	81.8	90.9	90.9	81.8	14	66.7	71.4	85.7	21.4	85.7	14.3
EU/EEA	**777**	**64.3**	**70.0**	**74.3**	**71.0**	**61.4**	**993**	**82.1**	**56.3**	**65.2**	**64.0**	**69.6**	**45.8**
Serbia	59	89.4	66.1	71.2	69.5	62.7	64	97.0	62.5	68.8	65.6	71.9	54.7

**PPS data representativeness was poor in Bulgaria and the Netherlands. N and %: number and percentage of hospitals replying at least once 'yes' or 'no' to one of the questions. For questions regarding ICUs, only hospitals with ICU beds were included; PN, BSI, UTI: percentage hospitals reporting guidelines for the prevention of healthcare-associated or device-associated pneumonia, bloodstream infections or urinary tract infections. SSI: percentage hospitals reporting guidelines for the prevention of surgical site infections. All: percentage hospitals reporting guidelines for the prevention of all included types of HAI.*

Core component 3. Infection prevention and control education and training

The presence of education and/or training was collected as part of the multimodal strategies for the prevention of the major types of HAI, both at hospital-wide level and specifically for intensive care units. France and Greece did not include any questions regarding multimodal strategies. UK-England only included questions at the hospital-wide level. The presence of education and training for the prevention of healthcare-associated or device-associated pneumonia, bloodstream infections and urinary tract infections in ICUs was reported by 48.9%, 53.8% and 47.2% of hospitals with ICU beds respectively, with 39.1% hospitals reporting education and/or training for all three types of HAI. The presence of education and/or training for the prevention of healthcare-associated or device-associated pneumonia, bloodstream infections, urinary tract infections and surgical site infections at hospital-wide level was reported by 35.0%, 47.2% and 49.0% and 44.7% hospitals respectively, with 30.4% hospitals reporting education and training for all four types of infection (Table 35). There was no correlation at country level between the reported presence of education and training and neither the prevalence of HAIs nor the composite index of AMR.

Table 35. Hospitals reporting the presence of education and training as part of multimodal strategies for the prevention of HAIs

Country	Intensive care units						Hospital-wide						
	N	%	PN	BSI	UTI	All	N	%	PN	BSI	SSI	UTI	All
Austria	38	77.6	26.3	28.9	21.1	21.1	47	95.9	17.0	23.4	17.0	19.1	12.8
Belgium	30	69.8	36.7	43.3	30.0	20.0	30	69.8	10.0	26.7	20.0	30.0	6.7
Bulgaria*	12	100.0	75.0	75.0	75.0	75.0	12	100.0	75.0	83.3	83.3	75.0	75.0
Croatia	30	88.2	60.0	66.7	73.3	56.7	30	88.2	53.3	66.7	60.0	70.0	50.0
Cyprus	6	75.0	33.3	50.0	50.0	33.3	8	100.0	25.0	50.0	50.0	50.0	25.0
Czechia	45	100.0	26.7	37.8	28.9	24.4	45	100.0	17.8	40.0	24.4	28.9	15.6
Estonia	14	60.9	50.0	50.0	28.6	28.6	19	82.6	42.1	47.4	57.9	52.6	42.1
Finland	26	51.0	76.9	76.9	69.2	65.4	48	94.1	54.2	62.5	79.2	72.9	54.2
France	0	0.0	-	-	-	-	0	0.0	-	-	-	-	-
Germany	35	71.4	28.6	25.7	22.9	14.3	49	100.0	6.1	10.2	18.4	20.4	6.1
Greece	0	0.0	-	-	-	-	0	0.0	-	-	-	-	-
Hungary	29	76.3	41.4	41.4	41.4	37.9	38	100.0	23.7	26.3	23.7	34.2	15.8
Iceland	2	100.0	50.0	50.0	0.0	0.0	2	100.0	0.0	0.0	0.0	0.0	0.0
Ireland	36	60.0	50.0	61.1	55.6	36.1	57	95.0	5.3	47.4	29.8	49.1	5.3
Italy	41	73.2	56.1	65.9	58.5	48.8	55	98.2	52.7	58.2	45.5	58.2	40.0
Latvia	13	92.9	7.7	15.4	15.4	7.7	14	100.0	7.1	21.4	28.6	21.4	7.1
Lithuania	54	87.1	40.7	38.9	33.3	9.3	57	91.9	35.1	40.4	38.6	42.1	33.3
Luxembourg	7	58.3	42.9	71.4	100.0	42.9	11	91.7	27.3	45.5	36.4	81.8	18.2
Malta	3	75.0	66.7	33.3	33.3	33.3	4	100.0	25.0	50.0	50.0	50.0	25.0
Netherlands*	19	100.0	10.5	10.5	10.5	10.5	19	100.0	5.3	5.3	0.0	10.5	0.0
Norway	23	53.5	39.1	56.5	47.8	39.1	24	55.8	29.2	33.3	33.3	41.7	29.2
Poland	73	91.3	56.2	67.1	63.0	53.4	79	98.8	54.4	60.8	63.3	62.0	50.6
Portugal	49	52.7	73.5	73.5	73.5	71.4	79	84.9	44.3	69.6	67.1	72.2	43.0
Romania	37	92.5	64.9	67.6	64.9	64.9	36	90.0	75.0	75.0	69.4	72.2	69.4
Slovakia	39	78.0	53.8	53.8	53.8	53.8	44	88.0	52.3	54.5	54.5	54.5	52.3
Slovenia	16	80.0	25.0	31.3	18.8	18.8	20	100.0	20.0	20.0	25.0	15.0	15.0
Spain	53	55.2	64.2	69.8	39.6	37.7	59	61.5	20.3	49.2	47.5	28.8	13.6
UK-England	0	0.0	-	-	-	-	32	100.0	53.1	53.1	40.6	53.1	37.5
UK-Northern Ireland	11	68.8	27.3	18.2	18.2	18.2	16	100.0	31.3	25.0	43.8	43.8	12.5
UK-Scotland	25	55.6	60.0	68.0	48.0	24.0	45	100.0	31.1	51.1	66.7	68.9	28.9
UK-Wales	11	52.4	90.9	100.0	100.0	90.9	14	66.7	78.6	85.7	21.4	92.9	21.4
EU/EEA	**777**	**64.3**	**48.9**	**53.8**	**47.2**	**39.1**	**993**	**82.1**	**35.0**	**47.2**	**44.7**	**49.0**	**30.4**
Serbia	59	90.8	55.9	61.0	61.0	52.5	65	98.5	43.1	47.7	46.2	49.2	38.5

**PPS data representativeness was poor in Bulgaria and the Netherlands. N and %: number and percentage of hospitals replying at least once `yes' or `no' to one of the questions. For questions regarding ICUs, only hospitals with ICU beds were included.*

Core component 4. Surveillance of HAIs

Activities on surveillance of HAIs were collected through two questions: surveillance as part of the multimodal strategies for the prevention of the major types of HAI and participation of the hospital in surveillance networks during the last year.

Surveillance as part of multimodal strategies

Surveillance as part of multimodal strategies refers to any type of surveillance performed at ICU or hospital-wide level, not necessarily as part of a national or regional surveillance network. The presence of surveillance of healthcare-associated or device-associated pneumonia, bloodstream infections and urinary tract infections in ICUs was reported by respectively 64.2%, 71.9% and 58.3% of hospitals with ICU beds, with 54.3% hospitals reporting surveillance for the three types of HAI. The presence of surveillance of healthcare-associated or device-associated pneumonia, bloodstream infections, surgical site infections and urinary tract infections at hospital-wide level was reported respectively by 40.0%, 62.6% and 61.9% and 48.2% hospitals, with 36.0% hospitals reporting surveillance for all four types of infection (Table 36). There was no correlation at country level between the presence of surveillance as part multimodal strategies and neither the prevalence of HAIs nor the composite index of AMR.

Table 36. Hospitals reporting the presence of surveillance as part of multimodal strategies for the prevention of HAIs

Country	Intensive care units						Hospital-wide						
	N	%	PN	BSI	UTI	All	N	%	PN	BSI	SSI	UTI	All
Austria	38	77.6	71.1	68.4	73.7	65.8	47	95.9	21.3	29.8	80.9	38.3	17.0
Belgium	30	69.8	70.0	83.3	40.0	30.0	30	69.8	16.7	83.3	46.7	40.0	10.0
Bulgaria*	12	100.0	83.3	83.3	83.3	75.0	12	100.0	83.3	83.3	75.0	75.0	75.0
Croatia	30	88.2	70.0	83.3	80.0	70.0	30	88.2	53.3	76.7	66.7	66.7	46.7
Cyprus	6	75.0	33.3	33.3	33.3	33.3	8	100.0	0.0	0.0	12.5	0.0	0.0
Czechia	45	100.0	53.3	66.7	42.2	37.8	45	100.0	33.3	62.2	55.6	40.0	33.3
Estonia	14	60.9	57.1	57.1	28.6	28.6	19	82.6	42.1	57.9	57.9	42.1	42.1
Finland	26	51.0	76.9	80.8	73.1	73.1	48	94.1	77.1	85.4	91.7	70.8	70.8
France	0	0.0	-	-	-	-	0	0.0	-	-	-	-	-
Germany	35	71.4	74.3	71.4	74.3	71.4	49	100.0	24.5	20.4	55.1	30.6	16.3
Greece	0	0.0	-	-	-	-	0	0.0	-	-	-	-	-
Hungary	29	76.3	82.8	86.2	82.8	82.8	38	100.0	57.9	78.9	55.3	63.2	47.4
Iceland	2	100.0	0.0	50.0	0.0	0.0	2	100.0	50.0	50.0	50.0	50.0	50.0
Ireland	36	60.0	36.1	83.3	36.1	22.2	57	95.0	5.3	77.2	54.4	38.6	5.3
Italy	41	73.2	58.5	78.0	53.7	48.8	55	98.2	30.9	49.1	52.7	41.8	29.1
Latvia	13	92.9	0.0	0.0	0.0	0.0	14	100.0	0.0	0.0	7.1	7.1	0.0
Lithuania	54	87.1	40.7	44.4	44.4	40.7	57	91.9	36.8	40.4	43.9	40.4	35.1
Luxembourg	7	58.3	100.0	100.0	71.4	71.4	11	91.7	9.1	18.2	18.2	18.2	0.0
Malta	3	75.0	0.0	33.3	0.0	0.0	4	100.0	0.0	50.0	50.0	0.0	0.0
Netherlands*	19	100.0	5.3	10.5	5.3	5.3	19	100.0	5.3	10.5	0.0	5.3	0.0
Norway	23	53.5	91.3	95.7	91.3	91.3	24	55.8	91.7	95.8	100.0	95.8	91.7
Poland	73	91.3	80.8	80.8	75.3	72.6	79	98.8	72.2	77.2	81.0	75.9	69.6
Portugal	49	52.7	81.6	85.7	79.6	79.6	79	84.9	43.0	79.7	60.8	54.4	35.4
Romania	37	92.5	89.2	91.9	91.9	89.2	36	90.0	83.3	86.1	83.3	86.1	80.6
Slovakia	39	78.0	38.5	38.5	38.5	38.5	44	88.0	38.6	38.6	38.6	38.6	38.6
Slovenia	16	80.0	18.8	31.3	18.8	18.8	20	100.0	15.0	25.0	30.0	20.0	15.0
Spain	53	55.2	77.4	79.2	64.2	64.2	59	61.5	39.0	57.6	71.2	44.1	35.6
UK-England	0	0.0					32	100.0	37.5	100.0	56.3	43.8	21.9
UK-Northern Ireland	11	68.6	36.4	100.0	63.6	18.2	16	100.0	0.0	87.5	87.5	43.8	0.0
UK-Scotland	25	55.6	92.0	96.0	32.0	32.0	45	100.0	35.6	88.9	97.8	44.4	35.6
UK-Wales	11	52.4	90.9	100.0	36.4	27.3	14	66.7	28.6	64.3	50.0	21.4	14.3
EU/EEA	**777**	**64.3**	**64.2**	**71.9**	**58.3**	**54.3**	**993**	**82.1**	**40.0**	**62.6**	**61.9**	**48.2**	**36.0**
Serbia	59	90.8	61.0	66.1	62.7	57.6	65	98.5	50.8	53.8	52.3	52.3	44.6

**PPS data representativeness was poor in Bulgaria and the Netherlands. N and %: number and percentage of hospitals replying at least once `yes' or `no' to one of the questions. For questions regarding ICUs, only hospitals with ICU beds were included.*

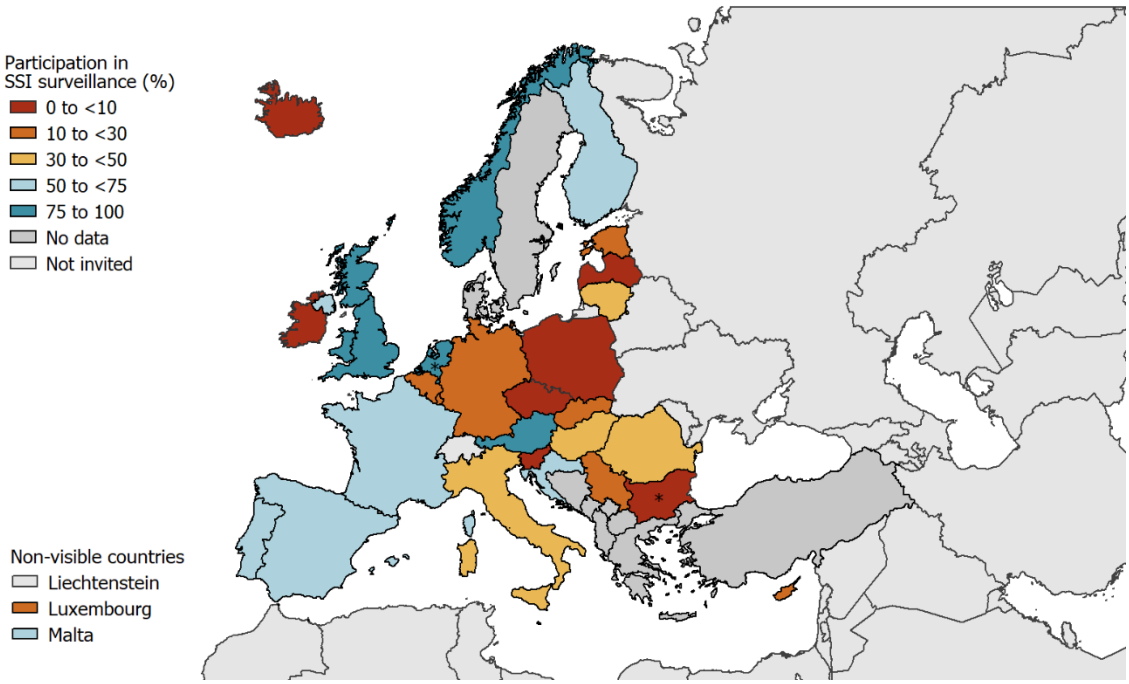
Participation in surveillance networks

Participation in national/regional surveillance networks was collected for four surveillance modules for which an ECDC-coordinated surveillance network is currently in place, surveillance of antimicrobial consumption at hospital level (see antimicrobial stewardship indicators) and participation in other national surveillance networks for HAIs or antimicrobial resistance.

Surveillance of surgical site infections

Participation in a network for surveillance of surgical site infections was reported by 45.0% (n=477/1060) hospitals, and varied between 0% in Iceland, Ireland and Latvia, less than 10% in Bulgaria, Czechia, Poland and Slovenia to 75% or more in Austria, the Netherlands, Norway and three UK administrations (England, Scotland and Wales) (Figure 91). Reporting participation in a SSI surveillance network was associated with reporting surveillance as part of the multimodal strategy to prevent SSIs (OR: 3.8, p<0.001), even though 44.4% of hospitals reporting the latter did not participate in a network and 21.4% of hospitals participating in a network did not report it as part of a multimodal strategy. In 27 (90%) countries, at least one hospital reported participation in a surveillance network and 19 countries of those reported data to ECDC's HAI-Net SSI surveillance network for 2016-2017. In four out of eight countries that did not submit data to HAI-Net SSI, more than 20% of hospitals reported participating in a surveillance network of SSIs (Belgium 26.7%, Croatia 68.8%, Luxembourg 27.3% and Spain 57.7%).

Figure 91. Percentage hospitals reporting participation in a national or regional network for the surveillance of surgical site infections

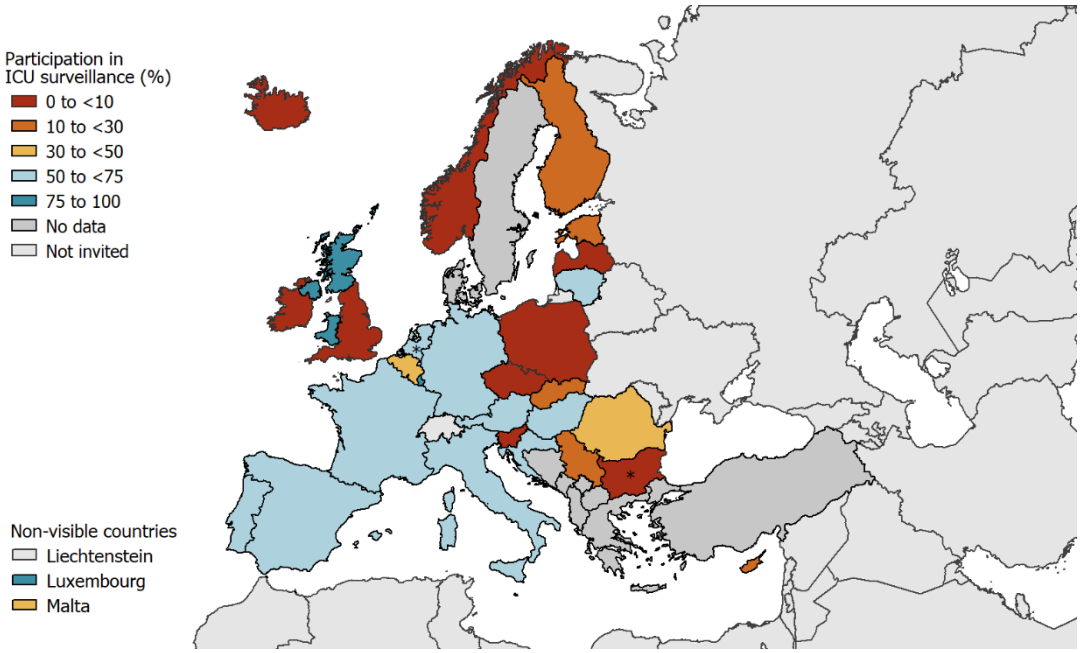


**PPS data representativeness was poor in Bulgaria and the Netherlands.*

Surveillance of HAIs in intensive care units

Participation in a network for surveillance of HAIs in intensive care units (ICUs) was only calculated for hospitals reporting ICU beds, i.e. 834 (78.7%) of 1 060 hospitals reporting data on participation in surveillance networks. Overall, 41.7% (n=348/834) hospitals reported participation in an ICU surveillance network, ranging from 0% in Iceland, Ireland, Norway and UK-England, less than 10% in Bulgaria, Czechia, Latvia, Poland and Slovenia to 75% or more in Luxembourg, UK-Northern Ireland, UK-Scotland and UK-Wales (Figure 92). Reporting participation in an ICU surveillance network was associated with reporting surveillance as part of the multimodal strategy to prevent HAIs in the ICU (OR 2.6, p<0.001), even though 51.8% of hospitals reporting the latter did not participate in an ICU surveillance network network and 15.6% of hospitals participating in a surveillance network did not report surveillance as part of a multimodal strategy. In 26 (86.7%) countries, at least one hospital reported participation in a surveillance network and 16 countries of those reported data to ECDC's HAI-Net ICU surveillance network for 2016-2017. In 5 of 10 countries that did not submit data to HAI-Net ICU, more than 50% of hospitals with ICU beds reported participation in an ICU surveillance network (Croatia 59.4%, Austria 62.5%, the Netherlands 73.7%, UK-Northern Ireland 81.8% and UK-Wales 93.8%).

Figure 92. Percentage hospitals reporting participation in a national or regional network for the surveillance of HAIs in ICUs

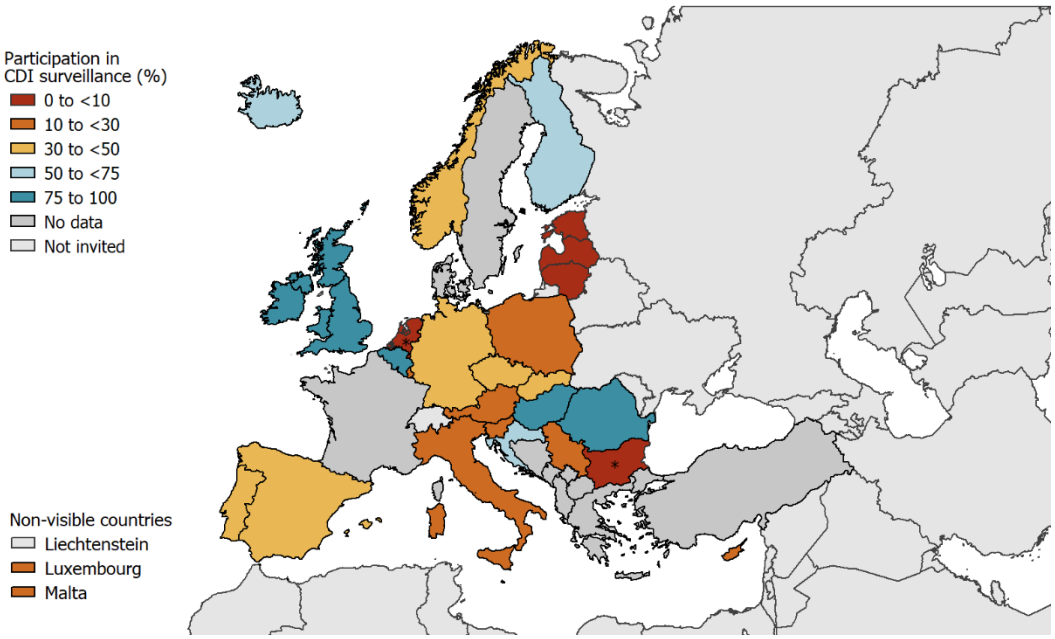


**PPS data representativeness was poor in Bulgaria and the Netherlands.*

Surveillance of C. difficile infections

Participation in a network for surveillance of *C. difficile* infections (CDIs) was reported by 48.2% (n=487/1010) hospitals, and varied between 0% in the Netherlands, less than 10% in Bulgaria, Estonia, Lithuania and Latvia to 75% or more in Belgium, Hungary, Ireland, Romania and all four UK administrations (Figure 93). France did not include this question in the national protocol. In 28 (93.3%) countries, at least one hospital reported participation in a national/regional surveillance network of CDIs and 18 countries of those reported data to ECDC's HAI-Net CDI surveillance network for 2016-2017. In 7 of 10 countries that did not submit data to HAI-Net CDI, more than 20% hospitals reported participation in a surveillance network of CDIs (Germany 36.7%, Iceland 50.0%, Norway 45.8%, Portugal 39.7%, Romania 94.7%, UK-England and UK-Northern Ireland - both with 100%). It should be emphasised however, that some national CDI surveillance networks use methods which are not compatible with HAI-Net CDI hospital-based surveillance (e.g. lab-based surveillance with general population denominators).

Figure 93. Percentage hospitals reporting participation in a national or regional network for the surveillance of CDI



**PPS data representativeness was poor in Bulgaria and the Netherlands.*

Surveillance of antimicrobial resistance and antimicrobial consumption

Participation in a network for surveillance of antimicrobial resistance, specified as surveillance according to the EARS-Net protocol in the ECDC PPS protocol, was reported by 57.2% hospitals (Table 37). Data are difficult to interpret as it was unclear whether the EARS-Net definition was always correctly applied, and whether hospital PPS staff was always aware of participation in the laboratory-based national network contributing to EARS-Net. Participation in a network for surveillance of antimicrobial consumption at hospital level was reported by 49.4% hospitals, varying between 0% in Cyprus, Czechia and Iceland to 100% in Norway, UK-England and UK-Northern Ireland (Table 37).

Table 37. Participation in national/regional networks for the surveillance of HAIs, antimicrobial resistance and antimicrobial consumption

Country	N hosp	SSI %	ICU %	CDI %	AMR %	AMC %	Other %	Mean N of modules	>=1 HAI %
Austria	47	89.4	62.5	14.9	31.9	19.1	21.3	2.3	95.0
Belgium	30	26.7	44.8	80.0	73.3	60.0	46.7	3.3	96.6
Bulgaria*	11	9.1	9.1	9.1	72.7	18.2	63.6	1.8	18.2
Croatia	32	68.8	59.4	68.8	62.5	62.5	15.6	3.4	75.0
Cyprus	7	14.3	20.0	14.3	42.9	0.0	0.0	0.9	60.0
Czechia	45	4.4	4.4	46.7	62.2	0.0	2.2	1.2	46.7
Estonia	21	19.0	20.0	4.8	47.6	9.5	9.5	1.0	26.7
Finland	38	65.8	20.8	60.5	39.5	23.7	50.0	2.5	83.3
France	50	62.0	61.1	-	-	88.0	94.0	-	-
Germany	49	28.6	57.1	36.7	24.5	32.7	55.1	2.2	68.6
Greece	36	-	-	-	-	50.0	-	-	-
Hungary	38	39.5	72.4	97.4	81.6	21.1	100.0	3.9	100.0
Iceland	2	0.0	0.0	50.0	50.0	0.0	50.0	1.5	50.0
Ireland	60	0.0	0.0	88.3	100.0	76.7	0.0	2.7	89.2
Italy	55	43.6	70.7	29.1	56.4	36.4	49.1	2.7	80.5
Latvia	14	0.0	7.7	7.1	7.1	7.1	28.6	0.6	7.7
Lithuania	62	43.5	59.3	6.5	32.3	96.8	100.0	3.3	59.3
Luxembourg	11	27.3	100.0	18.2	81.8	63.6	18.2	2.7	100.0
Malta	4	50.0	33.3	25.0	100.0	25.0	0.0	2.3	66.7
Netherlands*	19	94.7	73.7	0.0	52.6	52.6	0.0	2.7	94.7
Norway	24	100.0	0.0	45.8	100.0	100.0	100.0	4.5	100.0
Poland	67	6.0	9.8	28.4	23.9	6.0	31.3	1.1	34.4
Portugal	78	51.3	61.7	39.7	66.7	48.7	55.1	3.0	80.9
Romania	38	31.6	35.1	94.7	36.8	89.5	13.2	3.0	97.3
Slovakia	46	17.4	11.9	41.3	13.0	8.7	8.7	1.0	16.9
Slovenia	20	5.0	11.9	15.0	85.0	60.0	10.0	1.8	47.6
Spain	78	57.7	6.3	37.2	47.4	38.5	30.8	2.6	25.0
UK-England	32	100.0	63.1	100.0	100.0	100.0	100.0	5.0	76.9
UK-Northern Ireland	16	68.8	0.0	100.0	100.0	100.0	100.0	5.3	100.0
UK-Scotland	45	93.3	81.8	86.7	86.7	86.7	86.7	4.9	100.0
UK-Wales	21	90.5	96.0	90.5	81.0	81.0	4.8	4.2	100.0
EU/EEA	**1096**	**45.0**	**41.7**	**45.9**	**57.2**	**49.4**	**45.6**	**2.7**	**73.0**
Serbia	63	11.1	11.9	15.9	27.0	11.1	100.0	1.8	16.9

**PPS data representativeness was poor in Bulgaria and the Netherlands. N hosp: number of hospitals responding at least once `yes' or `no' for any of the surveillance networks; SSI: surveillance of surgical site infections; ICU: surveillance of HAIs in intensive care units; CDI: surveillance of C. difficile infections; AMR: surveillance of antimicrobial resistance in accordance with the EARS-Net protocol (surveillance of antimicrobial resistance in invasive isolates of S. pneumoniae, S. aureus, Enterococcus spp., E. coli, K. pneumoniae, P. aeruginosa and/or A. baumannii); AMC: surveillance of antimicrobial consumption in the hospital (surveillance at 5th ATC level in defined daily dose (DDD) per 1000 patient-days); Other: other HAI or AMR surveillance modules (national/regional protocols for which a European/ECDC protocol does not exist). Mean N of modules: mean number of surveillance modules implemented by hospital (maximum=6); >=1 HAI %: percentage hospitals reporting participation in at least one of SSI, ICU or CDI surveillance networks.*

Participation in other surveillance networks

Almost half (45.1%) of the hospitals reported participation in at least one other national/regional surveillance network (Table 37). The most frequently reported other surveillance modules were surveillance of one or more multidrug-resistant bacteria (30.8%), hospital-wide surveillance of bloodstream infections (21.8%) participation in repeated national PPSs (21.5%) and surveillance of alcohol-based handrub consumption (13.6%) (Table 38). These results should also be interpreted with caution because the interpretation of `other surveillance network' was not done in a uniform manner (e.g. repeated annual PPSs was not reported in the Netherlands, surveillance of alcohol-based handrub consumption was not reported in Ireland).

Table 38. Number of hospitals reporting participation in other national/regional surveillance networks

Country	>=1 other network	MDRO	BSI	Hand Hygiene	PPS	NICU	HAI	Other	NoS
Austria	10	3	0	4	0	2	2	2	0
Belgium	14	5	9	0	0	0	0	1	0
Bulgaria*	7	0	0	1	0	0	2	2	2
Croatia	5	0	0	1	0	0	1	3	1
Czechia	1	0	0	0	0	1	0	0	0
Estonia	2	0	0	0	2	0	0	0	0
Finland	19	1	16	1	0	0	0	1	0
France	47	45	0	0	0	0	0	21	47
Germany	27	13	0	15	1	3	1	1	0
Hungary	38	38	2	38	0	2	0	0	0
Iceland	1	1	0	0	0	0	0	0	0
Italy	27	15	0	0	4	0	0	6	2
Latvia	4	0	0	0	0	0	0	4	0
Lithuania	62	0	0	0	62	0	0	0	0
Luxembourg	2	2	0	0	0	0	0	0	0
Norway	24	0	0	0	24	0	0	0	0
Poland	21	2	0	4	8	1	0	6	0
Portugal	43	3	36	1	0	1	0	11	0
Romania	5	3	0	0	0	0	0	2	0
Slovakia	4	0	0	0	2	0	0	2	0
Slovenia	2	0	0	0	0	0	0	0	2
Spain	24	0	0	0	0	0	0	0	24
UK-England	32	0	0	0	0	0	0	0	32
UK-Northern Ireland	16	16	0	0	0	0	0	0	0
UK-Scotland	39	0	39	0	0	0	0	0	0
UK-Wales	2	0	2	0	0	0	0	0	0
EU/EEA	**478**	**147**	**104**	**65**	**103**	**10**	**6**	**62**	**110**
Serbia	63	0	0	0	0	0	62	1	0

**PPS data representativeness was poor in Bulgaria. >= 1 other network: number of hospitals reporting participation in at least one other national/regional surveillance network; MDRO: surveillance of one or more multidrug-resistant bacteria; BSI: hospital-wide surveillance of bloodstream infections (for specific microorganisms in UK-Scotland and UK-Wales, all microorganisms for other countries); Hand hygiene: surveillance of alcohol-based handrub consumption and/or hand hygiene compliance; PPS: HAI point prevalence survey; NICU: surveillance of HAIs in neonatal intensive care units; HAI: national HAI surveillance system, all HAIs or unspecified types of HAI; Other: other surveillance networks/modules; NoS: not specified.*

Despite these interpretation issues, the average EU/EEA hospital reported participation in 2.7 different surveillance modules, and 73.0% hospitals participated in at least one national network covering the same targets as ECDC's HAI-Net surveillance modules (SSI, ICU and/or CDI) (Table 37).

In univariate analysis at country-level, there was no association between the percentage of hospitals participating in any of the HAI surveillance networks and neither the prevalence of HAIs nor the composite index of AMR.

Core component 5. Multimodal strategies for implementation of infection prevention and control interventions

The presence of seven elements of multimodal prevention strategies were collected in the PPS protocol. Guidelines were the most frequently reported element, both in the ICU as at the hospital-wide level. The presence of checklists and audits of practices were the least frequently reported elements (Figure 94). Prevention of bloodstream infections (healthcare-associated and/or device-associated) was the most targeted type of HAI for prevention strategies, both in the ICU as at the hospital-wide level (Figure 95).

Figure 94. Number of HAI prevention targets by multimodal strategy element in ICU (left) and at hospital-wide level (right) (country mean)

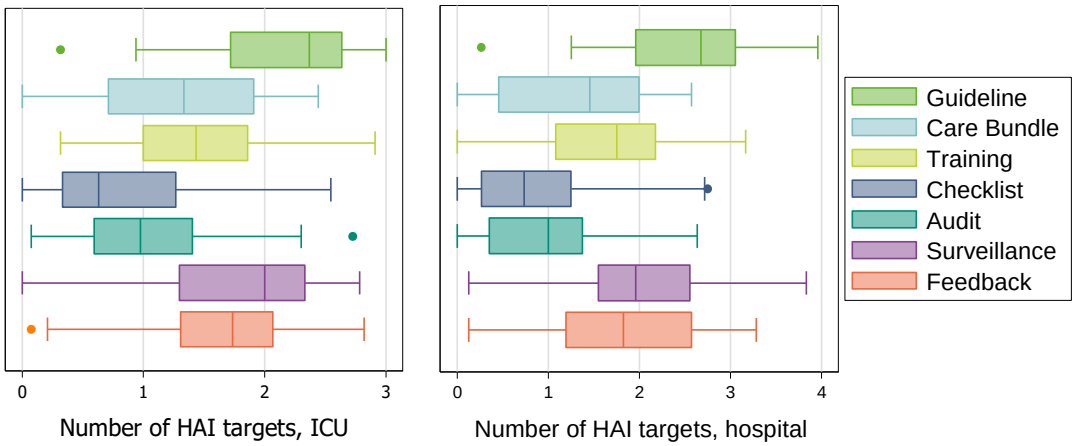
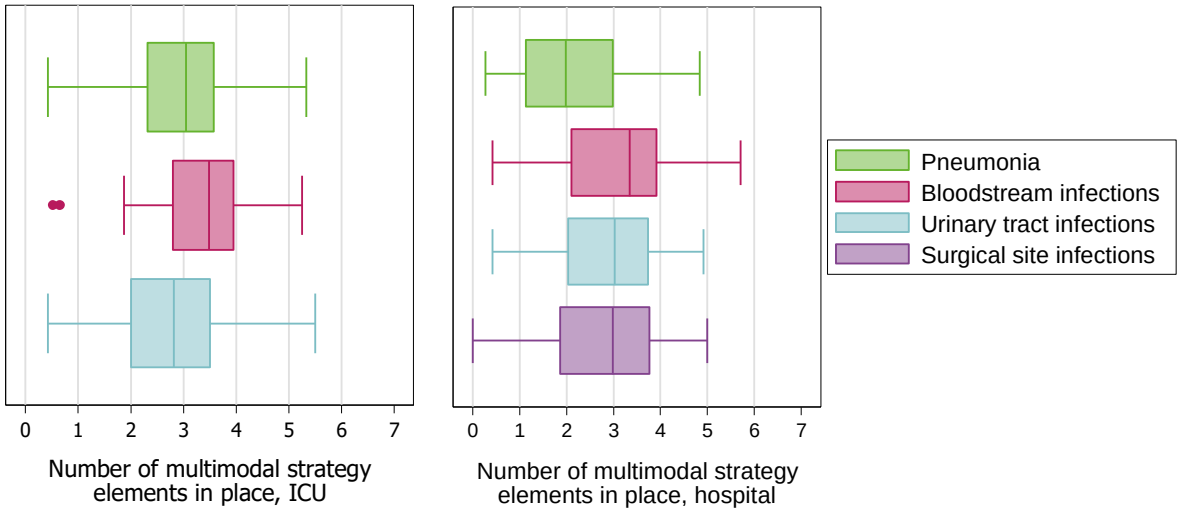
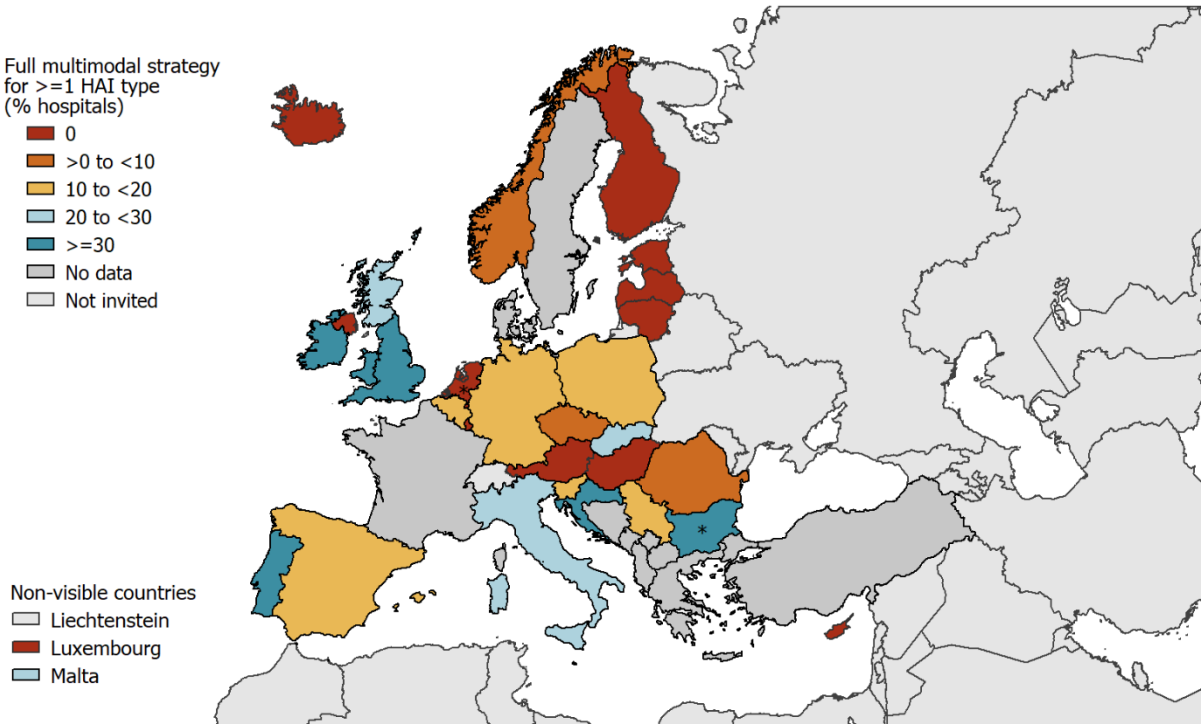


Figure 95. Number of reported multimodal strategy elements by HAI prevention target in ICU (left) and at hospital-wide level (right) (country mean)



The percentage of hospitals reporting all elements of the multimodal strategy for at least one type of HAI (pneumonia, bloodstream infections, urinary tract infections or surgical site infections) at hospital-wide level was 15.0% (n=149/993), ranging from 0% in 12 countries to 42.9% in UK-Wales and 50% in Bulgaria (Figure 96). In the ICU, the percentage of hospitals reporting all elements of the multimodal strategy for at least pneumonia, bloodstream infections or urinary tract infections was 18.9% (n=147/777), varying between 0% in 9 countries to more than 50% in Bulgaria and UK-Wales.

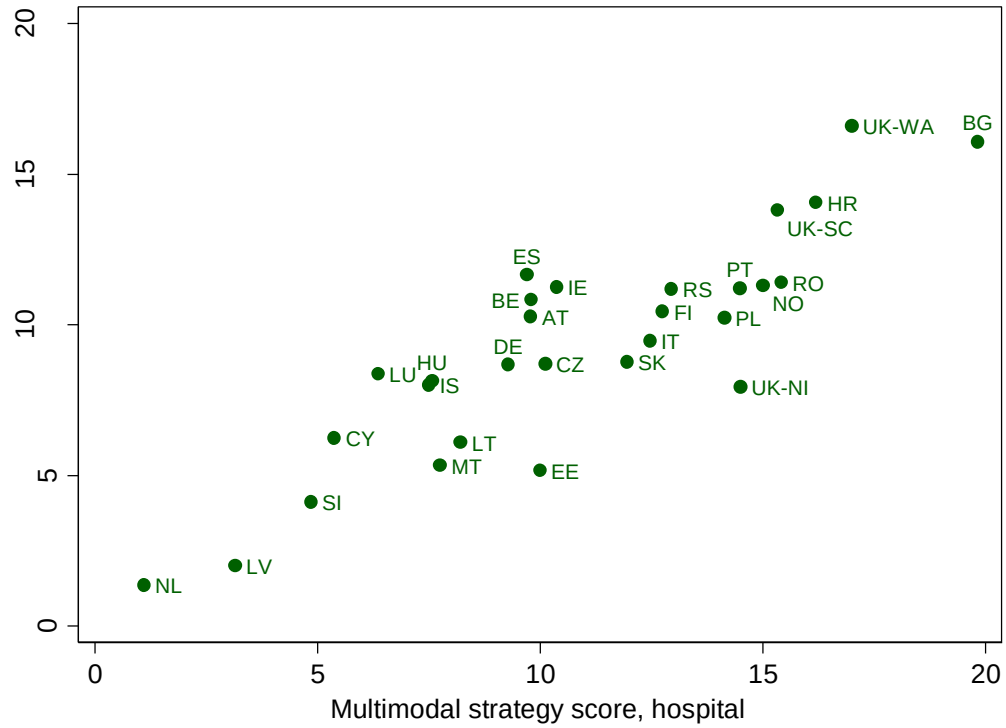
Figure 96. Percentage hospitals reporting all elements of a multimodal strategy for at least one type of HAI



**PPS data representativeness was poor in Bulgaria and the Netherlands.*

There was a strong correlation between reporting multimodal strategy elements for the hospital-wide level and reporting multimodal strategy elements for intensive care units, both at hospital-level (Spearman's rho 0.67, p<0.001) and at country-level (Spearman's rho 0.84, p<0.001,Figure 97).

Figure 97. Mean number of multimodal strategy elements reported for HAI prevention, ICU (max=21) *vs* hospital-wide (max=28)



Spearman's rho 0.84, p<0.001

In the univariate analysis at country level (Spearman correlation), there was no association between any of the multimodal strategy sub-scores and HAI prevalence. The composite index of AMR was positively correlated at the p<0.05 level with the multimodal strategy sub-scores (higher AMR levels for higher scores) for 1) the prevention of pneumonia and BSI at hospital level; 2) the prevention of UTIs in intensive care units; 3) the scores for training and checklists at hospital level; 4) the training score at ICU level and 5) the percentage of hospitals with complete multimodal strategy for at least one HAI at hospital level. However, none of these associations remained statistically significant after Bonferroni correction.

Core component 6. Monitoring/audit of IPC practices and feedback

Alcohol-based handrub (AHR) consumption

Alcohol-based handrub consumption data at hospital level were provided by 1 148 hospitals from 31 countries, of which 622 hospitals of 19 countries also provided data at ward level. Data from seven hospitals were discarded as outliers. Data were provided for the year preceding the survey by 95.3% hospitals. The median alcohol-based handrub consumption was 20.3 litres per 1000 patient-days (IQR: 11.6-34.6) and was significantly lower in primary hospitals than in tertiary hospitals (p<0.001,Table 39).

Table 39. Alcohol-based handrub consumption (litres per 1 000 patient-days) by type of hospital

Type of hospital	N of hospitals	Alcohol-based hand rub consumption (litres per 1000 patient-days)					
		Mean	P10	P25	P50	P75	P90
Primary	343	23.2	5.1	10.0	17.5	31.8	49.0
Secondary	393	26.8	6.3	11.6	20.0	34.7	58.9
Tertiary	238	30.9	7.4	14.0	24.4	38.3	64.1
Specialised	161	27.2	5.0	12.1	22.2	34.8	53.4
Unknown	6	29.0	5.5	19.1	22.8	45.1	58.4
Total	1 141	26.7	5.9	11.6	20.3	34.6	56.2

P: percentile.

At ward specialty level, the median consumption ranged from 4.0 L/1 000 patient-days (IQR: 2.2-7.2) in psychiatry wards to 59.1 L/1 000 patient-days (IQR: 34.1-89.1) in intensive care units (Figure 98).

The median hospital AHR consumption varied greatly between countries, from less than 10 L/1 000 patient-days in Bulgaria, Hungary, Latvia, Lithuania and Italy to more than 50 L/1 000 patient-days in Greece, Malta, Norway and Slovenia (Figure 99, Figure 100).

Figure 98. Alcohol-based handrub consumption (litres per 1 000 patient-days) by ward specialty

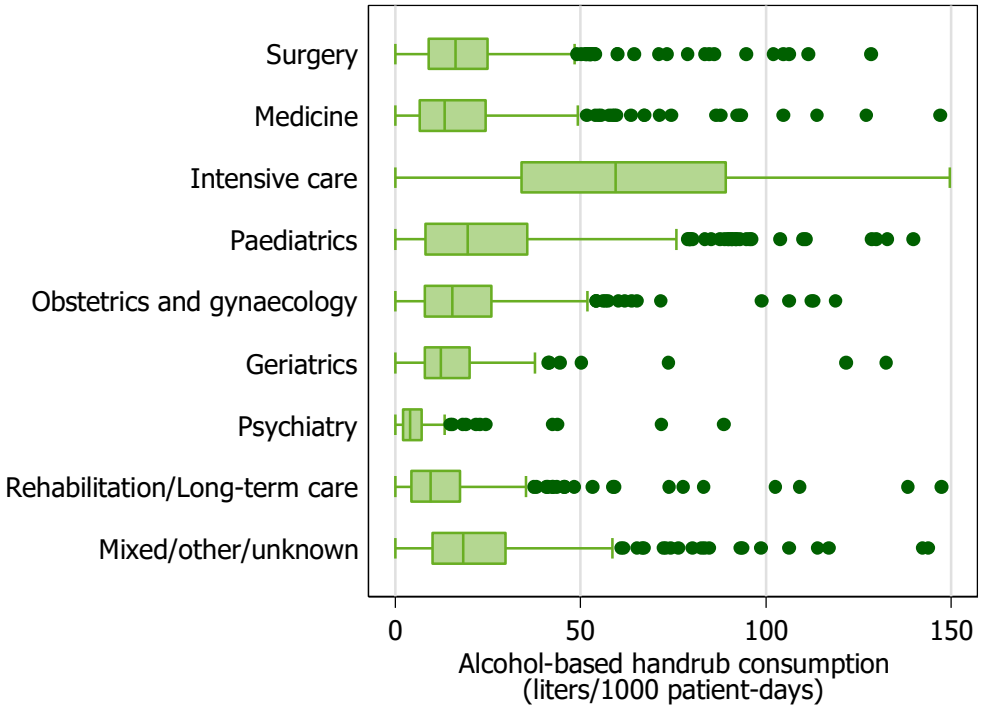
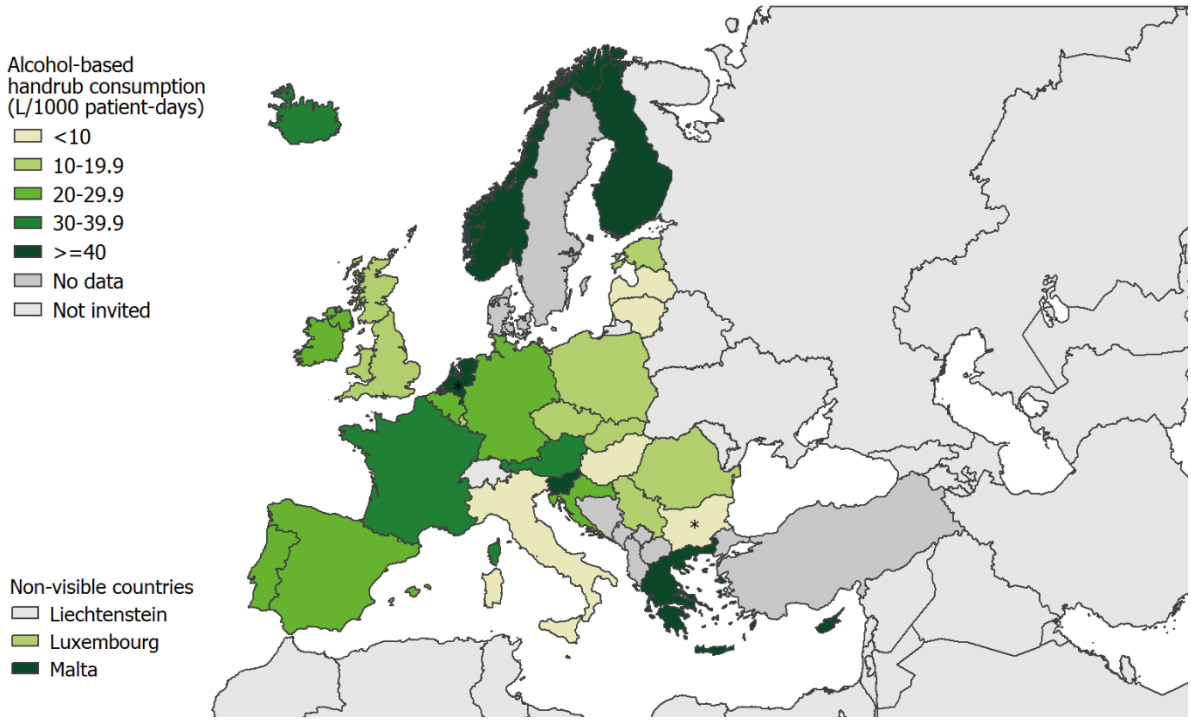
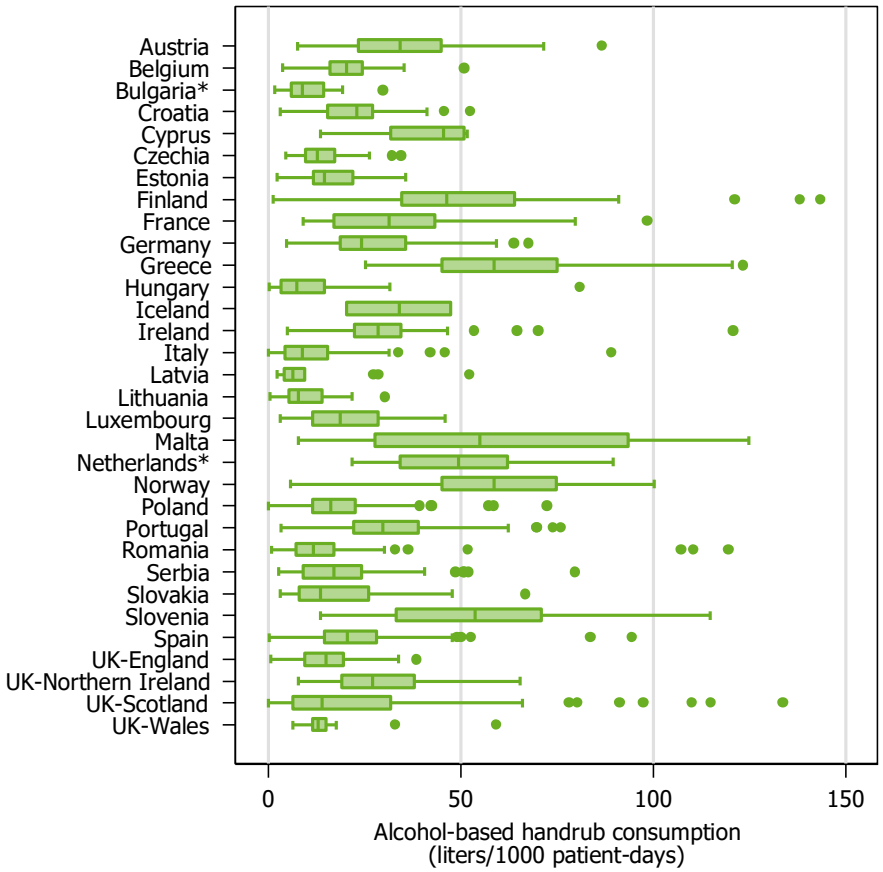


Figure 99. Median alcohol-based handrub consumption (litres per 1 000 patient-days)



**PPS data representativeness was poor in Bulgaria and the Netherlands.*

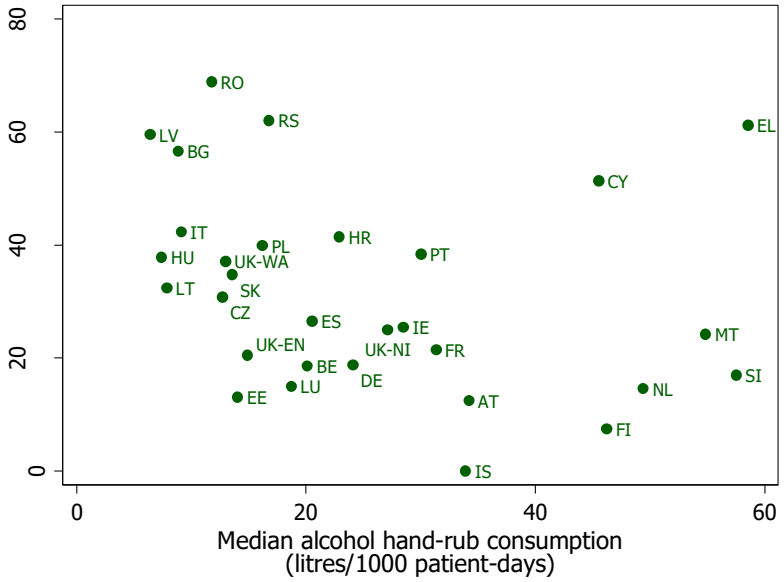
Figure 100. Alcohol-based handrub consumption (litres per 1 000 patient-days) by country



**PPS data representativeness was poor in Bulgaria and the Netherlands. Red vertical line=median.*

The median alcohol-based handrub consumption at country level was negatively correlated with the composite index of AMR (Spearman's rho -0.43, p<0.05), with two countries (Cyprus and Greece) being outliers in the correlation (Figure 101). When excluding outliers (Cyprus and Greece), the Spearman's correlation coefficient rho was -0.65 (p<0.001).

Figure 101. Correlation between the median alcohol-based handrub consumption and the composite index of AMR



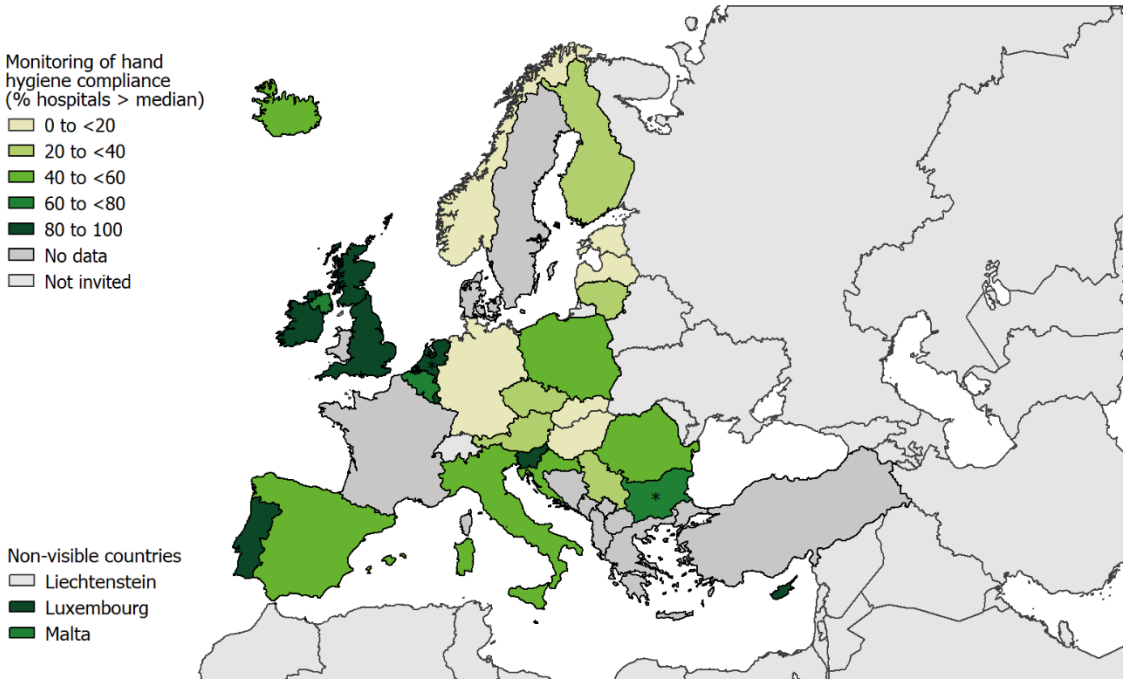
Spearman's rho -0.43, p<0.05

The median alcohol-based handrub consumption at country level was strongly associated with the number of blood cultures per 1 000 patient-days (Spearman's rho 0.60, p<001). There was also a positive correlation between the median alcohol-based handrub consumption and the HAI prevalence (Spearman's rho 0.46, p<0.01), but this association did not remain significant after adjustment for the number of blood cultures per 1 000 patient-days.

Number of observed hand hygiene opportunities

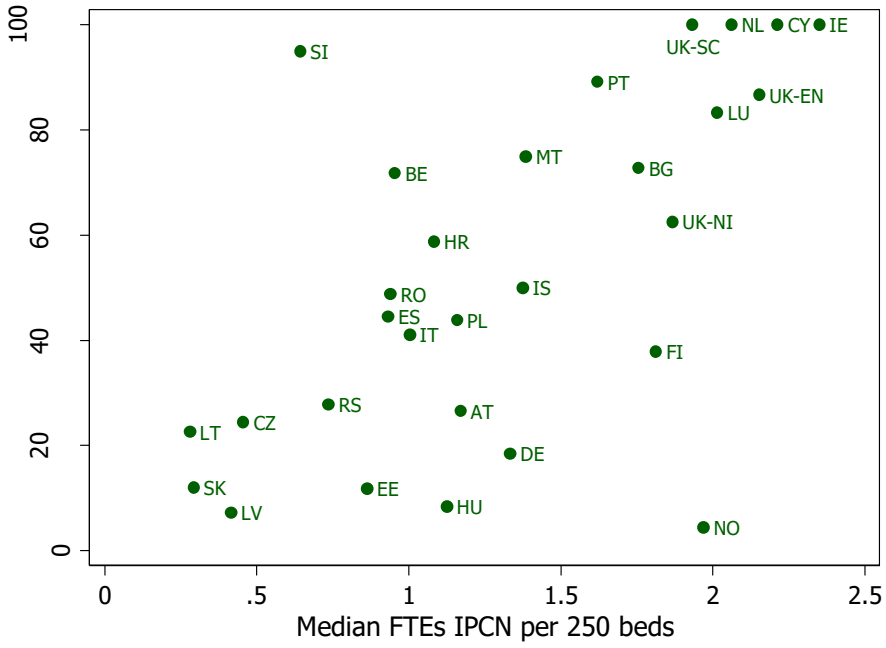
The number of observations of hand hygiene compliance performed during the most recent year was collected as a second indicator of hand hygiene monitoring. One thousand hospitals replied to the question (944 at hospital level and 643 at ward level), five of which were discarded as outliers, leaving 995 hospitals for analysis. The median number of observed hand hygiene opportunities in the previous year was 2.8 opportunities per 1 000 patient-days (IQR 0-22.8), with 31.0% hospitals not reporting any opportunity observation and 4.2% hospitals reporting more than 100 opportunities per 1 000 patient-days, mainly in Bulgaria, Cyprus, Ireland, Portugal and United Kingdom. Results by country are reported as the percentage of hospitals with a number of observed hand hygiene opportunities per 1 000 patient-days above the median. The percentage of hospitals with above median compliance monitoring varied from less than 10% in Norway, Latvia and Hungary to 100% in Cyprus, Ireland, the Netherlands and UK-Scotland (Figure 102). The median alcohol-based handrub consumption was 22.9 litres per 1 000 patient-days in hospitals with above median compliance monitoring and 16.0 litres per 1 000 patient-days in hospitals with below median compliance monitoring (p<0.001). At country-level, this indicator was associated with the number of FTEs IPCN per 250 beds (Spearman's rho 0.60, p<0.001, Figure 103) and with the number of blood cultures per 1 000 patient-days (Spearman's rho 0.42, p<0.05), but neither with the composite index of AMR nor with the HAI prevalence.

Figure 102. Percentage of hospitals with a number of observed hand hygiene opportunities above the median



**PPS data representativeness was poor in Bulgaria and the Netherlands.*

Figure 103. Correlation between the percentage of hospitals with a number of observed hand hygiene opportunities above the median and the median number of infection prevention and control nurse FTEs per 250 beds



Spearman's rho 0.60, p<0.001

Core component 7. Workload, staffing and bed occupancy

Staffing levels were evaluated by the number of registered nurses and nursing assistants employed by the hospital at hospital level and separately for intensive care units. Hospitals were asked to provide the situation at the time of the PPS or the situation for the earliest available year.

Staffing levels for registered nurses

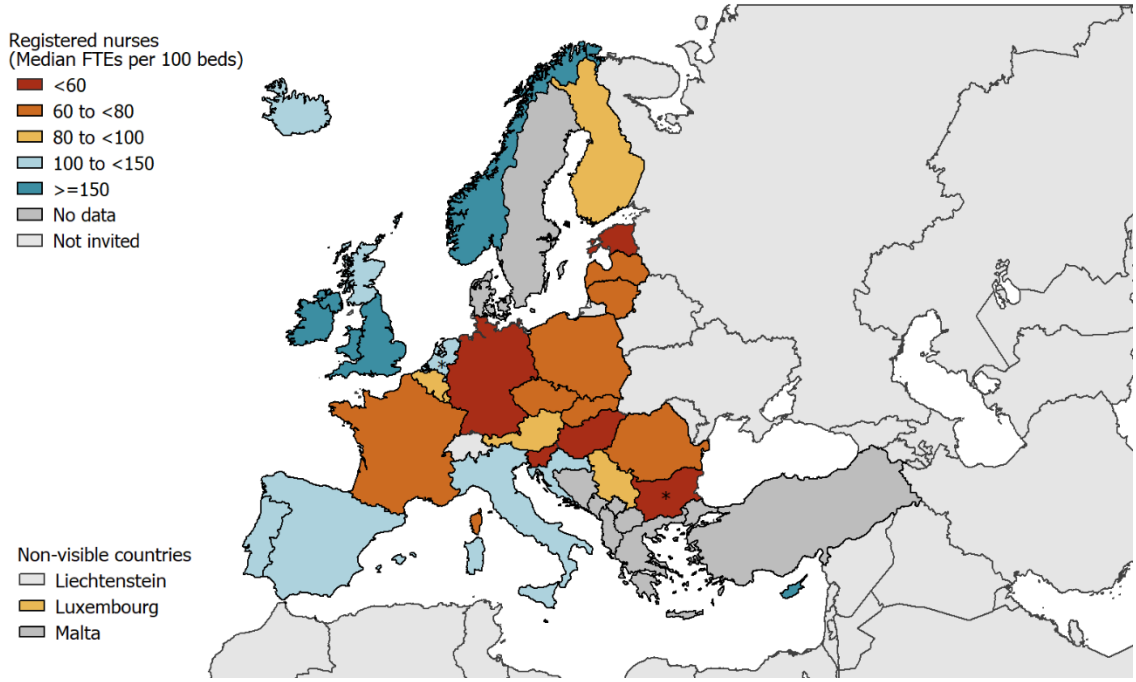
The number of registered nurse full-time equivalent (FTEs) for the entire hospital was reported by 1 074 hospitals, seven of which were discarded as outliers. The median was 86.2 registered nurse FTEs per 100 hospital beds and was significantly higher in secondary and tertiary hospitals than in primary hospitals (Table 40). The median varied between 37.7 FTEs per 100 hospital beds in Hungary and 212.0 in UK-Northern Ireland (Figure 104).

The number of registered nurse FTEs in intensive care units was reported by 816 hospitals, three of which were discarded as outliers. The median was 240.7 registered nurse FTEs per 100 ICU beds and varied between 122.3 in Slovakia and 616.3 in UK-Scotland (Figure 105).

Table 40. Distribution of the number of registered nurse FTEs per 100 hospital beds by type of hospital

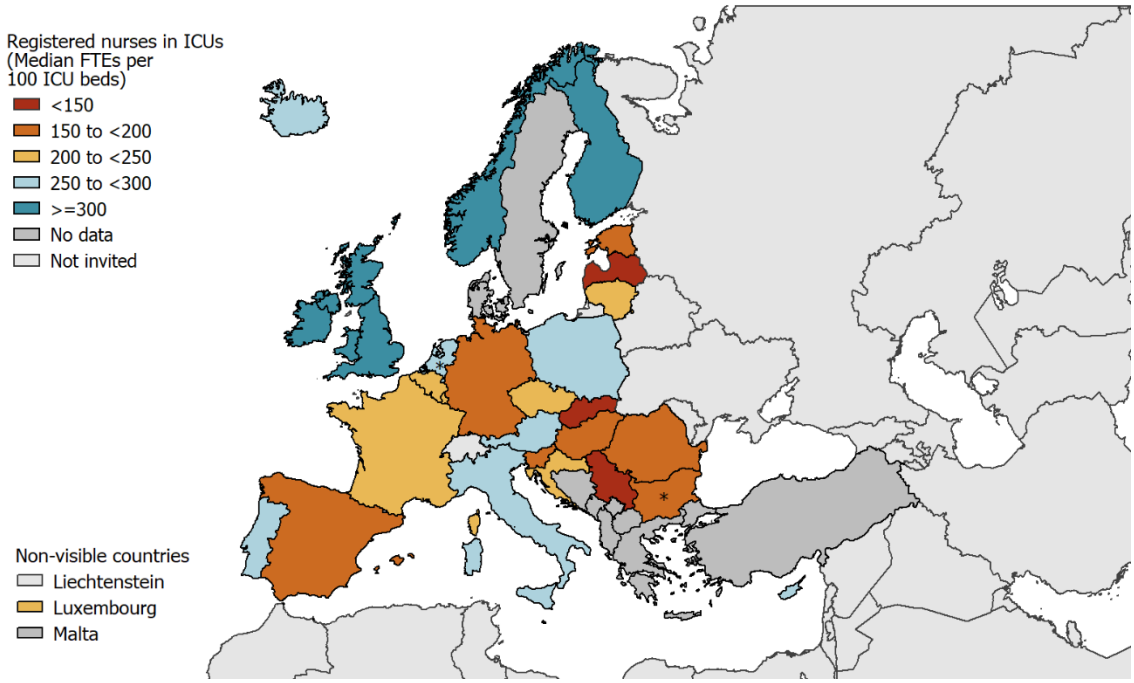
Type of hospital	N of hospitals	Registered nurse FTEs per 100 hospital beds					
		Mean	P10	P25	P50	P75	P90
Primary	332	84.5	31.8	49.6	75.1	106.6	152.2
Secondary	364	103.1	41.4	59.4	88.4	144.1	185.4
Tertiary	217	123.2	52.6	78.3	113.1	154.8	203.4
Specialised	150	105.7	32.5	48.7	80.9	141.0	215.0
Unknown	4	95.5	7.1	31.3	84.9	159.7	205.3
Total	**1 067**	**101.7**	**37.5**	**56.2**	**86.2**	**132.5**	**187.4**

Figure 104. Median number of registered nurse FTEs per 100 hospital beds



**PPS data representativeness was poor in Bulgaria and the Netherlands.*

Figure 105. Median number of registered nurse FTEs per 100 ICU beds



**PPS data representativeness was poor in Bulgaria and the Netherlands.*

Staffing levels for nursing assistants

The number of nursing assistant FTE for the entire hospital was reported by 1 046 hospitals, seven of which were discarded as outliers. The median number of nursing assistant FTE was 20.4 FTE nursing assistants per 100 hospital beds. Variations of the median according to the type of hospital were less important than for registered nurses (Table 41), with statistical significance depending on the statistical method used. The median varied between 0 FTE per 100 hospital beds in Croatia and Serbia and 89.5 in Portugal (Figure 106).

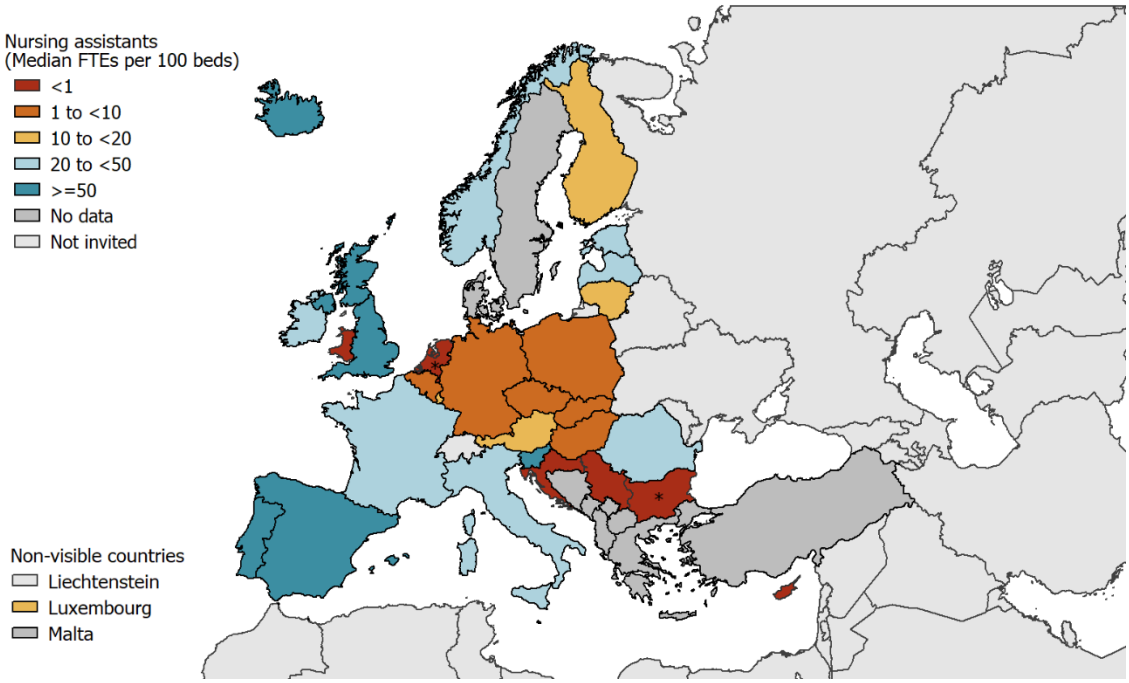
The number of nursing assistants FTE in intensive care units was reported by 802 hospitals, three of which were discarded as outlier. The median was 22.9 FTE nursing assistants per 100 ICU beds and varied between 0 in ten countries and 112.9 in France (Figure 107).

Table 41. Number of nursing assistant FTEs per 100 hospital beds by type of hospital

Type of hospital	N of hospitals	Nursing assistant FTEs per 100 hospital beds					
		Mean	P10	P25	P50	P75	P90
Primary	322	27.1	1.1	5.5	15.4	37.5	66.4
Secondary	348	37.3	2.3	7.1	23.0	58.0	89.6
Tertiary	215	40.2	0.6	6.3	25.7	64.6	99.7
Specialised	150	29.7	0.2	4.8	17.8	38.1	65.9
Unknown	4	32.1	0.0	2.3	29.7	62.0	69.2
Total	**1 039**	**33.6**	**1.3**	**6.3**	**20.4**	**49.8**	**84.5**

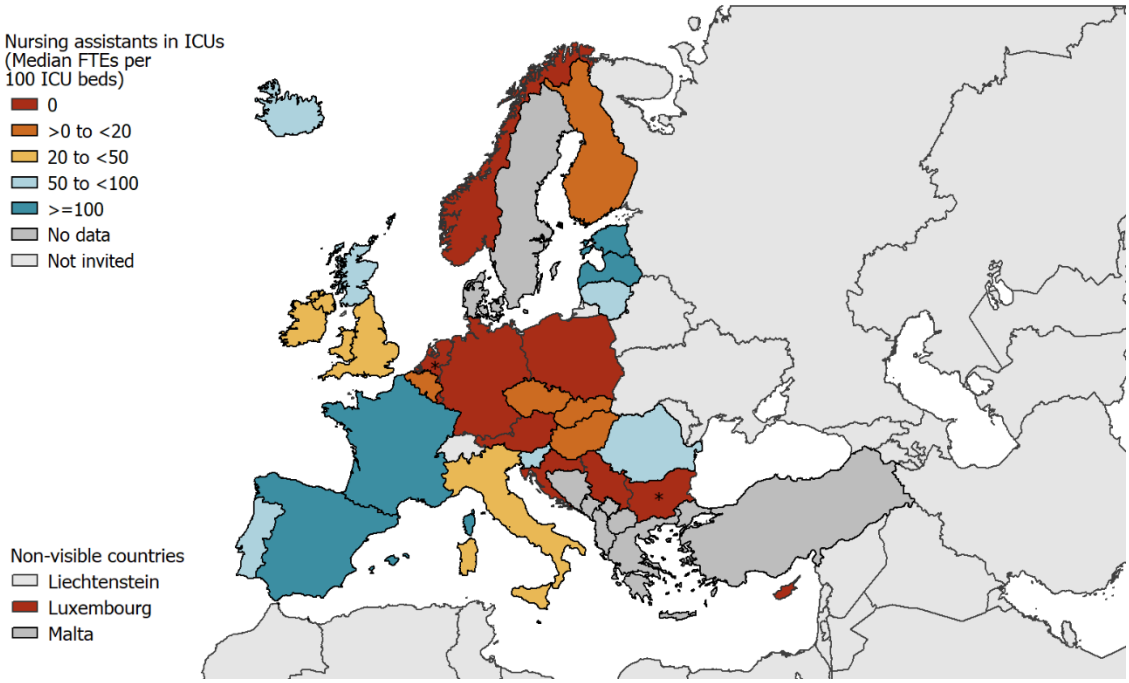
When combining the registered nurse FTEs and nursing assistant FTEs, the median was 108.5 FTEs nurses per 100 hospital beds (just over one nurse FTE per bed), ranging from 43.7 in Hungary to 270.6 in UK-England (Figure 108). In intensive care units, the median was 284.3 nurses per 100 ICU beds and ranged from 137.0 in Slovakia to more than 500 in Ireland and UK-Scotland (Figure 109).

Figure 106. Median number of nursing assistant FTEs per 100 hospital beds



**PPS data representativeness was poor in Bulgaria and the Netherlands.*

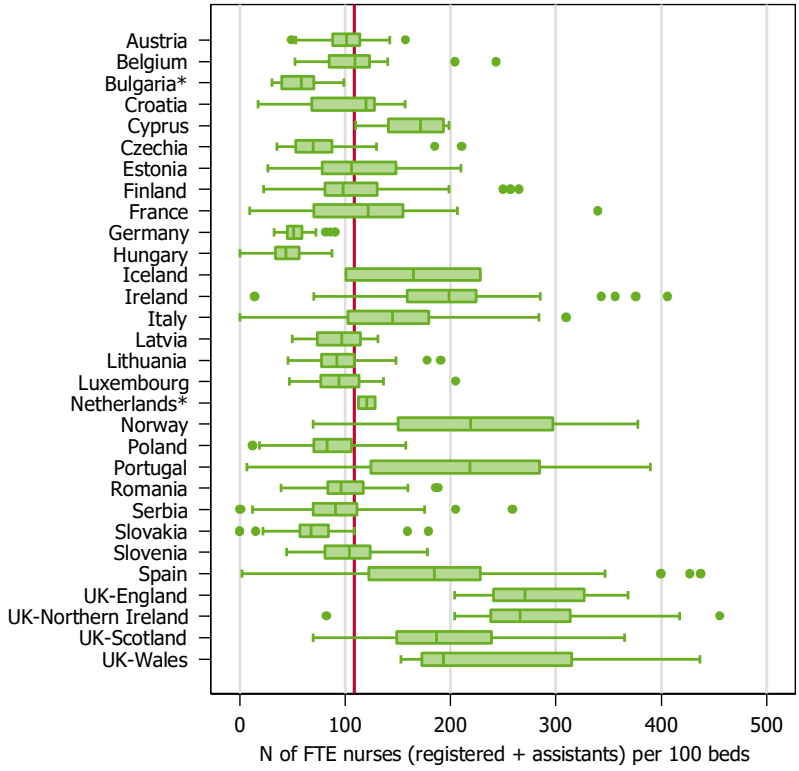
Figure 107. Median number of nursing assistant FTEs per 100 intensive care unit beds in ICUs



**PPS data representativeness was poor in Bulgaria and the Netherlands.*

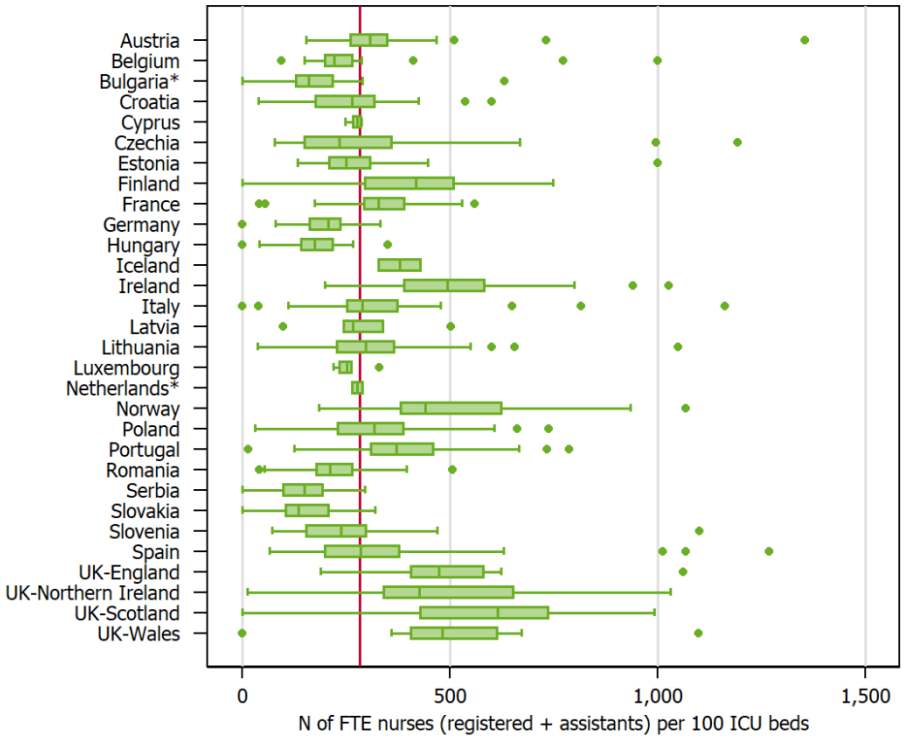
Staffing levels per 100 hospital beds were strongly associated with the number of blood cultures per 1 000 patient-days at country level, for registered nurses (Spearman's rho 0.75, p<001), nursing assistants (Spearman's rho 0.52, p<001) and total nurses (Spearman's rho 0.79, p<001). There was also a positive correlation of the staffing levels with the HAI prevalence (e.g. Spearman's rho total nurses 0.52, p<0.01), but these associations did not remain significant after adjustment for the number of blood cultures per 1 000 patient-days. There was no correlation of any of the staffing levels indicators with the composite index of AMR at country level. Staffing levels of registered nurses were also associated with staffing levels of IPCNs (Spearman's rho 0.74, p<0.001) at country level, while staffing levels of nursing assistants were not.

Figure 108. Combined FTE registered nurses and nursing assistants per 100 hospital beds by country



**PPS data representativeness was poor in Bulgaria and the Netherlands. Red vertical line=median.*

Figure 109. Combined registered nurse and nursing assistant FTEs in intensive care units per 100 ICU beds, by country



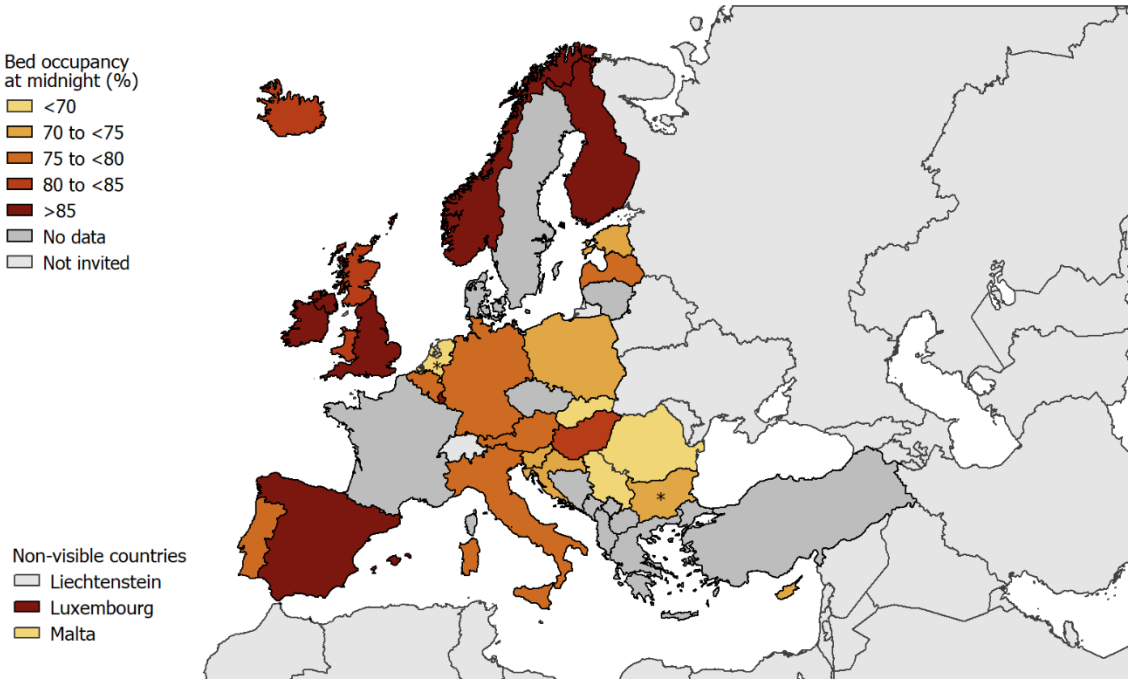
**PPS data representativeness was poor in Bulgaria and the Netherlands. Red vertical line=median.*

In 694 hospitals from 20 countries collecting the number of healthcare workers (HCWs) present on the ward at the time of the PPS (as denominator for the percentage of HCWs carrying alcohol-based handrub bottles, see below), the number of FTE nurses was significantly associated with the number of HCWs per 100 beds present on the ward (Spearman's rho 0.29, p<0.001). This correlation was only significant in seven countries (Croatia, Lithuania, Poland, Portugal, Romania, Slovenia and Slovakia). In these countries (n=337 hospitals), the median combined number of FTE nurses was 98.0 per 100 beds (IQR: 73.1-128.6), the median number of HCWs present on the ward at the time of the survey was 36.4 HCWs per 100 beds (IQR: 29.1-47.9) and the Spearman correlation coefficient rho was 0.51 (p<0.001).

Bed occupancy at midnight

The bed occupancy measured at midnight on the day of the PPS was reported at hospital level by 588 hospitals, at ward level by 722 and at either level, together with denominator data (number of beds assessed for occupancy) by 888 hospitals from 23 EU/EEA countries and the four UK administrations. The median bed occupancy at midnight was 79.0% and varied between 54.6% in the Netherlands and more than 90% in Finland, Norway, Spain and UK-Northern Ireland (Figure 110).

Figure 110. Median percentage of occupied beds, measured at midnight



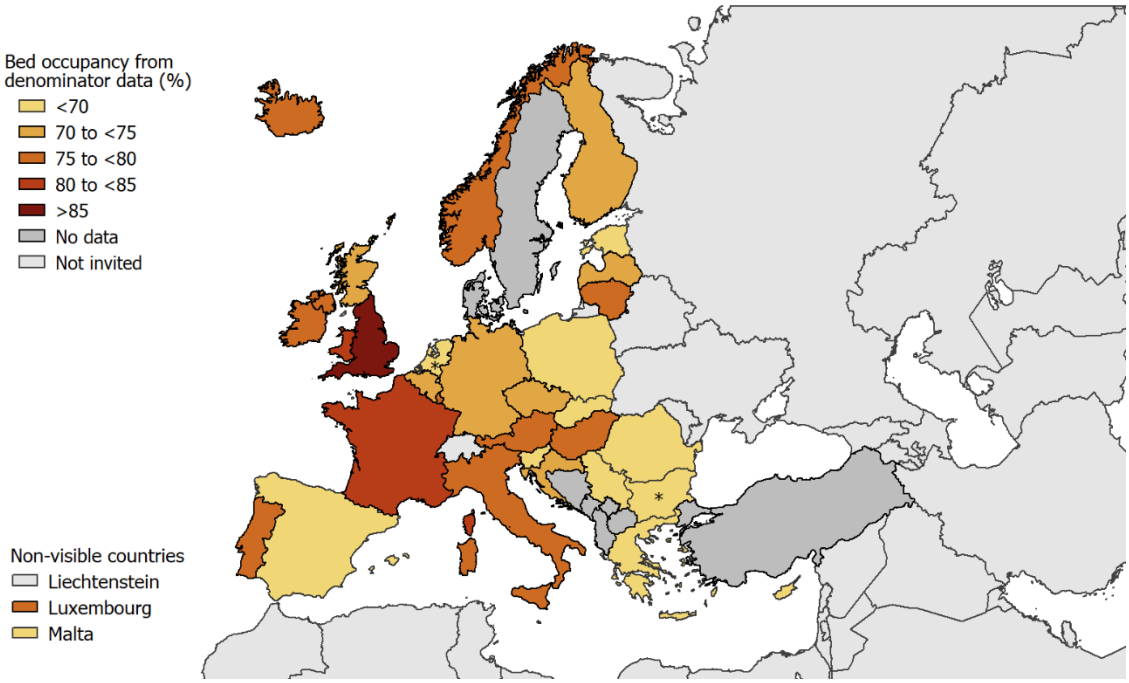
**PPS data representativeness was poor in Bulgaria and the Netherlands.*

Bed occupancy in previous year

The bed occupancy for the previous year calculated from hospital denominator data (number of patient-days × 100/number of beds × 365) was available for 1 189 hospitals from 27 EU/EEA countries and the four UK administrations.

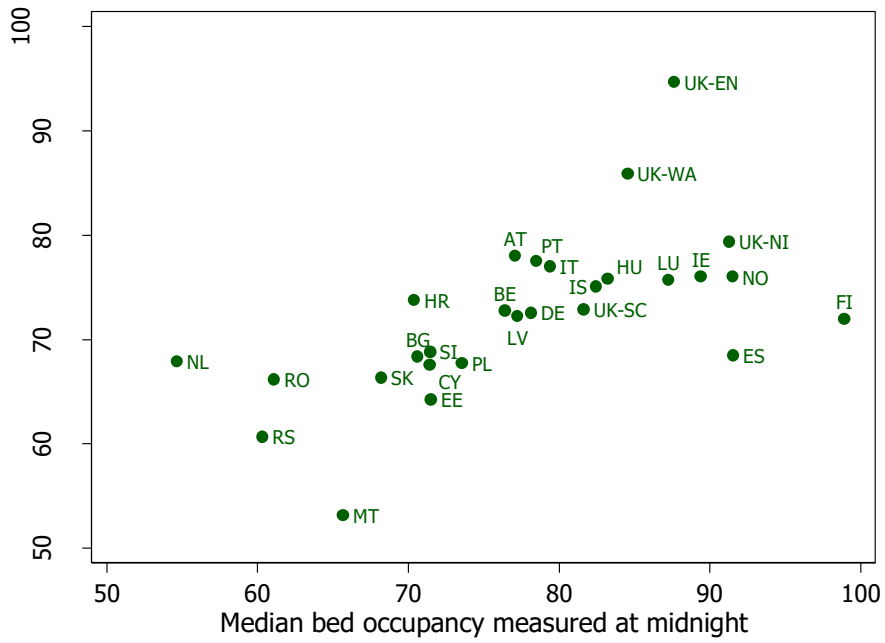
The median bed occupancy in the previous year was 72.9% and varied between 53.1% in Malta to 94.7% in UK-England (Figure 111). The Spearman correlation coefficient for the correlation between the two measures of bed occupancy was 0.47 (p<0.001) at hospital level and 0.68 (p<0.001) for the medians at national level (Figure 112).

Figure 111. Median bed occupancy in the previous year (from hospital denominator data)



**PPS data representativeness was poor in Bulgaria and the Netherlands. **Norway used a national protocol.*

Figure 112. Correlation between bed occupancy in the previous year with the bed occupancy measured at midnight



Spearman's rho 0.68 (p<0.001)

At hospital level, the bed occupancy in the previous year was negatively associated with the alcohol-based handrub consumption in litres per 1 000 patient-days (regression coefficient -0.26, p<0.001) while adjusting for the staffing levels per 100 beds for total nurses (regression coefficient 0.07, p<0.001). In univariate analysis at country level, there was no association between the bed occupancy indicators and neither the prevalence of HAIs nor the composite index of AMR.

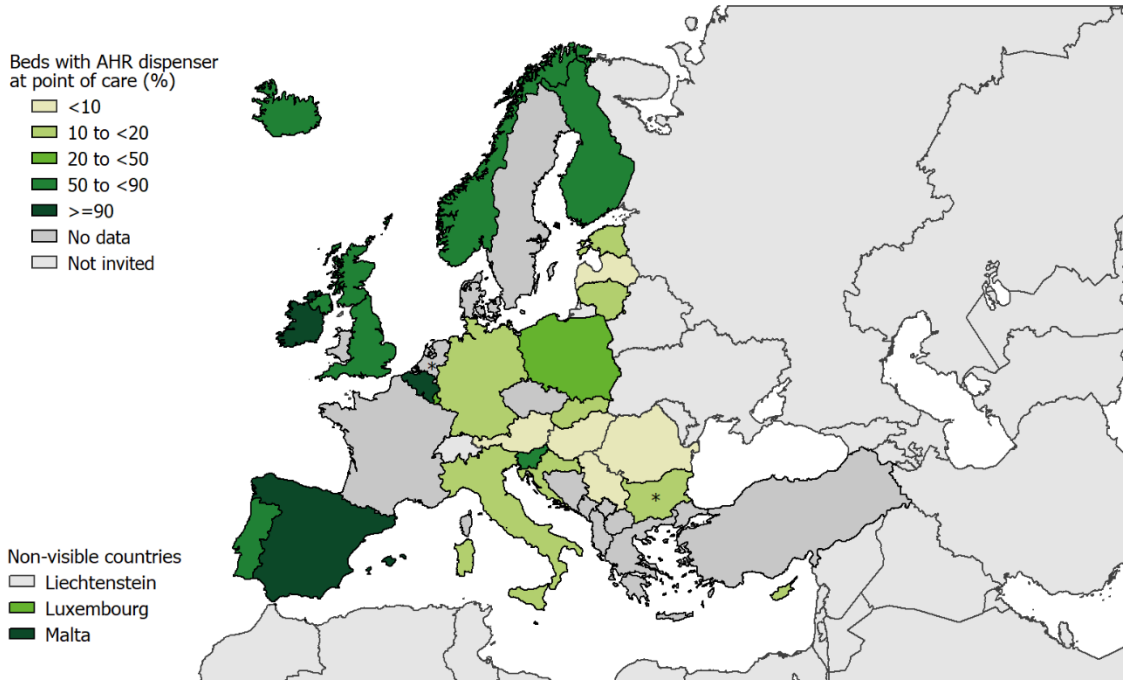
Core component 8. Built environment, materials and equipment for IPC at the facility level

Alcohol-based handrub (AHR) dispensers at point of care

The number of beds with an alcohol-based handrub (AHR) dispenser at the point of care was reported at hospital level by 663 hospitals, at ward level by 767 and at hospital or ward level, together with denominator data (number of beds assessed for the presence of a AHR dispenser) by 967 hospitals in 23 EU/EEA countries and three UK administrations.

The median percentage of beds with an AHR dispenser at the point of care was 52.8% and varied between less than 10% in Austria, Hungary, Latvia, Romania and Serbia and more than 90% in Belgium, Ireland, Malta and Spain (Figure 113). It was significantly higher in tertiary hospitals than in primary hospitals (Table 42).

Figure 113. Median percentage of beds with an alcohol-based handrub dispenser at the point of care



**PPS data representativeness was poor in Bulgaria and the Netherlands.*

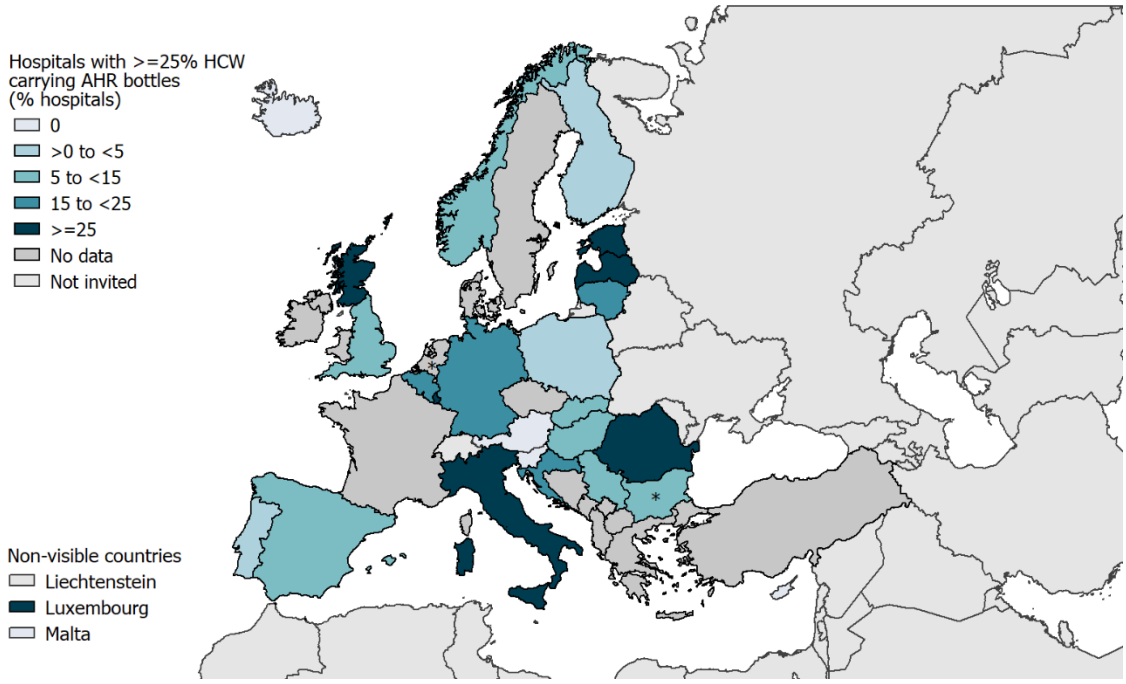
Table 42. Percentage of beds with an alcohol-based handrub dispenser at the point of care by type of hospital

Type of hospital	N of hospitals	Percentage of beds with an AHR dispenser at the point of care					
		Mean	P10	P25	P50	P75	P90
Primary	291	46.5	0.0	3.8	42.2	92.9	100.0
Secondary	322	51.3	2.4	7.3	57.8	90.9	100.0
Tertiary	193	57.6	8.5	20.4	61.0	96.5	100.0
Specialised	155	55.2	0.0	7.2	61.7	100.0	100.0
Unknown	6	60.9	0.0	2.0	81.6	100.0	100.0
Total	967	51.8	0.0	8.5	52.8	94.6	100.0

Healthcare workers with a personal alcohol-based handrub (AHR) bottle

To allow better interpretation of the availibility of AHR dispensers at the point of care, the percentage of healthcare workers (HCWs) with a personal AHR bottle was collected. This variable was reported at hospital level (in five categories) by 666 hospitals, at ward level by 653 hospitals and at hopsital or ward level, together with denominator data and excluding outliers by 856 hospitals in 22 EU/EEA countries and two UK administrations. Of those, 56% reported the percentage of HCWs with a personal AHR bottle as zero, 32.9% hospitals between 0 and <25% of HCWs, 5.1% hospitals between 25% and <50%, 2.9% hospitals between 50% and <75% and 3.1% hospitals reported ≥75% HCWs with a personal AHR bottle. The percentage of hospitals where ≥25% HCWs had a personal AHR bottle varied between 0% in five countries to more than 30% in Latvia and Romania (Figure 114).

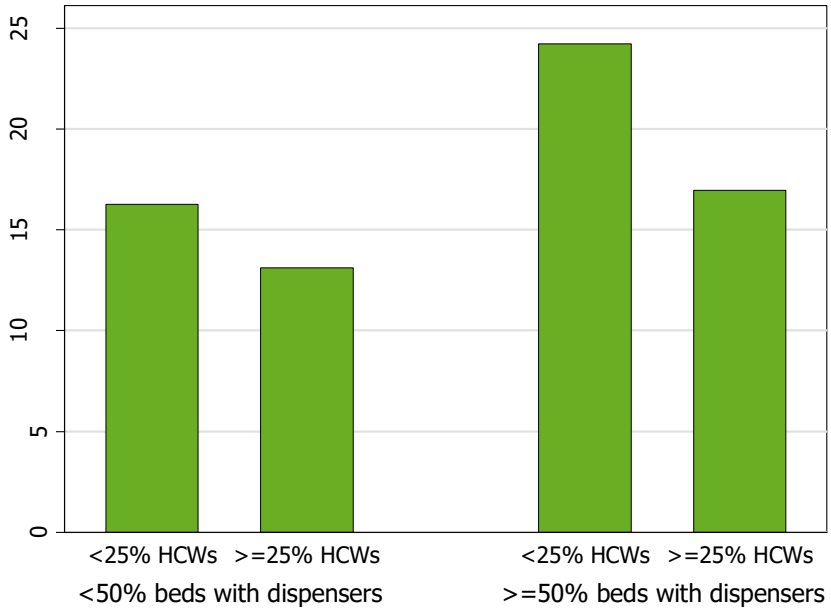
Figure 114. Percentage of hospitals where ≥25% of healthcare workers had a personal alcohol-based handrub bottles



**PPS data representativeness was poor in Bulgaria and the Netherlands.*

At hospital level, alcohol-based handrub consumption (in L/1 000 patient-days) was the highest in hospitals with high availability of AHR dispensers at the point of care and a low percentage of HCWs with a personal AHR bottle (Figure 115). This association (as well as the interaction with having a personal AHR bottle) remained statistically significant after adjustment for the type of hospital. However, when also adjusting for the country level in multivariable analysis, only high availibility of AHR dispensers remained significantly associated with high AHR consumption. The Spearman correlation coefficient rho at country level was 0.51 (p<0.01) (Figure 116).

Figure 115. Median alcohol-based handrub consumption by levels of availability of AHR dispensers at point of care and percentage of HCWs with a personal AHR bottle

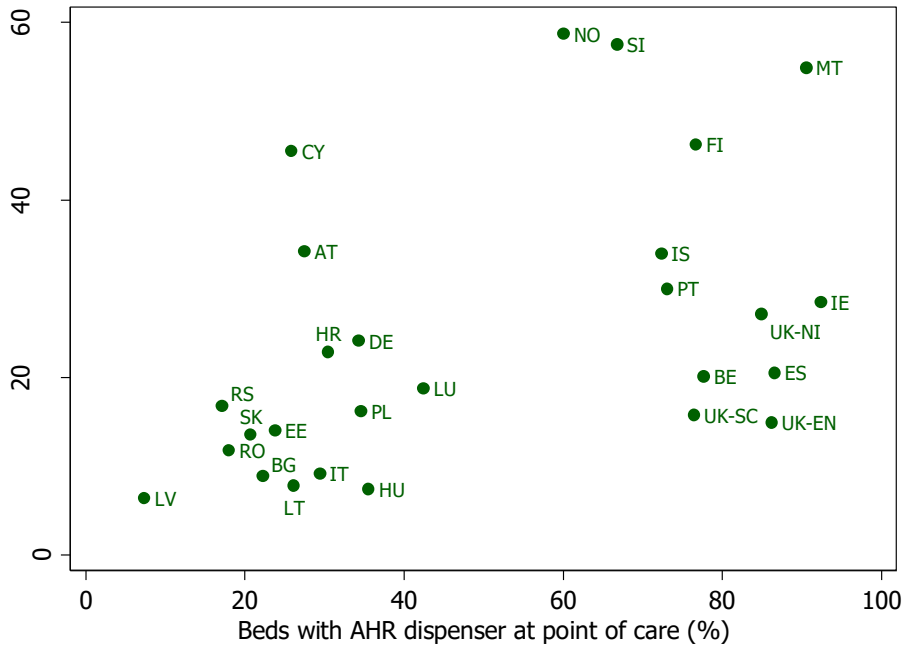


<25% HCWs, ≥25% HCWs: percentage of healthcare workers having an AHR bottle; <50%, ≥50% beds with dispensers: percentage of beds with an AHR dispenser at the point of care (within arm's reach).

In univariate analysis at country level, the percentage of beds with an AHR dispenser at the point of care was associated with the composite index of AMR (Spearman's rho -0.54, p<0.01, Figure 117). Similar to the AHR consumption and the nurse

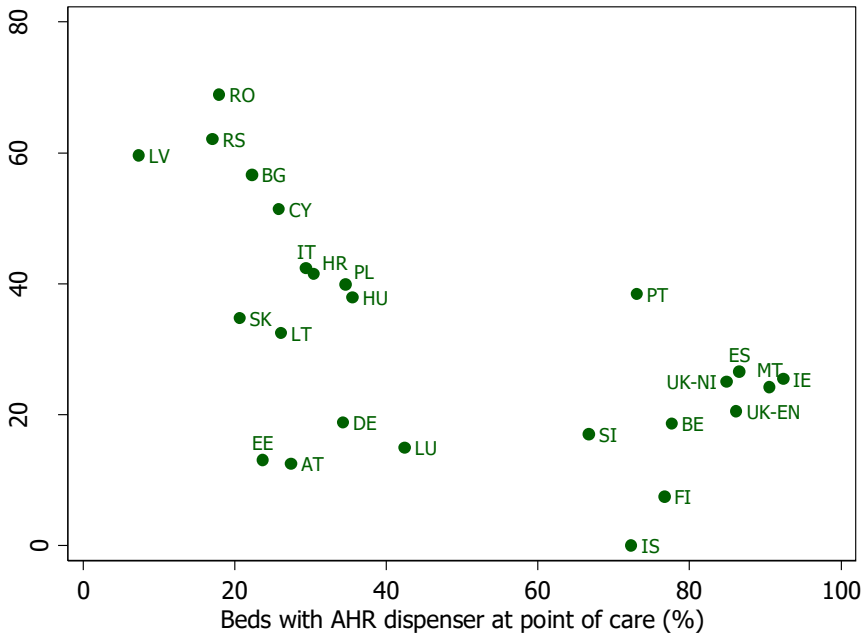
staffing levels, the percentage of beds with an AHR dispenser at the point of care was positively correlated with the number of blood cultures per 1 000 patient-days (Spearman's rho 0.74, p<0.001) and with HAI prevalence (Spearman's rho 0.59, p<0.01), but the association with HAI prevalence did not remain significant after adjustment for the number of blood cultures per 1 000 patient-days.

Figure 116. Correlation between the percentage of beds with an alcohol-based handrub dispenser at the point of care and consumption of AHR in L/ 1 000 patient-days



Spearman's rho 0.51 (p<0.01)

Figure 117. Correlation between the percentage of beds with an alcohol-based handrub dispenser at the point of care and the composite index of AMR



Spearman's rho -0.54, p<0.01

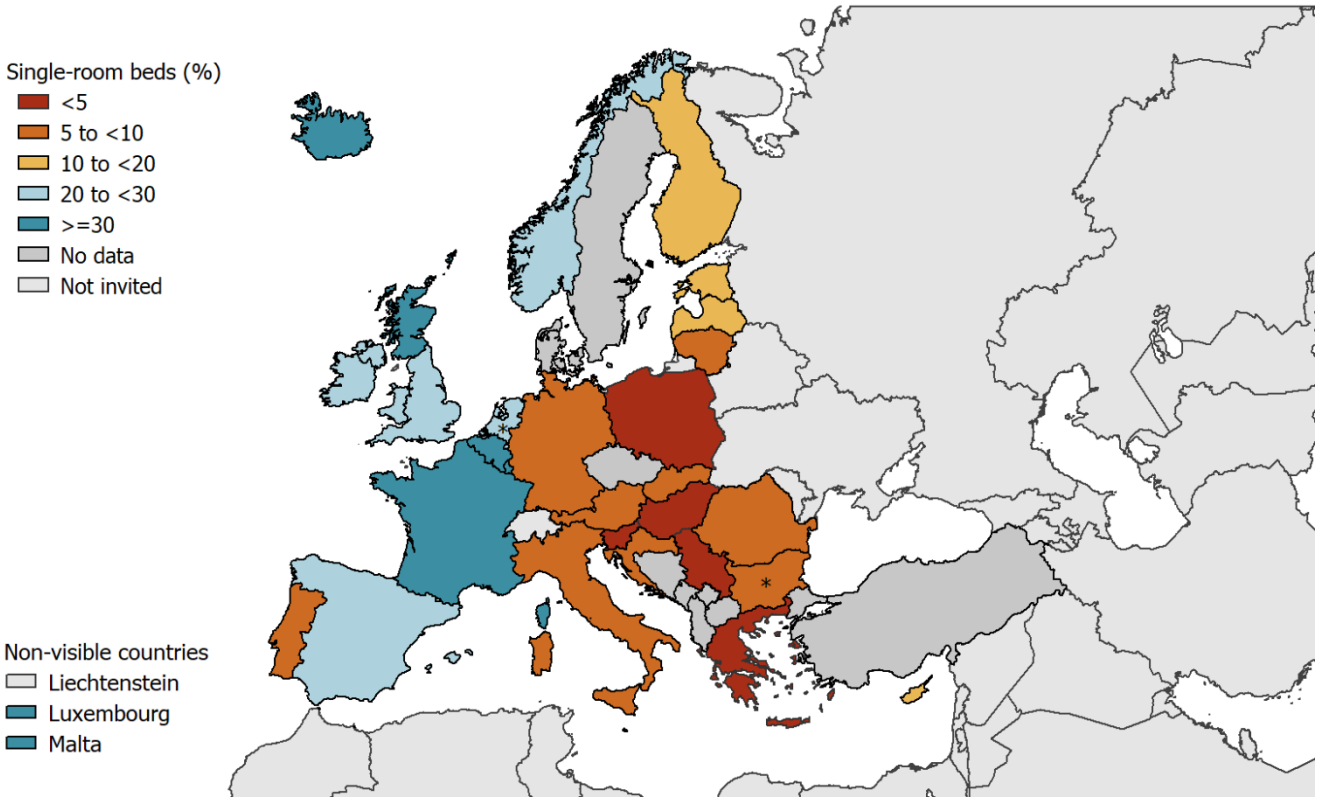
Single rooms and beds in single rooms

The number of single rooms was provided at hospital level by 872 hospitals, at ward level by 775 hospitals and at either level, together with denominator data and excluding outliers, by 1 077 hospitals from 26 EU/EEA countries and the four UK administrations. The country median percentage of single-bed rooms (as a percentage of the total number of rooms) was 32.1% (25th percentile 14.5%, 75th percentile 49.1%) and the country median percentage of single-room beds (as a percentage of the total number of beds) was 13.6% (25th percentile: 5.9%, 75th percentile: 27.0%). The median percentage of single-room beds was less than 5% in Greece, Hungary, Poland, Slovenia and Serbia, but more than 50% in France (Figure 118, Figure 119). The overall hospital median was 25.5% of single-bed rooms and 10.6% of single-room beds, with a median room size of 2.2 beds per room (25th percentile: 1.7 beds, 75th percentile: 2.7 beds).

The percentage of single-room beds did not vary significantly according to type of hospital (Table 43). In 23 countries where data were collected at ward level, the median percentage of single-room beds by ward specialty ranged from 5.9% in rehabilitation and long-term care wards to 16.7% in geriatric wards and 16.8% in intensive care units (Figure 120).

The mean percentage of single-room beds at country level was associated with the composite index of AMR (Spearman's rho -0.58, p<0.001, Figure 121) but not with the prevalence of patients with at least one HAI. The mean percentage of single-room beds was also associated at country level with the staffing levels of nurses (Spearman's rho 0.59, p<0.001), the staffing levels of IPCNs (Spearman's rho 0.49, p<0.01), the percentage of beds with AHR dispensers at the point of care (Spearman's rho 0.67, p<0.001), the number of blood cultures per 1 000 patient-days (Spearman's rho 0.56, p<0.01), but not with the median AHR consumption, participation in HAI surveillance networks nor the average multimodal strategy scores.

Figure 118. Median percentage of single-room beds among the total number of hospital beds



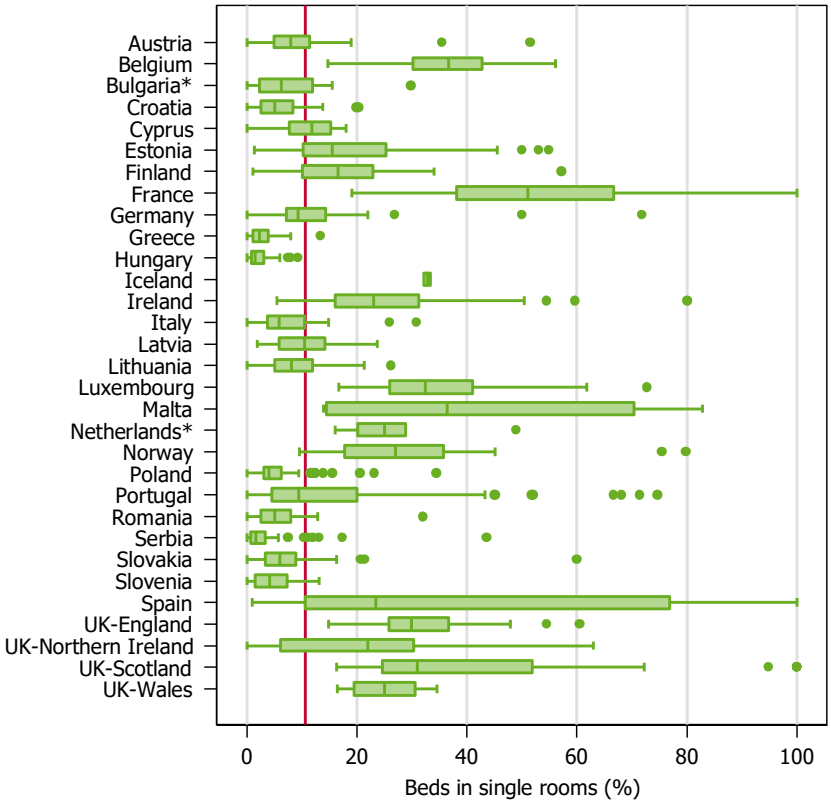
**PPS data representativeness was poor in Bulgaria and the Netherlands.*

Table 43. Percentage of single-room beds among the total number of hospital beds by type of hospital

Type of hospital	N of hospitals	Percentage of single-room beds					
		Mean of means	P10	P25	P50	P75	P90
Primary	331	18.6	2.0	5.4	10.7	28.0	46.4
Secondary	361	18.5	1.8	4.2	10.8	24.1	45.1
Tertiary	221	16.4	2.0	4.2	8.4	22.8	37.4
Specialised	158	21.5	1.1	4.3	11.4	28.5	59.7
Unknown	6	37.7	0.9	14.5	25.2	71.4	89.2
Total	**1 077**	**18.6**	**1.8**	**4.6**	**10.6**	**25.8**	**46.0**

P: percentile.

Figure 119. Percentage of single-room beds by country



**PPS data representativeness was poor in Bulgaria and the Netherlands. Red vertical line=median.*

Figure 120. Percentage of single-room beds by specialty

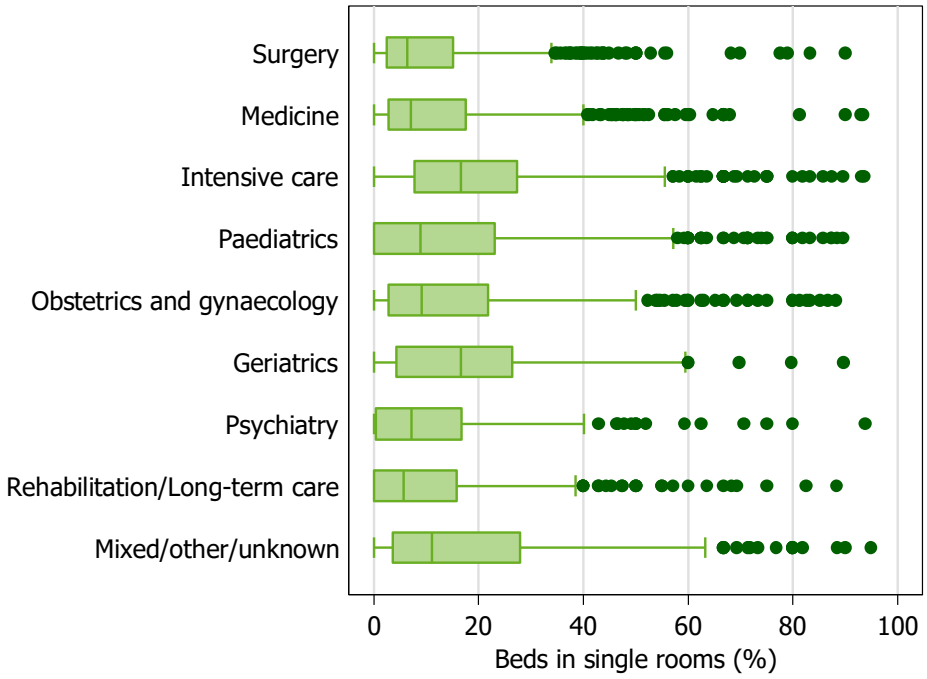
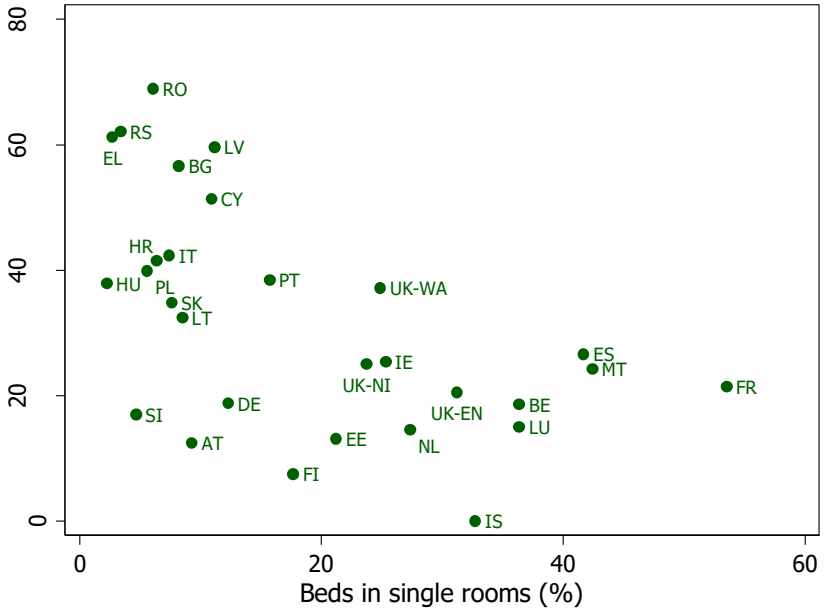


Figure 121. Correlation between the percentage of single-room beds and the composite index of AMR

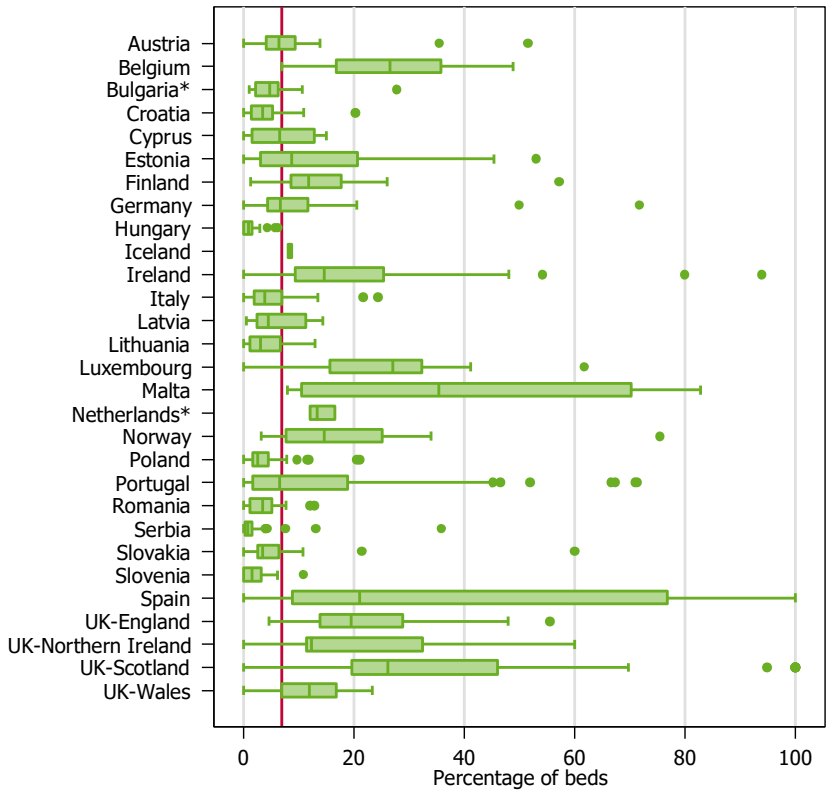


Spearman's rho -0.58, p<0.001

Single rooms/beds with individual toilet and shower

The number of single rooms with an individual toilet and shower was provided at hospital level by 709 hospitals, at ward level by 776 hospitals and at either level, together with denominator data and excluding outliers, by 949 hospitals from 25 EU/EEA countries and the four UK administrations. Hospitals reporting more single rooms with a toilet and shower than single rooms overall were excluded (n=32).

Figure 122. Percentage of beds in single rooms with individual toilet and shower by country



**PPS data representativeness was poor in Bulgaria and the Netherlands. Red vertical line=median.*

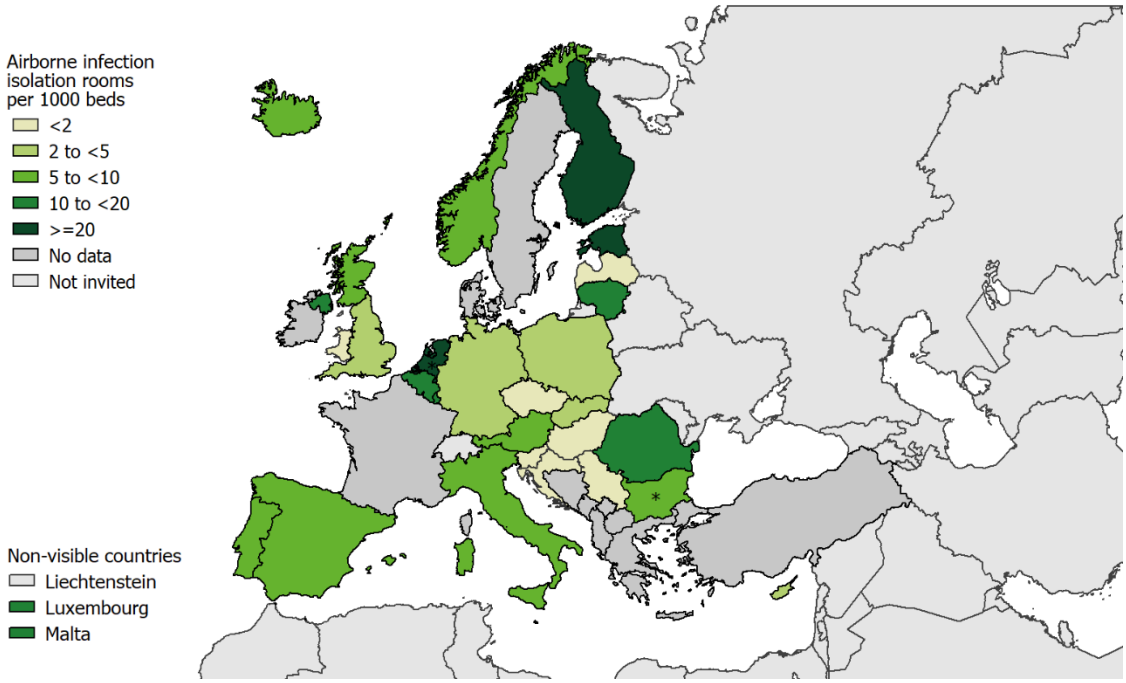
The median percentage of beds in single rooms with an individual toilet and shower was 6.9%, varying between less than 1% in Hungary and Serbia and more than 20% in Belgium, Luxembourg, Malta, Spain and UK-Scotland (Figure 122). The average percentage of single rooms that had an individual toilet and shower was 67.4%.

Number of airborne infection isolation rooms

The number of airborne infection isolation rooms was reported by 951 hospitals from 28 countries, including hospitals reporting zero isolation rooms. France, Greece and Ireland did not collect this information. Hospitals that did not reply in countries that collected the information were assumed to have no isolation rooms.

The country median number of isolation rooms was 7.9 airborne infection isolation rooms per 1 000 hospital beds and varied between less than one per thousand in Croatia and Hungary to 20 per thousand or more in Estonia, Finland and the Netherlands (Figure 123).

Figure 123. Number of airborne infection isolation rooms per 1 000 hospital beds



**PPS data representativeness was poor in Bulgaria and the Netherlands.*

The number of airborne infection isolation rooms per 1 000 hospital beds was associated with the composite index of AMR (Spearman's rho -0.45, p<0.05) but not with the prevalence of patients with at least one HAI. It was also associated with the percentage of single-room beds (Spearman's rho -0.49, p<0.01), and the association with the composite index of AMR did not stay significant when adjusting for this variable.

Antimicrobial stewardship indicators

The median full-time equivalents for antimicrobial stewardship consultants per 250 beds was 0.08 (country range: 0–0.60 (Table 44)), with 54.1% of hospitals reporting some dedicated time for antimicrobial stewardship, varying from 0% in Cyprus and Iceland to 100% of hospitals in UK-England and UK-Northern Ireland (Figure 124). Among the hospitals that submitted information on structure and process indicators for antimicrobial stewardship, the percentage of hospitals in the EU/EEA participating countries that had implemented a formal policy for post-prescription review in at least one ward was 52.5%. The percentage of hospitals reporting antimicrobial use guidelines was 76.3%. The percentage of hospitals participating in a national or regional hospital antimicrobial consumption surveillance network was 49.3% or 60.2%, depending on whether hospitals that replied at least once to one of the surveillance network questions were counted in the denominator or not (Table 44).

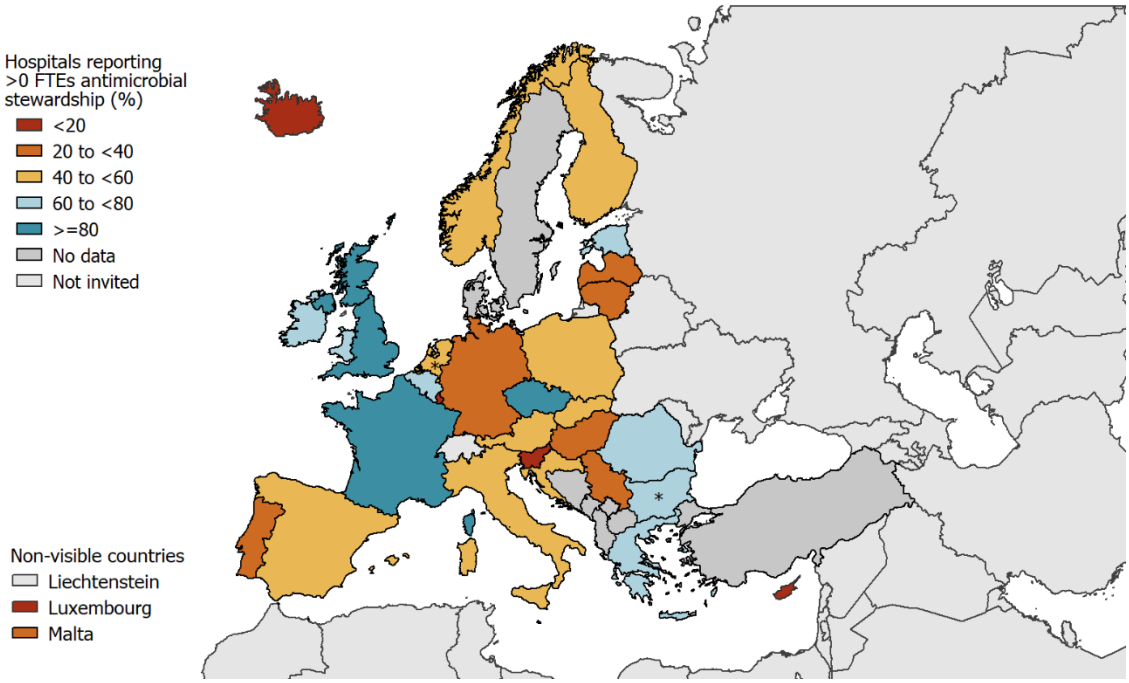
At hospital level, having dedicated FTEs (>0 FTE) for antimicrobial stewardship was associated with 1) a higher median percentage of antimicrobials changed during treatment (22.5 *vs* 16.6%, p<0.001), 2) a lower median percentage of broad-spectrum antimicrobials (34.1 *vs* 37.5%, p<0.01), 3) a lower median percentage of antimicrobials administered parenterally (71.3 *vs* 78.3%, p<0.001), 4) higher presence of a policy for post-prescription review in at least one ward (67.5 *vs* 34.7%, p<0.001), 5) higher presence of antimicrobial use guidelines (84.7 *vs* 59.1%, p<0.001), 6) higher participation in an antimicrobial consumption surveillance network (56.6 *vs* 37.8%, p<0.001) and 7) a higher mean multimodal strategy score for antimicrobial stewardship (3.8 *vs* 2.0, p<0.001).

Table 44. Structure and process indicators of antimicrobial stewardship, by country

Country	Number of hospitals	Antimicrobial stewardship consultant in the hospital			Formal procedure for post-prescription review in the hospital[1]		Participation in a national or regional hospital antimicrobial consumption surveillance network	
		Total number replied	Mean FTE per 250 beds	Median FTE per 250 beds	Total number replied	Number with procedure	Total number replied a/b	Number with participation
Austria	49	49	0.14	0	49	31	9/47	9
Belgium	43	35	0.33	0.23	41	18	25/30	18
Bulgaria*	12	12	0.63	0.50	11	9	3/11	2
Croatia	34	31	0.60	0	34	12	25/32	20
Cyprus	8	8	0	0	8	1	5/7	0
Czechia	45	45	0.49	0.28	5	2	45/45	0
Estonia	23	14	0.13	0.13	20	11	15/21	2
Finland	51	35	0.28	0.08	46	23	9/38	9
France	50	50	0.67	0.25	50	46	50/50	44
Germany	49	46	0.14	0	49	12	49/49	16
Greece	42	27	0.14	0.09	27	18	36[2]	18
Hungary	38	38	0.16	0	35	5	8/38	8
Iceland	2	2	0	0	2	0	1/2	0
Ireland	60	56	0.54	0.60	58	43	60/60	46
Italy	56	55	0.42	0	55	21	53/55	20
Latvia	14	11	0.11	0	14	2	14/14	1
Lithuania	62	60	0.35	0	61	34	62/62	60
Luxembourg	12	12	0.71	0	12	3	9/11	7
Malta	4	4	0.16	0	4	1	4/4	1
Netherlands*	19	7	0.03	0	4	3	12/19	10
Norway	43	24	0.22	0.08	24	18	24/24	24
Poland	80	80	0.16	0.07	79	32	43/67	4
Portugal	93	81	0.22	0	93	37	60/78	38
Romania	40	36	0.54	0.24	40	27	36/38	34
Slovakia	50	46	0.50	0	50	32	29/46	4
Slovenia	20	20	0.07	0	20	3	20/20	12
Spain	96	80	0.46	0.12	72	29	78/78	30
UK – England	32	32	0.58	0.45	32	32	32/32	32
UK – Northern Ireland	16	16	0.53	0.55	16	14	16/16	16
UK – Scotland	45	42	0.58	0.29	45	28	45/45	39
UK – Wales	21	21	0.75	0.32	19	17	21/21	17
EU/EEA	**1 209**	**1 075**	**0.37**	**0.08**	**1 075**	**564**	**898/1 160**	**541**
Serbia	65	59	0.24	0	65	24	8/63	7

*[1]Review of the appropriateness of prescribed antimicrobials within 72 hours (three calendar days) from the initial order, in at least one of the hospital wards. [2]Data for Greece were collected after the national PPS, for antimicrobial stewardship indicators only. *PPS data representativeness was poor in Bulgaria and the Netherlands.*

Figure 124. Percentage of hospitals with reporting dedicated time (> zero FTE]) for antimicrobial stewardship

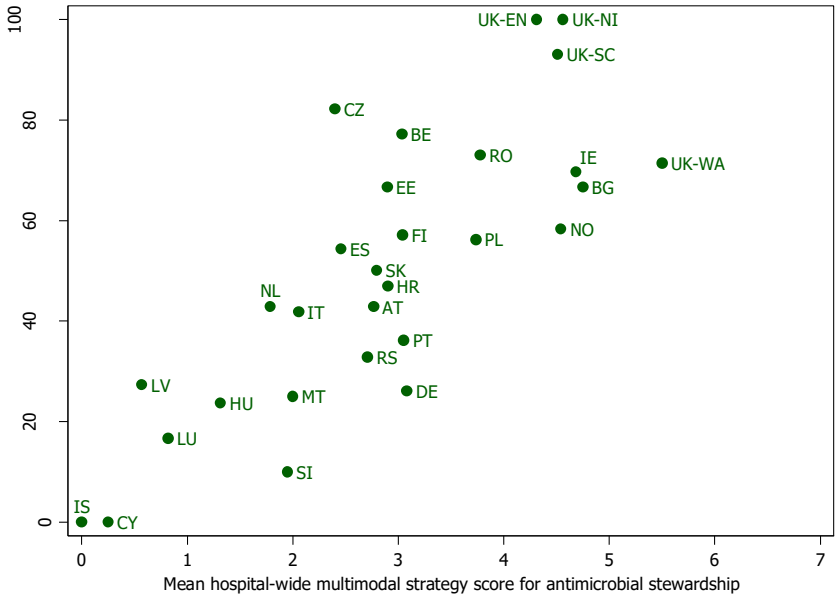


**PPS data representativeness was poor in Bulgaria and the Netherlands.*

Having dedicated FTEs (>0 FTE) for antimicrobial stewardship was also associated with a lower composite index of AMR at hospital level, depending on the statistical method used (mean composite index 29.0% *vs* 34.3% in hospitals reporting 0 FTE antimicrobial stewardship consultant, p<0.05; not significant when using quantile regression or ordinal logistic regression).

At country level, none of the antimicrobial stewardship indicators measured at hospital or ward level were significantly associated with indicators measured at antimicrobial use level nor with the composite index of AMR. However, indicators measured at hospital/ward level were inter-correlated. For example, the percentage of hospitals reporting dedicated time for antimicrobial stewardship was strongly associated with the mean hospital-wide multimodal strategy score for antimicrobial stewardship (Spearman's rho 0.77, p<0.001,Figure 125).

Figure 125. Correlation between the percentage of hospitals reporting dedicated time for antimicrobial stewardship (> zero FTE) and the mean number of multimodal strategy elements reported for antimicrobial stewardship at hospital-wide level (max=7)



Spearman's rho 0.77, p<0.001

Validation of structure and process indicators

National validation studies

Based on the lessons learned from the 2011-2012 ECDC PPS, the 2016-2017 national validation protocol included questions about the interpretation of key structure and process indicators. In addition, the external validation teams that visited countries during the national validation studies investigated how indicators were interpreted using in-depth interviews with the hospital IPC staff or other staff involved in the data collection.

Table 45. National validation study results for structure and process indicators

Country	Hospital indicators reported for the same hospital population as HAI and antimicrobial use data?				Data source of alcohol-based handrub consumption in most recent year (liters)					Correct reporting of (partial) full-time equivalents			Antimicrobial stewardship included in job description?			Correct distinction between FTE IPC and antimicrobial stewardship?		
	Yes	Partially	No	Unknown	Dispensed	Purchased	Used	Other	Unknown	Yes	No	Unknown	Yes	No	Unknown/NA	Yes	No	Unknown/NA
Austria	5	0	0	0	2	3	0	0	0	5	0	0	1	4	0	3	2	0
Belgium	4	1	0	0	2	0	2	1	0	5	0	0	4	1	0	4	1	0
Bulgaria	5	1	1	0	0	0	6	1	0	6	1	0	5	1	1	5	0	2
Croatia	5	0	0	0	5	0	0	0	0	4	1	0	1	4	0	5	0	0
Czechia	6	0	0	0	6	0	0	0	0	6	0	0	6	0	0	6	0	0
Estonia	5	0	0	0	5	0	0	0	0	5	0	0	3	1	1	4	0	1
Finland	5	0	0	0	2	3	0	0	0	4	1	0	1	4	0	2	3	0
France	0	0	0	5	0	0	0	0	5	0	0	5	0	0	5	0	0	5
Germany	10	0	0	0	5	2	3	0	0	10	0	0	9	1	0	9	1	0
Greece	8	0	0	0	3	4	0	0	1	8	0	0	3	5	0	6	2	0
Hungary	5	0	0	0	3	1	0	0	1	3	0	2	2	0	3	3	0	2
Iceland	2	0	0	0	2	0	0	0	0	2	0	0	1	1	0	2	0	0
Ireland	6	0	0	0	0	0	0	0	6	0	0	6	0	0	6	0	0	6
Italy	5	0	0	0	4	0	1	0	0	5	0	0	2	2	1	2	1	2
Latvia	7	1	2	1	7	3	0	0	1	4	4	3	0	10	1	0	9	2
Lithuania	21	0	0	0	21	0	0	0	0	20	1	0	3	17	1	7	12	2
Luxembourg	11	0	0	1	10	1	1	0	0	12	0	0	2	10	0	12	0	0
Malta	3	1	0	0	3	1	0	0	0	3	0	1	0	3	1	3	0	1
Netherlands	4	0	0	0	0	0	0	0	4	4	0	0	0	4	0	0	4	0
Poland	15	0	0	4	12	0	6	0	1	19	0	0	14	5	0	8	10	1
Portugal	26	0	0	0	6	2	5	0	13	25	1	0	6	7	13	6	7	13
Romania	6	0	0	2	6	0	0	0	2	6	0	2	6	0	2	6	0	2
Slovakia	4	1	0	0	1	1	3	0	0	5	0	0	3	2	0	5	0	0
Spain	2	1	2	0	5	0	0	0	0	5	0	0	5	0	0	5	0	0
UK – England	10	0	0	0	0	10	0	0	0	10	0	0	10	0	0	10	0	0
UK – Northern Ireland	13	0	0	0	0	13	0	0	0	13	0	0	13	0	0	13	0	0
UK – Scotland	0	9	0	0	0	9	0	0	0	9	0	0	9	0	0	9	0	0
UK – Wales	0	0	0	10	0	0	0	0	10	0	0	10	0	0	10	0	0	10
EU/EEA, number of hospitals	193	15	5	23	110	53	27	2	44	198	9	29	109	82	45	135	52	49
EU/EEA, % hospitals	90.6	7.0	2.4	-	57.3	27.6	14.1	1.0	-	95.7	4.4	-	57.1	42.9	-	72.2	27.8	-
Serbia	5	0	0	0	4	0	1	0	0	5	0	0	4	1	0	4	1	0

FTE: full-time equivalent; IPC: infection prevention and control; Dispensed: alcohol-based handrub dispensed to the wards (by pharmacy); Purchased: alcohol-based handrub purchased by the hospital pharmacy; Used: alcohol-based handrub used by the wards; NA: not applicable. Cyprus, Norway and Slovenia did not perform a validation study.

Results of the questions included in the national validation protocol are shown in Table 45. National validation teams reported that nine out of ten hospitals reported the numbers of the hospital indicator data for the same hospital population as HAI and antimicrobial use data. In those who didn't, the reason was mostly that wards which were excluded for the HAI and antimicrobial use data collection could not be excluded for one or several hospital-wide indicators (e.g. exclusion possible for alcohol-based handrub consumption but not for staffing levels).

The reported AHR consumption mostly reflected the quantity dispensed to the wards during the most recent year (57%), followed by the quantity purchased by the hospital (28%, for ≥ 50% hospitals in Austria, Finland, Greece and United Kingdom) and the quantity actually used in the wards (14%). Partial full-time equivalents (e.g. 0.5 FTE for a half-time occupation instead of 0 or 1 FTE) were correctly reported by 96% hospitals.

In 43% hospitals, antimicrobial stewardship activities were not specified in the job description of the antimicrobial stewardship consultant. In 25% of those (or 10% of all hospitals), the number of FTE antimicrobial stewardship consultant was higher than zero. Surprisingly, 29% of hospitals in which antimicrobial stewardship activities were specified in the job description did not report any FTE antimicrobial stewardship. Finally, in 28% hospitals, the FTE antimicrobial stewardship were not correctly distinguished from the FTE infection prevention and control, when both functions were performed by the same person.

External validation

The external validation teams identified a number of discrepancies in the structure and process indicator data presented by the local IPC teams from the visited hospitals. These related in the main to data definition issues.

Examples included:

General:

FTE data may vary by country due to definitions e.g. in Poland paramedics were included as they work on the ward as nursing assistants. Further, contract nurses may account for almost half of the workforce, but FTE numbers for these workers from administrative sources were not always accurate. In these cases, IPC teams had to calculate FTEs manually, which was resource intensive.

Antimicrobial stewardship indicators:

- Antimicrobial post-prescription review:
  - reported as "yes" for the entire hospital although not done by an external (from ward) person;
  - not documented as a formal procedure in the hospital (only on selected wards but not hospital-wide);
  - is not national or local policy in the country.
- Antimicrobial stewardship consultant FTE
  - sometimes not formally included in job description;
  - antimicrobial stewardship was interpreted as microbiologists working on the wards and may be overestimated.

Infection prevention and control indicators:

- Annual IPC report not actually available either online or on paper (not a formal report);
- Microbiology services ticked as available during weekends however only emergency samples done (not compliant with definitions);
- ICU surveillance reported as 'no' since the reporting was made for the year 2016 and ICU surveillance was in place since 01/2017;
- AHR dispensers at bedside in some translations of the ECDC protocol meant outside the patient zone, therefore risk of overestimation;
- AHR consumption in the wards had to be done by the IPC team based on data from AHR procurements; sometimes an average had to be calculated because of different methods of distribution at the specialty level i.e. not available at ward level;
- Both under- and over-reporting of multimodal strategy components, most commonly over-reporting, especially of feedback and training, mostly related to understanding/translating what these terms mean (also 'all-yes' reporting was encountered):
  - confusion of audit with surveillance instead of measurement against a standard;
  - counting clinical ward rounds or patient reviews as surveillance;
  - counting a casual conversation as feedback or a one-to-one information as training;
  - counting a professional society guidance as a hospital guideline purely because it existed.

Not all indicators were routinely used by the IPC teams for their routine work, e.g. blood cultures and CDI tests, discharges or admissions, patient-days, FTE nursing staff. Only few local hospital IPC teams thought they were of use for their work, but they intended to consider them in the future. Nonetheless, it was noted that these data were easy to retrieve from administrative systems.

Discussion

The ECDC PPS 2016-2017 provides an update on hospital-wide data on HAIs and antimicrobial use in acute care hospitals in EU/EEA countries and the UK, with a representative sample acquired in the majority of countries. The final ECDC PPS database included data reported from 1 209 acute care hospitals in Europe (14.6% of all acute care hospitals in these countries) and included records from 310 755 patients (16.0% of beds in acute care hospitals). Twenty-eight countries performed validation studies that helped acquire more robust estimates on international HAI prevalence. Despite limitations and inherent difficulties arising from the magnitude of the survey and the need for adherence to uniform definitions, methodology and requirements, the 2016-2017 ECDC PPS has:

- provided the most robust estimate of the overall burden of HAIs and use of antimicrobials in acute care hospitals in the EU to date;
- described HAIs and antimicrobial use by type of hospital, patient and by country;
- described key structures and processes for the prevention of HAIs and antimicrobial resistance at the hospital and ward level
- increased surveillance skills through the training of healthcare workers across Europe;
- provided targets for quality improvement through rapid dissemination of results by hospital and country.

These objectives were achieved through the ECDC PPS protocol developed together with experts from all Member States and supporting tools such as free hospital software, hospital reports comparing local results to the national data, standardised training materials and a protocol as well as financial support for PPS data validation at national level.

Healthcare-associated infections

The prevalence of patients with at least one HAI in acute care hospitals in the EU/EEA was 5.9% in the PPS sample and was estimated at 6.5% (95% CI: 5.4–7.8%) after weighting by country and correcting for the results of the validation study. The HAI prevalence point estimate in the PPS sample was similar to the 6.0% found in the previous ECDC PPS point prevalence survey in 2011-2012 [5]. This finding suggests that whilst there was no overall increase in the HAI prevalence, there also was no major overall progress seen in preventing healthcare-associated infections. More in-depth analysis such as that performed by the US Centres for Disease Control and Prevention [45] and considering differences in patient case mix between the two surveys is needed to assess more detailed changes between 2011-2012 and 2016-2017. For example, long-term care wards in acute care hospitals were included in the 2016-2017 survey but not in the 2011-2012 survey. Such differences in patient case mix (see Table A1.2 in the appendix of the current report and of reference [5]) must be accounted for when comparing results between both surveys, but these analyses fall beyond the scope of this report.

The results of the validation study, as well as the risk adjustment model show that the national interpretation of the methods and definitions still affects the observed HAI prevalence significantly. In addition, the 2016-2017 PPS suggested that the high variability of diagnostic testing resulted in under-ascertainment of HAI cases and lower HAI prevalence results in countries performing diagnostic testing less frequently, irrespective of the patient case-mix severity. Direct comparison of HAI prevalence figures between countries should be avoided for several reasons that were addressed in the results section and are further discussed below (see limitations). At least confidence intervals or predicted values based on patient case mix (preferably both), as well as the results of the validation studies (in particular the specificity) and the frequency of blood culture testing should be taken into account when interpreting the observed prevalence. Because of the risk of misinterpretation of the HAI prevalence by country presented as a single indicator, ECDC did not publish a map of the observed HAI prevalence and advises against doing so, even though the results by country are given in the report (Table 20).

The total annual number of patients with at least one HAI in acute care hospitals in the EU/EEA after validation was estimated at 4.1 million patients per year with a wide 95% confidence interval of 3.4 to 4.9 million patients per year. The point estimate before validation was 3.3 million and was similar to the estimate of 3.2 million patients per year with HAI in the EU/EEA following the 2011-2012 PPS [5], and the confidence intervals of these estimates largely overlap. The higher estimate of 4.1 million was thus due to the correction for the results of the validation study and should not be interpreted as an increase compared with the first ECDC PPS performed five years earlier.

The most common types of HAI in the ECDC PPS sample were pneumonia (21.4%, together with lower respiratory tract infections accounting for 25.7% of HAIs), urinary tract infections (18.9%), surgical site infections (18.3%), and bloodstream infections (10.8%). In the 2011-2012 PPS, surgical site infections were slightly more frequent than urinary tract infections, but otherwise the distribution of the most frequent types of HAI followed closely the distribution observed in 2011-2012, apart from the relative increase in gastro-intestinal system infections, and especially *Clostridioides difficile* infections which represented 4.8% of HAIs and 55% of gastro-intestinal HAIs in 2016-2017 compared to respectively 3.6% and 48% in 2011-2012. Figure 22 suggests, in comparison with Figure 35 in the PPS 2011-2012 report [5], that the increase of CDIs is related to a combination of new or increasing national epidemic problems in some countries (e.g. Romania and Slovakia), and a considerable improvement of the diagnostic testing for CDIs while the relative frequency of healthcare-associated gastro-intestinal infections remained similar, in other countries (Lithuania, Slovenia, Spain, Bulgaria).

The percentage of HAIs with microbiological results (52.7%) was slightly lower than the results of the 2011-2012 PPS (54.1%). As in the previous ECDC PPS, PPS surveyors were not supposed to revisit files of patients with an HAI after the day of the PPS to collect microbiological data, which partially affects the relatively low proportion. Another reason for the overall lower percentage, was that Norway for example did not report any microbiological data in 2016-2017 due to a methodological discrepancy in their national protocol. For these reasons, the percentage in the ECDC PPS underestimated the true percentage of HAIs that were microbiologically documented.

The five microorganisms most frequently isolated from HAIs in the ECDC PPS – *E. coli* (16.1% of microorganisms), *S. aureus* (11.6%), *Klebsiella* spp. (10.4%) *Enterococcus* spp. (9.7%) and *P. aeruginosa* (8.0%) – were the same as in the 2011-2012 PPS, but the rank of *Klebsiella* spp. rose from rank five (8.7%) to rank three. *C. difficile* (7.3%, rank six) was more common in 2016-2017 than in the previous PPS (5.4%, rank eight). These results are consistent with the still ongoing epidemics of extended-spectrum beta-lactamase (ESBL)- and carbapenemase-producing *K. pneumoniae* [30] and overall increase of *C. difficile* [46]. As mentioned above, the increase of *C. difficile* was likely also partially attributable to improved testing for CDI in several countries.

Antimicrobial resistance data for microorganisms isolated from HAIs were only collected for selected bug–drug combinations. Because of the cross-sectional (single day) study design, the number of microorganisms for which antimicrobial susceptibility data were known by country was relatively small, and results should be interpreted with caution. Nevertheless, when combining different bug-drug combinations in a composite index of AMR, there was an excellent correlation between the resistance percentages found in the ECDC PPS and those found in the European Antimicrobial Resistance Surveillance Network (EARS-Net), as reported in Eurosurveillance [1]. AST data were available for 8 031 (88.9%) of 9 034 microorganisms included in the composite index of AMR. The index was 31.6% overall (mean of countries: 30.8%) and varied from 0% in Iceland to 68.9% in Romania. The index by country was strongly correlated with the index calculated from 2016 EARS-Net data on invasive isolates (Spearman's rho 0.93; $p < 0.001$; $R^2=0.86$ [1]) and was on average 36% higher for HAI in acute care hospitals from the PPS than in the EARS-Net data (mean of countries in EARS-Net: 20.3%). The total number of patients acquiring an HAI with at least one resistant microorganism was estimated at 291 067 (95% cCI: 162 417–504 270) patients for the composite index of AMR and 31 696 (95% cCI: 14 611–78 205) patients for carbapenem-resistant Enterobacterales. It should be noted that the composite index of AMR was calculated differently in 2016-2017 than in 2011-2012. In 2016-2017, only resistant isolates were counted, while in 2011-2012 both resistant and intermediate (non-susceptible) isolates were counted. Only in France was it not possible to exclude intermediate isolates, as AST data were collected in the same way as in the first PPS (R and I combined). The `composite index of antimicrobial non-susceptibility' in 2016-2017 (re-calculated as in 2011-2012) was 32.7% overall, with 3.5% of the non-susceptible isolates included in the index being intermediate. This percentage of non-susceptible bacteria was similar to the 34.0% found in 2011-2012, not adjusting for differences in patient case mix.

The risk model for HAI presented in this report included all types of HAI in order to obtain a single summary predicted value and risk score by hospital and country. Whilst we could also perform a risk analysis for each type of HAI separately, presenting these multiple sub-models would be beyond the scope of this report. The methodology for the standardisation was based on multiple logistic regression as in the first ECDC PPS and as frequently used for mortality and for other diseases, including HAIs [5, 47-53].

Antimicrobial use

The prevalence of antimicrobial use of 32.9% was lower than the prevalence found in the previous ECDC PPS (35.0%) that was measured with the same methodology and was performed on a sample with good representativeness for two thirds of the participating countries [5]. Because of the lower antimicrobial use prevalence in Germany and France, the prevalence extrapolated to the average daily number of occupied beds per country was lower at 30.5%, with a 95% confidence interval (29.2–31.9) not including the 2011-2012 point estimate of the country-weighted prevalence of 32.7%. After correction for validation, the country-weighted prevalence in 2016-2017 was estimated at 31.4% (95%cCI 27.7-35.3). Similar to other comparisons with 2011-2012 however, more detailed comparative analyses between the two PPSs should be done in order to take into account differences in patient case mix, especially the fact that long-term care wards in acute care hospitals were included in the 2016-2017 PPS while they were excluded in 2011-2012. For example, the prevalence of antimicrobial use among ICU patients in 2016-2017 was 55.6%, similar to the 56.5% in 2011-2012.

The antimicrobial use measured in DDD per 100 patient-days was correlated with the consumption of antibacterials for systemic use in the hospital sector expressed in DDD per 1 000 inhabitants per day in ESAC-Net [54] and varied significantly among the participating countries. Part of this variability is related to differences in patient case mix, similar to the observed prevalence of antimicrobial use. However, the antimicrobial use measured in DDD per 100 patient-days was also related to the average number of DDDs per prescription and the average number of antimicrobials per patient. Recommended antimicrobial dosages differ across countries leading to differences when the dosage is converted to DDD. Moreover, the proportion of patients receiving more than one antimicrobial also differed among the participating countries, ranging from one in five to more than one in three patients on antimicrobials. This can be the result of antimicrobial combinations for the treatment of a single infection, broad-spectrum empirical treatment, prophylaxis or, uncommonly, treatment of multiple infections. Although antimicrobial combinations are appropriate for the treatment of specific infections, part of combination prescriptions may be redundant and reflect overprescribing [55]. Broad-spectrum combination empirical treatment may be indicated during the first days of a serious infection but if prolonged or overused may be inappropriate. Altogether, inappropriate antimicrobial combination prescriptions are a target for antimicrobial stewardship programmes and the results of the PPS provide a measure of the extent of combination use.

Patient case mix contributed in large part to the variation of the antimicrobial use prevalence per country and explained 59.3% of the variation between countries (Figure 54, Figure 55). Varying proportions of patient groups with a lower or higher prevalence of antimicrobial use in a given country may result in a lower or higher predicted prevalence of antimicrobial use based on patient case mix. The countries with the lowest and the highest standardised antimicrobial use ratio were Hungary and Greece, respectively.

The most used antimicrobials in the ECDC PPS were in line with the ECDC PPS in 2011-2012, with the various beta-lactams (penicillins, cephalosporins and carbapenems) accounting for more than half of all antimicrobials used. The pattern of antimicrobial use differed greatly between treatment of hospital infection versus treatment of community infection and was consistent with the type of infections and microbiological data reported in the HAI part of the PPS. The prevalence of the use of glycopeptides and the prevalence of the use of polymyxins/tigecycline was correlated with the percentage of MRSA and carbapenem-resistant Enterobacterales respectively. This observation further supported the validity of the antimicrobial resistance data collected in the PPS, even though the percentages were often based on small numbers of isolates.

Oral treatment of *C. difficile* infections was better correlated with the relative percentage of *C. difficile* infection than in the ECDC PPS 2011-2012, when it was better correlated with the percentage of all gastro-intestinal infections. This observation supports the hypothesis that the diagnosis of *C. difficile* infections improved in several countries since the first PPS. The only unexpected finding was the relatively high use of oral metronidazole or vancomycin in UK-Scotland (Figure 69), compared to the relatively low percentage of CDIs (Figure 22).

The most common indication for antimicrobial use was treatment of a community-acquired infection, accounting for 49% of the prescriptions, similar to the previous ECDC PPS (48%). Treatment of an HAI was the indication for 19% of antimicrobials, also similar to the previous ECDC PPS (21%). As in the 2011-2012 PPS, the prevalence of patients receiving antimicrobials for the treatment of a hospital infection (6.2%) was similar (slightly higher) than the HAI prevalence (5.9%) found in the survey.

Surgical prophylaxis accounted for 14% of antimicrobials used, and was excessively prolonged for more than one day in 54% of the cases, lower than the respective proportion on the previous ECDC PPS (59%). Surgical prophylaxis should cover the peri-operative period only and a single dose is usually enough unless there is extensive blood loss or the procedure is prolonged. One has to bear in mind that the percentage of prolonged surgical prophylaxis is overestimated in the PPS, because a different recall period is used for surgical prophylaxis (24 hours before 8 am on the survey day) and a treatment given for more than one day has a higher probability of being captured in the PPS study than a treatment given for one day only. Nonetheless, comparing this indicator between hospitals (and countries) using the same methodology is valid, and countries with a high percentage of prolonged surgical prophylaxis (Figure 57) may consider specific measures in this area.

Medical prophylaxis accounted for 11% of antimicrobial use, similar to the previous ECDC PPS (11%). Further details regarding medical prophylaxis are scarce in the PPS data because information regarding the infection site for which prophylaxis was given was not collected in the ECDC PPS protocol. The type of antimicrobials used suggested that a considerable proportion of medical prophylaxis was prescribed for the prevention of urinary tract and fungal infections.

The percentage of antimicrobials administered parenterally (73%) was similar to the previous ECDC PPS (71%). Promoting earlier change of parenteral to oral administration of antimicrobials seems to be a priority in several eastern European countries and Portugal (Figure 59). The reason for prescribing the antimicrobial was, on average, well documented but was still absent for one in five prescriptions (Figure 60).

The proportion of broad-spectrum antibacterials among all antibacterials for systemic use, as defined by the ECDC, EFSA and EMA Joint Scientific Opinion, reflects their level of consumption in hospitals and the corresponding selection pressure [34]. These antibacterials correspond to the 'Watch' and 'Reserve' groups of antimicrobials, as defined in the WHO Model Lists of Essential Medicines [56]. The proportion of broad-spectrum antibacterials in the PPS ranged from 20% to more than 60% across the participating EU/EEA countries and the UK. This can, in part, be explained by the differences in prevalence of resistance among a number of reported microorganisms, e.g. MRSA, vancomycin-resistant enterococci or third-generation cephalosporin-resistant Enterobacterales. However, many of these antibacterials are also associated with the emergence and spread of healthcare-associated *Clostridioides difficile* and multidrug-resistant bacteria and in particular for third-generation

cephalosporins, fluoroquinolones and carbapenems, with the emergence of multidrug-resistant gram-negative bacteria [57]. The wide variation and sometimes extensive use of broad-spectrum antibacterials indicates the need to review their indications in many countries and hospitals. Antimicrobial stewardship programmes must be designed to consider both the risk of emergence of AMR and patient safety. Ensuring that broad-spectrum antibacterials are used appropriately is a key element of any strategy against AMR [58].

Among the reasons for change of antimicrobial during the infection episode, the proportion of de-escalation and switch from intravenous to oral administration varied among participating countries. In several countries, de-escalation or switch to oral treatment was uncommon. It was not possible to assess the appropriateness of low proportions of change, as no information was collected about the reasons for continuing or changing antimicrobial. However, both de-escalation and switch to oral treatment likely reflect the result of review of antimicrobial treatment when microbiological information is available, or when the condition of the patient improves, and are recommended measures to support the prudent use of antimicrobials. The proportion of prescriptions that were the result of change was negatively correlated with the composite indicator of antimicrobial resistance, the proportion of broad-spectrum antibacterials among all antibacterials for systemic use and long surgical prophylaxis courses. On the one hand, the correlation partly reflects the challenges in de-escalation and switch from intravenous to oral treatment in countries with high prevalence of antimicrobial resistance. On the other hand, the correlation demonstrates the value of the proportion of prescriptions that were the result of change as a process indicator for antimicrobial stewardship.

Structure and process indicators

The ECDC PPS 2016-2017 provided data on hospital- and ward-level infection prevention and control (IPC) structure and process indicators, developed by ECDC and Member State experts in 2013-2015 according to the key components of the SIGHT project [9]. For this report, the indicators were classified according to the similar WHO core components for hospital infection programmes at healthcare facility level [21] (Table 1). However, it should be noted that the ECDC PPS indicators are different from the variables/indicators published by WHO in 2018 in the self-assessment tool `Infection prevention and control assessment framework at the facility level' (IPCAF, [22]), which were specifically designed to evaluate the implementation of the WHO core components at facility level.

Only three indicators were also collected in the first ECDC PPS in 2011-2012: infection prevention and control staffing levels (number of full-time equivalents), alcohol-based handrub consumption as a proxy indicator of hand hygiene and the percentage of single-room beds as a proxy indicator for isolation capacity.

Indicators for core component one (infection prevention and control programmes) included the presence of an approved annual IPC plan and report, IPC staffing levels and three indicators of microbiological lab support.

Infection prevention and control nurses (IPCN) were present in 85% of hospitals (compared to 86% in 2011-2012) and infection prevention and control doctors (IPCD) in 76% of hospitals (compared to 73% in 2011-2012). The median staffing levels were 1.04 IPCN FTEs per 250 beds (1.00 in 2011-2012) and 0.28 IPCD FTEs per 250 beds (0.36 in 2011-2012). The SENIC standard of 1 FTE IPCN per 250 beds was reached by 51.5% of hospitals, only slightly higher than in 2011-2012 (47%). However, the higher IPCN staffing level proposed in recent scientific literature of 1 FTE per 100 occupied beds [21,59,60] was only reached by 17% hospitals. In this survey we found that IPCN staffing levels of minimum 1.5 FTE per 250 beds were associated with lower levels of antimicrobial resistance in HAIs, with a `dose-response' effect (Figure 80). The lowest AMR levels were observed in hospitals with 2 or more FTE IPCN per 250 beds, which indeed corresponds to approximately 1 FTE per 100 occupied beds.

The number of FTE for IPCDs was not directly comparable with the ECDC PPS in 2011-2012 because in 2016-2017, IPCD antimicrobial stewardship FTEs had to be reported separately in the variable FTE antimicrobial stewardship consultant (which could also include time from specialised consultants not previously counted as IPCD time). The median FTE antimicrobial stewardship consultant was 0.08 FTE per 250 beds, but the mean was 0.37 FTE per 250 beds, showing an important investment in this function in a small group of hospitals, while a high percentage of hospitals (45.7%) reporting no dedicated time for antimicrobial stewardship. There was thus a large variability among participating countries in the human resources available for antimicrobial stewardship as well as in the implemented antimicrobial stewardship strategies. Although in almost all participating countries, some hospitals had a consultant in charge of antimicrobial stewardship, the majority of hospitals still have no or very limited dedicated staff for antimicrobial stewardship.

There was extreme variability in microbiological testing frequency across EU/EEA countries and the UK which was only partially explained by differences in types of patients (case mix) and hospitals. Countries with very low testing frequency (<10 blood cultures per 1 000 patient-days) were all central-eastern EU countries, while countries in the highest testing frequency category (>=50 blood cultures per 1 000 patient-days) were all North- or West-European countries. The blood culture use rate measured as number of blood cultures per 1 000 patient-days was strongly correlated with the prevalence of patients with at least one HAI, also after adjustment for patient case mix and validation results. Almost half of the inter-country variation of the HAI prevalence was explained by this variable. It is thus likely that the blood culture use rate reflects the intensity of the diagnostic testing for HAIs as a whole, which is also supported by the correlation with the (seemingly unrelated) frequency of stool testing for CDI. Hospitals/countries that search more intensively for HAIs by microbiology testing, report a higher HAI prevalence, because they find more infections (for equal risk exposure) and/or because the HAIs in these hospitals are better documented

and therefore more frequently match the HAI case definitions so that they are `eligible to be reported' in the PPS (or in surveillance of HAIs). The association with blood culture frequency of use also remained significant after adjustment for patient case mix (expected HAI prevalence), indicating that it is not because patients are less ill that less diagnostic tests are performed. In addition, the fact that there were no significant associations at country level between respectively 1) the blood culture use rate and the relative frequency of bloodstream infections and 2) the CDI stool testing frequency and the relative frequency of CDIs, corroborates the hypothesis that the inter-country variation of the testing frequency does not merely depend on the frequency of the disease they are designed to diagnose. Furthermore, it should be noted that infections which are not reported as HAI because a diagnostic test is missing to confirm the case definition, will not be detected as a false negative by a validation process either. This means that validation studies alone are not enough to adjust for the variability of the case finding process between countries and that HAI prevalence cannot be interpreted without taking into account an indicator of diagnostic testing (or case finding), in addition to validation parameters (sensitivity and specificity) and patient case-mix adjustment. So far, the blood culture use rate seems to be the best indicator to adjust for diagnostic test intensity of use/case finding, but indicators of other diagnostic processes (e.g. radiologic imaging for the diagnosis of pneumonia, other microbiological tests) should be considered for future PPSs.

Finally, the wide inter-country variation of microbiological sampling/testing frequency observed in this survey across the EU/EEA calls for medical practice guidelines in diagnostic stewardship [61-63]. The potential under-testing gap emphasises the need to enhance access to diagnostic testing in – especially low-resource – EU/EEA countries and the UK because of its impact on the detection, treatment and prevention of infections in general, and HAIs in specific, and by consequence also on the prevention of antimicrobial resistance in EU/EEA hospitals. Without harmonised diagnostic stewardship pathways and case finding approaches, any comparison of HAI prevalence or incidence figures between countries will be compromised.

Indicators tended to be inter-correlated. Hospitals without IPC nurse (0 FTE) were at higher risk of not having an approved IPC plan and/or report. Hospitals with two or more FTE IPC nurses per 250 beds had a 9-fold higher blood culture rate per 1 000 patient-days than hospitals without IPC nurse. Countries frequently performing blood cultures also performed stool tests for *C. difficile* infections more frequently. And in hospitals with clinical microbiological services available on both weekend days, blood cultures were performed 2.2 times more frequently than in hospitals where clinical tests could not be requested during weekends. These findings indicate that when hospitals (or countries) invest more in infection prevention and control programmes, this is reflected at different levels: higher IPC staff levels and also better microbiological services. This combination is expected to result in, for example, improved HAI case finding processes in these hospitals. Higher staffing levels of IPC nurses were indeed associated with higher HAI prevalence. However, in multivariate analysis of IPCN staffing levels, blood culture and stool culture rate, only the blood culture rate remained significantly associated with HAI prevalence.

At country level, the blood culture rate was also strongly associated ($p<0.001$) with indicators from other core components such as the alcohol-based handrub consumption (core component 6), the percentage of beds with an AHR dispenser at the point of care (core component 8) and the staffing levels of registered nurses and nursing assistants (core component 7). It was also associated at the $p<0.001$ level with the percentage of changed antimicrobials. By consequence, all these indicators were also – paradoxically - positively correlated with the HAI prevalence, but none of these associations remained significant after adjustment for the blood culture rate.

This shows again that when countries invest more in infection prevention and control, this is reflected at different levels of the prevention process, including antimicrobial stewardship.

The median alcohol-based handrub consumption was 20.3 litres per 1 000 patient-days, slightly higher than the 18.7 litres per 1 000 patient-days in 2011-2012, again with a large variation from 6.4 litres per 1 000 patient-days in Latvia to 58.7 litres per 1 000 patient-days in Norway. In countries with a national surveillance system in place for alcohol-based handrub consumption in hospitals, the median value compared well with national reports: in Ireland, the PPS figure (PPS in 2017, 2016 data) was 28.5 litres per 1 000 patient-days whereas the national median in 2016 was 29.7 litres per 1 000 patient-days [64]; in Germany, the 2016 PPS (2015 data) median of 101 litres per 1 000 patient-days in ICU wards was slightly lower than the national median of 109 litres per 1 000 patient-days in ICU wards for 2015 in the HAND-KISS surveillance module, and in non-ICU departments the consumption was 22 liters per 1 000 patient-days in the German PPS hospitals, slightly lower than the national median of 26 liters per 1 000 patient-days in HAND-KISS 2015 [65]. The small differences in Germany may be easily explained by the fact that for the PPS data from a representative sample of hospitals were submitted, while many more hospitals participate in the HAND-KISS surveillance, on a voluntary basis.

The median alcohol-based handrub consumption was associated with other indicators related to hand hygiene, i.e. the percentage of beds with AHR dispensers at the point of care and the process indicator of hand hygiene compliance monitoring (number of observed hand hygiene opportunities). At hospital level, the AHR consumption was independently associated with higher percentages of AHR dispensers at the point of care, higher staffing levels of IPC nurses and, importantly, higher staffing levels of nurses (registered nurses and nursing assistants) combined with lower bed occupancy rates. These findings are compatible with previous studies that found that high workload or low staffing levels were associated with inadequate adherence to hand hygiene compliance [9,21,66].

The median percentage of single-room beds in the 2016-2017 ECDC PPS hospitals was 13.6%, slightly higher than in the 2011-2012 PPS (9.9%), but still with very low percentages in most eastern countries (Figure 119) and 36 times more single beds in the highest-ranking country (France, median 51.1%) than in the lowest (Hungary, median 1.4%). The largest hospital-based European survey before the first ECDC PPS looking at infection control indicators – carried out by the EU-funded ARPAC project

in 169 acute hospitals from 32 European countries in 2001 – also found that an insufficient number of isolation rooms was a permanent problem for most hospitals in central-eastern Europe, although the percentage of single-room beds was not measured in that study [67]. Isolation of patients with MRSA in single rooms was shown to be associated with lower MRSA percentages and acquisition, particularly if combined with rapid MRSA detection and contact precautions [68].

Correlations of structure and process indicators with the composite index of AMR in HAIs were easier to interpret. First, it is important to mention that the composite index of AMR was also significantly associated with the blood culture rate at country level, but in the opposite direction (negative correlation). However, the strength of the association was smaller than for HAI prevalence (Spearman's rho -0.40, $p<0.05$). A negative correlation of the blood culture frequency with AMR is expected because in countries performing less frequent microbiological testing, cultures are likely to be performed at a later stage, when empiric treatment of the infection has failed. Importantly, the composite index of AMR was associated with two indicators of antimicrobial stewardship - the prevalence of antimicrobial use and the percentage of antimicrobials changed during treatment – and with three indicators of infection prevention and control – the percentage of beds in single rooms, the staffing levels of infection prevention and control nurses and the percentage of beds with alcohol-based handrub dispensers at the point of care. Alcohol-based handrub consumption was negatively correlated with the composite index of AMR as well, but not independently of the percentage of beds with AHR dispensers at the point of care. Although these observations need confirmation with further (multivariable) analyses at hospital level, they suggest that antimicrobial stewardship aiming at decreasing the use of antimicrobials and changing to more appropriate antimicrobial use when indicated, hand hygiene (and optimal access to AHR dispensers), patient isolation and high staffing levels of infection prevention and control (ideally 2 FTE/250 beds) are crucial factors for the prevention of antimicrobial resistance in acute care hospitals.

We did not find any association between the composite index of AMR or HAI prevalence and the scores of multimodal strategies for HAI prevention at hospital-wide or at ICU level. Multimodal strategy scores also did not correlate with other quantitative IPC indicators, such as the nursing or IPC staffing levels or the percentage of beds with AHR dispensers. However, the multimodal strategy score did correlate significantly with other 'Yes/No' indicators, especially the presence of an approved IPC plan and report (Spearman's rho 0.64, $p<0.001$) and the presence of any post-prescription review procedure (Spearman's rho 0.61, $p<0.001$). On the other hand, we also did not find any correlation between the presence of any post-prescription review procedure and the actual percentage of antimicrobials that was changed during the treatment (measured at the antimicrobial use level for each registered antimicrobial agent). Our results suggest that 'yes/no' (present/not present) indicators collected at facility or ward level behave differently than the quantitative indicators and may be more susceptible to reporting behaviour, rather than reflecting the true presence of well-established procedures, readily available documents or existing structures.

Furthermore, for several of the 'yes/no' variables, especially some of the components of the multimodal strategy, the definitions in the protocol may have been too vague or too complicated. These conclusions were also supported by some of the findings of the on-site visits by the external validation team. Finally, the inconsistent results of the 'yes/no' variables were certainly also influenced by the low quality of the data. The 'yes/no' variables did not only have `yes' and `no' as possible values, but also `unknown' and empty. In several hospitals, only `yes' answers were reported, with other answers were left empty. In these cases, it was impossible to know whether empty meant `no' or unknown. To standardise the analysis for all hospitals and countries, we considered empty and unknown values as `no' if there was at least one `yes' or `no' answer within the variable group (e.g. multimodal strategy for the prevention of pneumonia in the ICU). When all values within a variable group were empty, the values were excluded from the denominator. This approach may have resulted in both over- or underestimations, and certainly in misclassification.

Despite the reliability problems of the multimodal strategy variables, especially affecting inter-country comparisons, the EU/EEA averages of these variables did provide some information. The multimodal strategy score in the ICU was similar to the score at hospital-wide level for the prevention of bloodstream infections and urinary tract infections. However, there was little hospital-wide activity in pneumonia prevention, despite the fact that non-ventilator-associated healthcare-associated pneumonia ('non-VAP HAP') accounts for a substantial proportion of HAIs, in the current survey (13.7% of HAIs, Table 7) and in previous surveys in Europe and the U.S. [7,69,70]. Results also showed that checklists and audits were by far the least implemented components of multimodal strategies in European hospitals, suggesting that more emphasis should be given to the development of tools and training materials in these areas.

Limitations

Data representativeness

Data representativeness in the 2016-2017 PPS was optimal (representative sample and sample size achieved) in 20 (63%) countries and good (sample size achieved) in 10 (31%) countries. Nonetheless, for all results presented in this report, one must keep in mind that the representativeness of the PPS sample was poor for two countries (Bulgaria and the Netherlands). Results for these countries could be heavily biased as a result of the low number of participating hospitals and the low sample size. Low sample size also results in large confidence intervals and might lead to a lack of sufficient numbers to calculate certain indicators, e.g. some of the antimicrobial resistance markers, for which a minimum of 10 isolates with known antimicrobial susceptibility results was required. In addition, two EU Member States – Denmark and Sweden - did not participate in the 2016-2017 survey. This has an impact on the estimates (e.g. of the total number of patients with HAI per year) for the EU/EEA,

where EU/EEA averages needed to be applied on the most recent national denominators of these countries. Also, for the interpretation of the EU/EEA medians and averages, the non-participation of these countries should be considered. It is known from other sources that for indicators of IPC practices and AMR these Scandinavian countries are performing better than the EU/EEA average. Also, in nine countries with a sufficiently large sample size, the representativeness was less than optimal because hospitals participated on a voluntary basis rather than, for example, based on a systematic sampling process as recommended in the protocol. However, when the number of participating hospitals is sufficiently large, even voluntary participation often results in fairly representative samples, as shown in many national HAI surveillance systems. In addition, risk adjustment compensated for differences in patient case mix, including those resulting from less representative samples. Finally, the average length of stay and size of the hospitals in the ECDC PPS were similar to the overall national averages in most countries, which also supported good overall representativeness of the data.

Data validity

The ECDC PPS in 2011-2012 showed that the main result of the ECDC PPS – the HAI prevalence - was by far the most difficult indicator to interpret. The discrepancies between the observed and predicted HAI prevalence were too important to be explained by differences in quality of care and raised concerns about the validity of the data. As a consequence, validation during the national PPSs in 2016-2017 was made mandatory, and ECDC provided financial support to all national PPS coordinating centres to organise a national validation study. Validation studies were carried out in all but three participating countries and found on average 2.3% false negatives and 20.3% of false positives for the presence of an HAI. This resulted in a rather low average sensitivity of 69.6% and a specificity of 98.8%. The interrater reliability (kappa statistic) for the presence of an HAI between primary PPS hospital staff and national validators was on average 0.75, which is considered as `substantial' by some [42] but only as `moderate' by others [43].

As expected, countries with higher HAI prevalence found more false positives on average, resulting in lower specificity. Variations in specificity explained 37% of the variation of the observed HAI prevalence. A multiple regression model of the observed (primary PPS) HAI prevalence at country level including the specificity, the predicted prevalence (case-mix index) and the number of blood cultures per 1000 patient-days explained 84% of the inter-country variation of the HAI prevalence (adjusted R-squared 0.843). Surprisingly however, higher sensitivity was not associated with higher primary PPS prevalence. Indeed, the 2016-2017 PPS revealed that the reported prevalence depended mainly on the intensity of the diagnostic process. When infections lack diagnostic tests necessary to confirm the case definition, then neither the primary PPS team, nor the national validation teams are able to confirm the infection. The external validation teams also frequently flagged the lack of laboratory data (particularly the absence of microbiology data) in combination with the lack of notes, poorly written patient charts and illegible notes as frequently encountered problems during the validation studies. Nonetheless, with 69.4% sensitivity on average in EU/EEA countries and the UK, underreporting clearly did occur independently of microbiological or diagnostic testing, but not more in low prevalence countries than in high prevalence countries, at least not according to the national validation teams. Overall, the relatively low sensitivity resulted in a weighted EU/EEA prevalence of 6.5% (95% CI 5.4-7.8) corrected after validation compared to 5.5% (95% 4.5-6.7) before correction. This resulted in an increase of the estimated number of patients with HAI with approximately 386 000 affected patients from 3.4 million to 3.8 million patients per year [1].

External validation teams found that the national validators with 3.0% false negatives (compared to 2.3% for the primary PPS teams), were probably not overly sensitive in detecting HAI cases, even though the relatively high percentage of false negatives was based on a small number of negative cases presented by the national validators, including, in some countries, difficult cases which were not representative of all negative cases. However, national validators were much more specific than the primary PPS teams, with only 1.8% of false positives (compared to 20.3% for the primary surveyors). These observations suggest that the `net' under-estimation found in the national validation studies (resulting a 1% higher HAI prevalence after correction) is not in itself an over-estimation.

Low sensitivity (false negatives, or underreporting) of HAIs is a frequently encountered problem in national HAI surveillance systems [71-74]. Both low sensitivity and low specificity may be related to one or more of following factors:

- Difficulty in confirming the case definition of an infection if signs and symptoms were not well verified in the patient's records. If possible sources of information were not all verified during the primary PPS data collection, certain elements of a case definition may have been missed, which would result in false negatives if these sources were verified by the validation teams. If certain symptoms are assumed to be present even though they were not documented in any data source, this might result in false positives. Failure to systematically check criteria for all case definitions included in the protocol may also result in incomplete case ascertainment and therefore in false negatives, especially for less severe types of HAI. The external validation study found sub-optimal knowledge of the ECDC protocol to be a major reason for under-reporting, especially in the area of case definitions.
- Not following the definition of the key term 'healthcare-associated': even if the case definition of an infection is matched, hospital PPS staff may decide not to report the infection as 'healthcare-associated' even though it should according to the definition in the protocol. For example, the failure to report an infection with a typical community pathogen that starts after Day 2 of the current hospitalisation as an HAI. More detailed analysis of the national validation study results will allow to partially assess whether this has occurred or not. The recognition of an infection as healthcare-associated still has a negative connotation in many countries, because an HAI is perceived as a medical error. Cultural differences between European countries may result in different reporting behaviour, particularly for the recognition of an infection as

healthcare-associated. Such reporting behaviour is possibly influenced by historical or still existing punitive consequences of reporting HAIs (e.g. to health authorities) or by the fear of a negative financial impact of the (public) disclosure of an existing HAI problem.

While differences in data validity (sensitivity and specificity) and case ascertainment had a major impact on the prevalence of patients with HAIs, the validity of the other HAI data (e.g. isolated microorganisms, types of HAIs, antimicrobial resistance markers, origin of HAIs) are less affected. Therefore, indicators such as relative frequencies and percentage resistance are more valid even though they are based on smaller numbers (large confidence intervals) and the frequency of some types of HAI or microorganisms may be influenced by a specific lack of diagnostic testing or case ascertainment. The strong correlation of the composite indices of AMR in the ECDC PPS with the EARS-Net data supports the validity of AMR data collected in the PPSs. The 36% higher percentage of resistant isolates in HAI in the ECDC PPS was expected given that in EARS-Net a large proportion of isolates are from community-associated bloodstream infections, especially for MRSA and *E. coli* resistant to third-generation cephalosporins [1].

Data validity was less of a problem for antimicrobial use prevalence because sensitivity and specificity of the prevalence of patients with antimicrobial use were high in the national PPS validation surveys, even though also here the correction after validation resulted in a higher mean prevalence of antimicrobial use at EU/EEA level of 34.5% (30.8-37.7) compared to 33.9% before correction. The interrater reliability for the presence of at least one antimicrobial was 0.92 on average, which corresponds to `almost perfect' according to both references used for the interpretation of the magnitude of the kappa statistic [42, 43]. However, the external validation study frequently found problems with some of the other antimicrobial use variables, especially the indication used by the clinician, the reason for change and the start dates of the antimicrobials. The ECDC PPS results showed that the indication for antimicrobial use, in particular the intention to treat a hospital-acquired infection, was strongly correlated with HAI prevalence. Therefore, the prevalence and relative frequency of this indication is subject to the same validity issues as for the prevalence of HAIs, since the indication as perceived by the clinician was often not available in the patient files and was filled by the PPS data collectors. Also here, more detailed analysis of the results of the national validation studies should be performed to assess the reliability of these variables.

Adjustment for patient case mix

Differences in HAI and antimicrobial use prevalence may also be explained to a large extent by differences in patient case mix and types of hospitals and healthcare between countries. The ECDC PPS protocol was designed to be adjustable for many of these differences by including the most important known risk factors for HAIs and antimicrobial use in the protocol. We estimated the number of predicted infections in each hospital and country based on logistic regression models developed on two thirds of the total ECDC PPS database and validated on the remaining third. Standardised infection and antimicrobial use ratios (SIR and SAUR) were calculated as the number of observed over the number of predicted patients with an HAI or on antimicrobials, respectively.

An important limitation of this method of standardisation is that the prediction is made using the database of the ECDC PPS itself as the reference. The risk applied for each of the factors is the average (adjusted) risk for all countries together, i.e. it was not based on a model that assumes all possible infection prevention and antimicrobial stewardship measures were fully implemented. The predicted values should therefore not be interpreted as good practice targets.

Another limitation of applying the European average risk coefficients to each patient in every country is that we assume that each of the risk factors means the same thing across countries. This assumption is probably true for factors such as the presence of invasive devices, but for factors such as the medical specialty, the type of hospitals or even the McCabe score, country-specific differences in the definitions or in the interpretation of the definitions cannot be excluded. In addition, the same risk factor does not necessarily give rise to the same risk in each country. For the factor age for instance, it is well known that large inter-country or genetic differences exist with regard to life expectancy and health status in older age groups. Another example is the patient/consultant specialty `intensive care' (ICU), which was recoded for patients with a different specialty who were on an ICU ward (see methods section, `recoding of variables'). We made this approach in order to harmonise data analysis for all countries, however it may have led to a higher number of ICU patients for some countries than e.g. published in the national PPS reports of these countries and may in some cases overestimate the true number of intensive care patients (e.g. Ireland).

We built a single model for HAIs and another for antimicrobial use. Prediction could be more precise with prediction models for specific types of HAI or antimicrobial use indications. This would, however, be beyond the scope of the current report. Another important limitation of the antimicrobial use model is that the presence of many risk factors could not be ascertained before the start of the antimicrobial treatment, as the start date was not collected for risk factors. Prolonged length of stay, for instance, may also be the consequence of the reason for prescribing the antimicrobials (e.g. an infection), therefore the antimicrobial use model is conceptually less robust than the HAI model. In the HAI model, however, the length of stay was calculated as being until onset of infection, the presence of intubation and urinary catheters was only included if present before onset of pneumonia or urinary tract infection, respectively, and the protocol specified that the McCabe score had to be estimated without (before) the influence of an HAI, if one was present. For both models, we excluded the presence of a central and peripheral vascular catheter because of the correlation with parenteral antimicrobial treatment.

Burden estimates

Point prevalence surveys are generally accepted as a cost-effective way of gathering hospital-wide information on all types of HAI. Hospital-wide surveillance of HAIs is very resource-intensive and the US CDC National Nosocomial Infections Surveillance system (NNIS) discontinued its hospital-wide surveillance component in 1999 partly because too few hospitals had sufficient resources to perform hospital-wide surveillance using NNIS methods [75,76]. Since then, the US CDC and other national HAI surveillance systems have used only targeted surveillance protocols, most frequently for infections acquired in ICUs and targeted surveillance of surgical site infections, or for specific microorganisms. Repeated prevalence surveys at hospital-wide level are a valuable and sustainable alternative method for hospital-wide surveillance of all types of HAI, at least for specific surveillance objectives, e.g. estimation and follow-up of the burden of HAIs and antimicrobial use, identification of priorities for infection prevention and control and antimicrobial stewardship, increasing HAI surveillance and IPC skills, raising awareness at hospital-wide, regional, national and international level, evaluation of regional or national interventions (depending on the frequency of the outcome under evaluation and comparability of the repeated sampled populations). The objectives of continuous surveillance that cannot, or much less, be met by prevalence surveys are HAI prevention at hospital level through continuous participation in surveillance networks with feedback of risk-adjusted HAI rates, as well as the detailed follow-up of trends, including evaluation of IPC measures and detection of new epidemics. As HAIs are relatively rare events, only surveillance can provide stabilised baseline infection rates needed for benchmarking at hospital level to meet these objectives.

Prevalence surveys only allow a direct estimate of the total number of patients with an HAI or on antimicrobials on a given day. There is, however, a mathematical relationship between prevalence and incidence which theoretically enables a conversion from prevalence into incidence and vice versa, taking into account the length of hospital stay of infected and non-infected patients as well as the time from admission to HAI onset [38, 77]. To estimate the total annual number of patients with HAIs in Europe, we used the Rhame and Sudderth formula as done in the 2011-2012 ECDC PPS [5]. A major problem with this method is that the formula is based on length-of-stay data of the 'incidence series', which would only be known if hospital-wide surveillance had been performed during the same period. In a study by Gastmeier, et al. that combined the two approaches (simultaneous surveillance and nested PPS) to validate the relationship of incidence and prevalence, the Rhame and Sudderth formula performed well, even though the authors did not recommend its use on a routine basis because repeated PPSs are indeed inferior to continuous surveillance as a tool for HAI prevention, in particular for targeted surveillance [78]. For the ECDC PPS, length of stay for all patients was collected at the hospital level for the year preceding the survey, which was used as a proxy for the length of stay in the year of the survey. To approximate the length of stay for patients with an HAI, we used the observation that the hospital length of stay from the previous year was well correlated with the median length of stay until survey date (Figure 7). We therefore used both the mean and median length of stay from HAI onset until the day of the PPS as the denominator in the Rhame and Sudderth formula. We calculated the point estimate of the incidence as the average with a wide 95% confidence interval encompassing confidence intervals of both estimates and which expresses the high degree of uncertainty inherent in the incidence and burden estimates. In addition, we performed sensitivity analyses using a recent methodology based on the Grenander estimator of the Rhame and Sudderth parameters [39] which yielded an estimate for participating EU/EEA countries and the UK (before correction for validation) of 3.19 million patients per year, close to the estimate of 3.29 million patients reported in Table 22. Considering the wide CIs, this gave more weight to our estimates (see Supplement of [1]). However, at individual country level, differences between the two methods were more important, with the Grenander estimates being more than 10% lower in 15 countries (in particular in Germany) and more than 10% higher in seven (in particular in United Kingdom).

Finally, burden estimations are strongly dependent on the denominator data available both at hospital and at national level, and part of these differences may be due to different definitions of these denominator data (different inclusion of patients). This could explain differences between the mean length of stay from denominator data and the Grenander estimator of the mean length of stay which is based on the actual distribution of the length of stay of the patients included in the PPS. In addition, different inclusion of patients in the total number of discharges at national level will also influence the burden estimations, because the estimated incidence percentage from the Rhame and Sudderth conversion is applied to these national denominators in order to calculate the estimated number of patients with HAI per year. For example, in Czechia, it is known that the total number of discharges are overestimated with approximately 20% because transfers of patients between wards are counted as separate hospital stays.

Structure and process indicators

The infection control structure and process indicators collected at the hospital level in the ECDC PPS need to be interpreted with caution since they may, in some cases, not necessarily reflect what they are supposed to measure. Learning from the 2011-2012 ECDC PPS, questions about the interpretation of structure and process indicators were included in the validation protocol. The first concern was that partial FTEs were not correctly reported by some hospitals (e.g. 0.5 FTE reported as 0 FTE). However, national validation teams found correct FTE reporting in 96% hospitals, and other reasons for incorrect FTE reporting in the remaining 4%. Another issue also mentioned for the first ECDC PPS was that the reported FTE specialised infection control staff did not always reflect the actual time spent on infection control/hospital hygiene-related tasks, nor the quality of the specialised training as an infection control nurse or doctor. Finally, in the first ECDC PPS, Czechia and Estonia mentioned that the presence of infection control staff was a condition to be included in the survey. As the number of participating hospitals in both these countries increased considerably for the ECDC PPS 2016-2017, the representativeness of the data was not or much less affected by this problem in the current survey.

As for the new variable `FTE antimicrobial stewardship consultant', several data quality problems were found during data validation. Firstly, the definition of antimicrobial stewardship consultant which required mentioning of antimicrobial stewardship activities as part of the job description, was not respected in 25% of hospitals reporting at least some FTE antimicrobial stewardship consultant. This item therefore deserves more attention in future PPS training activities. The larger problem, i.e. the fact that antimicrobial stewardship activities were not part of any job description in 43% of hospitals, can only be addressed by national and/or local hospital management recognising the importance of the function of antimicrobial stewardship consultant. Secondly, in some countries (e.g. France), antimicrobial stewardship FTEs for 250 beds were overestimated because the reported number of FTEs did not take account the fact that antimicrobial stewardship consultants worked in several hospitals. Thirdly, national validation teams reported that in 28% hospitals, the FTE antimicrobial stewardship were not correctly distinguished from the FTE infection prevention and control. By consequence, in these hospitals, the reported FTE IPC doctors was likely overestimated. The latter issues should also be addressed by future training activities.

Another aspect which was verified during the national validation studies was the way the number of litres of alcohol-based handrub is collected. In the majority of hospitals, (57%) this was based on volumes dispensed by the hospital pharmacy to the wards and in 27% on volumes purchased by the hospital pharmacy in the given year. These quantities were not necessarily used by the healthcare workers in the same year. Used quantities were only reported by 14% of hospitals. In addition, the indicator does not take into account the consumption of other hand hygiene agents (e.g. medicated liquid soap), the wastage of handrub (e.g. replacement of handrub dispensers before they are empty), handrub usage for other purposes than hand hygiene and does not distinguish between usage by visitors, patients and healthcare workers.

Single rooms may be primarily used for private patients (against supplemental fees, thus generating additional income for the hospital) or for purposes other than the isolation of patients with 'alert' microorganisms.

The external (international) validation team found the multimodal strategy to be the IPC indicator with the highest number of discrepancies. Both under- and over-reporting of items were detected, most commonly over-reporting, of the elements feedback and training. There was a large variability in the understanding and interpretation of the multimodal strategy elements, partially due to difficult or unprecise definitions - often complicated by translation problems - and partially because 'yes/no' variables are susceptible to wishful 'yes' reporting, depending on what the perception is on how the data will be used and the consequences of reporting harmful events. We found indeed no consistent or only weak correlations between quantitative indicators and the dichotomous 'yes/no' indicators. The external validation teams also confirmed problems with other such variables, e.g. the annual IPC report or availability of microbiology services at weekends. Maintaining or replacing these variables for future PPSs should be discussed, as spending more time on these items during training courses may not solve the problems of translation and especially of over-reporting of 'yes' answers in some hospitals/countries, which make inter-hospital or inter-country comparisons of these indicators invalid. Finally, there were difficulties in interpreting the frequently missing values of 'yes/no' variables as either `no' (item not present) or unknown (see higher in discussion section). This is another problem inherent to this type of variables which is difficult to overcome and contributes to the fact that 'yes/no' variables are less robust than numeric indicators.

Correlations

The correlations presented in this report between structure and process indicators of IPC and antimicrobial stewardship and other indicators such as the composite index of AMR and the prevalence of HAIs should be interpreted with caution. Correlations of variables measured at the same time in cross-sectional observational studies do not imply that there is a causal relationship between them. Criteria of causality such as those proposed by Bradford Hill in 1965 [79], should be used to evaluate the correlations. In the best-case scenario - with some criteria being met and no criteria violated - the correlations can merely suggest hypotheses, support existing evidence and possibly recommend future studies.

The first criterion that needs to be considered for cross-sectional studies is the principle of temporality. An indicator could equally precede or be the consequence of the other indicator ('chicken or egg' problem). For example, the observation that the composite index of AMR decreased for increasing levels of the consumption of alcohol-based handrub did not hold for Greece and to a lesser extent for Cyprus (Figure 101), suggested that the high AHR consumption in these countries may be the

reflection of increased efforts to control higher levels of antimicrobial resistance. However, as the high AHR consumption in Greece and Cyprus was also observed in the 2011-2012 PPS, it also seems likely that use of AHR for other purposes than hand hygiene (e.g. environmental cleaning and disinfection) is the reason for the unexpectedly high consumption in these countries. Furthermore, several structure and process indicators assumed to be on the `predictor-side' of the association were reported for the year preceding the PPS, while the `outcome' variables (composite index of AMR, prevalence of patients with at least one HAI or at least one antimicrobial) reflect the situation on the day of the PPS. Data for the most recent year were reported for AHR consumption, the number of blood cultures, the number of stool tests for CDI, the number of hand hygiene observations and the hospital denominator data (number of patient-days and number of discharges). For these indicators, it is therefore known that they preceded the outcome. The other indicators such as the staffing levels (FTEs), the number of single rooms and airborne infection isolation rooms and the multimodal strategy components usually reflected the situation on the day of the PPS. Several of these indicators however can be expected to remain stable across months or even years (e.g. number of single rooms).

Secondly, any third variable related with both the `predictor' indicator and the `outcome' variable may explain an observed correlation (also referred to as confounding). We assumed that this was the case for the correlation between the blood culture rate and the frequency of stool testing for CDI (Figure 90), where we hypothesised that the underlying factor explaining the correlation is the overall intensity of diagnostic testing, or at least of microbiological laboratory support. Therefore, we also assumed that the correlation between the blood culture rate and the HAI prevalence was mainly explained by the intensity of diagnostic testing, the more as both correlations were independent of patient case-mix severity. More complex to explain are associations between e.g. the blood culture rate and the FTE IPC nurses. One possibility is a direct effect of IPC nurses on better implementation of guidelines for HAI prevention (including case finding algorithms). Another potential explanation is that when hospitals invest more in IPC and/or antimicrobial stewardship, this is reflected at different levels in several indicators, but not necessarily with a direct relationship between them. A third explanation is that all this is basically driven by the hospital's financial resources, which depend to a large extent on the national investment in health care, which depends on the gross domestic product per capita of the country and the percentage of the GDP dedicated to health functions. This mechanism may explain the observed correlation at country level between e.g. the staffing levels of registered nurses and nursing assistants per 100 beds and the blood culture rate on one hand and the HAI prevalence on the other. However, in multivariate analysis, only the blood culture rate (and patient case-mix severity) remained significantly associated with the HAI prevalence, supporting the hypothesis that the diagnostic (case finding) process is (one of) the main driver(s) of the reported prevalence of HAIs.

Further multivariable analyses are needed to better understand and confirm the correlations described in the current report. In addition, other study designs be required to confirm some of the hypotheses generated from these observations.

Conclusions

The 2016–2017 ECDC PPS was the second EU-wide point prevalence survey of healthcare-associated infections and antimicrobial use in acute care hospitals and the largest European PPS performed to-date in a total of more than 1 200 hospitals from 27 EU/EEA countries and the UK (United Kingdom counted as one country) and Serbia. All countries used the same standardised protocol developed during a collaborative effort involving numerous experts from Member States and from the international level, and including several support projects outsourced by ECDC to perform national validation studies and external (international) validation visits.

The ECDC PPS confirmed that healthcare-associated infections are a major public health problem in the EU/EEA with a corrected prevalence of 6.5% (95%cCI: 5.4–7.8%) or 98 166 (95%cCI 81 022-117 484) patients with an HAI on any given day in European acute care hospitals. Based on findings from the PPS, the estimated total annual number of patients with an HAI in acute care hospitals in EU/EEA was 3.8 million, albeit with a wide confidence interval of 3.1 million to 4.5 million patients. The number of HAI episodes per year in EU/EEA acute care hospitals was estimated at 4.5 million (95% cCI: 2.6–7.6 million). An unprecedented validation effort with national validation studies performed by 24 EU/EEA countries, the four UK administrations and Serbia, including a total of 241 validated hospitals and 12 447 validated patient files, made these estimates the most robust estimates of the number of HAIs in EU/EEA to-date.

The epidemiology of healthcare-associated infections in 2016-2017 at European level was similar to that in 2011-2012. ICU patients, haematology/bone marrow transplantation and burns care patients were at the highest risk of an HAI. The five most common types of HAI were pneumonia, urinary tract infections, surgical site infections, bloodstream infections and gastro-intestinal infections. Also, the five most frequently isolated microorganisms in HAIs were the same, although *Klebsiella* spp. increased from rank 5 in 2011-2012 (8.7% of microorganisms) to rank 3 in 2016-2017 (10.4%), probably reflecting the ongoing epidemic of carbapenem-resistant gram-negative bacteria in Europe. The relative frequency of *C. difficile* increased from 5.4% of all microorganisms in 2011-2012 (rank 8) to 7.3% in 2016-2017 (rank 6), reflecting the ongoing epidemic of virulent *C. difficile* strains across European countries as well as improved diagnostic testing.

The overall prevalence of antimicrobial use extrapolated to the total number of occupied beds corrected after validation was 31.4% (27.7-35.3%) and 472 525 (416 771-531 520) patients were estimated to receive at least one antimicrobial on any given day in European acute care hospitals in 2016–2017. Hungary recorded the lowest standardised antimicrobial use ratio (adjusted for patient case mix) and Greece the highest. Prolonged surgical prophylaxis and high use of broad-spectrum antimicrobials

were frequent in many European acute care hospitals and should be a priority target for future efforts on antimicrobial stewardship.

The 2016-2017 ECDC PPS collected a large number of structure and process indicators of infection prevention and control and antimicrobial stewardship for the first time. Perhaps the most striking finding was the extreme variability of microbiological testing across EU/EEA countries and the UK, as measured by two indicators, the number of blood cultures and the number of stool tests for CDI, expressed per 1 000 patient-days. The testing frequency explained almost half of the variation of the HAI prevalence between countries and was not explained by differences in patient case mix or type of hospitals. EU-wide efforts to harmonise basic diagnostic testing in European acute care hospitals should be prioritised to enable inter-country comparisons of HAI prevalence and incidence, improving prevention of HAIs and antimicrobial resistance as well as ensuring appropriate treatment of patients with an HAI.

Antimicrobial resistance data in HAIs collected in the ECDC PPS 2016-2017 were validated through a strong correlation of the composite index of AMR between the ECDC PPS and ECDC's EARS-Net surveillance of AMR. Correlations between the composite index of AMR and indicators of antimicrobial use and IPC supported existing evidence for AMR prevention and control. Lower prevalence of antimicrobial use, a higher percentage of antimicrobials that were changed during treatment, higher staffing levels of IPC nurses, a higher percentage of beds with alcohol-based handrub dispensers at the point of care and a higher percentage of beds in single rooms were all associated with lower levels of AMR. These observations support further investment in antimicrobial stewardship, IPC staff and structural changes to the hospital environment to improve isolation capacity and access to hand hygiene products. In addition, low nursing staffing levels combined with high occupancy rates were also associated with lower AHR consumption at hospital level, supporting the WHO recommendation that care worker staffing levels should be appropriate to patient workload in order to reduce the risk of HAI and the spread of AMR [21].

While major steps have been taken in increasing the HAI surveillance skills and the awareness of healthcare workers across Europe, more training to harmonise the interpretation of case definitions as well as continued validation efforts are needed before reliable comparisons of – even risk-adjusted – prevalence figures for HAIs between countries can be made. Direct comparison of HAI prevalence percentages between countries were not an objective of the ECDC PPS and these cannot be made without taking patient case mix, confidence intervals, indicators of diagnostic testing and data validity into account. Validation results could only be used to correct prevalence estimates at the EU/EEA level, as national validation samples were mostly too small and could only be considered as representative for the national PPS in 10 countries (with the largest validation study performed in Portugal). With an average percentage of HAIs that were detected/reported (sensitivity) of 69.4% and an average specificity of 98.8% (with 20.3% of false positive HAIs), the overall performance of the primary PPS teams still showed room for improvement, emphasising again the importance of training in HAI case definitions. Data validity was much less a problem for the prevalence of antimicrobial use in the ECDC PPS. The interrater reliability for the presence of an antimicrobial was `almost perfect' with an average kappa statistic of 0.92.

The results were largely comparable to those of the 2011–2012 PPS, which is both reassuring in terms of methodology but disappointing in terms of little change of prevention of healthcare-associated infections and antimicrobial prescription practice in European acute care hospitals in the past five years.

The prevention of HAIs and antimicrobial resistance in European healthcare institutions requires the continued implementation of existing guidelines and recommendations (see Recommendations chapter). Specific recommendations from the findings of the 2016-2017 ECDC PPS include:

- an urgent need to diagnostic stewardship and improve access to microbiological diagnostic testing in EU/EEA hospitals;
- increasing IPC staffing levels to (ideally) 1 FTE IPC nurse per 100 occupied beds;
- improving hand hygiene, in particular by ensuring easy access to alcohol-based handrub dispensers at the point of care and ensuring appropriate nursing staffing levels in accordance with workload;
- ensuring sufficient isolation capacity for patients with alert microorganisms;
- reducing inappropriate antimicrobial use by targeting prolonged surgical prophylaxis and the use of broad-spectrum antimicrobials, increasing post-prescription review of antimicrobial treatments and ensuring dedicated skilled personnel and time for antimicrobial stewardship consultancy.

Further analyses of the ECDC PPS data are needed, e.g. to study risk-adjusted differences between the 2011-2012 and the 2016-2017 ECDC PPSs, to confirm and interpret observed correlations of indicators of IPC and antimicrobial stewardship with outcome indicators at country and hospital level, to identify case definitions and other variables with validity problems in order to tailor PPS training materials and improve the methodology of future PPSs.

Recommendations

At least 20% of HAIs are estimated to be preventable by sustained and multifaceted infection prevention and control programmes, including surveillance of HAIs. The proportion preventable by employing current evidence-based strategies is the highest for device-associated infections and surgical site infections [36,80-82].

Optimal prevention of HAIs and antimicrobial resistance in European healthcare institutions requires the continued implementation of existing guidelines and recommendations such as the WHO guidelines on core components of infection prevention and control programmes [21] and on prevention of surgical site infection [83], ESCMID guidance on prevention of *C. difficile* infections [84] and the EU Council Recommendation (2009/C 151/01) on Patient Safety, including the Prevention and Control of Healthcare Associated Infections [8], whose main components with regard to HAI prevention and control are reiterated below.

- Have infection prevention and control programmes in place at national and hospital level, including recommendations on organisational and structural arrangements, diagnostic and therapeutic procedures (for example antimicrobial stewardship), resource requirements, surveillance objectives, training and information to patients.
- Continue the development of guidance on the prevention and control of HAIs and antimicrobial resistance at the EU level and have guidelines available at national and hospital level.
- Improve surveillance by:
  - repeating national point prevalence surveys of HAIs to monitor the burden of HAIs in all types of healthcare institutions, to identify priorities and targets for intervention, to evaluate the impact of interventions and to raise awareness,
  - ensuring that surveillance of targeted types of HAI is in place, e.g. surveillance of HAIs in ICU and surveillance of surgical site infections,
  - implementing surveillance systems for the timely detection and reporting of alert healthcare-associated organisms and strengthening the ability to respond to the spread (including across borders) of such organisms and prevent their introduction into healthcare settings,
  - developing an evaluation system with a set of indicators in Member States to assess the implementation of the strategy/action plan and its success in improving the prevention and control of HAIs.
- Enhance infection prevention and control staffing and training by:
  - ensuring adequate numbers of specialised infection control staff with time set aside for this task in hospitals and other healthcare institutions,
  - improving the training of specialised infection control staff and better aligning qualifications between Member States.
- Improve information for patients and strengthen their involvement in compliance with infection prevention and control measures.
- Develop research at EU level in the area of the prevention and control of HAIs, including studies on cost-effectiveness of prevention and control measures.

Regarding recommendations for the improvement of antimicrobial prescribing in hospitals, it is important to bear in mind the principles of the Council Recommendation of 15 November 2001 on the prudent use of antimicrobial agents in human medicine (2002/77/EC) [85] and adhere to evidence-based guidance on antimicrobial use where available [86].

Based on 2016-2017 ECDC PPS results, we propose following specific recommendations in the area of prevention and control of HAIs, antimicrobial resistance and antimicrobial use in acute care hospitals.

- There is an urgent need to harmonise diagnostic stewardship [61-63] and support access to adequate diagnostic testing across EU/EEA countries and the UK. The need to improve diagnostic laboratory testing capacity for HAIs was already identified in the 2011-2012 ECDC PPS. New indicators collected in the 2016-2017 ECDC PPS showed an extreme variability of sampling practices/diagnostic testing use across European hospitals and countries which compromise the validity of HAI prevalence data and therefore also the prevention of HAIs and AMR because of poor case finding in countries with low diagnostic activity. Possible actions to tackle this problem include 1) performing an in-depth analysis of the mechanisms behind little diagnostic testing (e.g. clinical diagnostic algorithms, medical guidelines, laboratory test financing/reimbursement mechanisms, cultural aspects, etc.); 2) developing EU-wide guidance on best practice for diagnostic stewardship in EU/EEA acute care hospitals; 3) developing support mechanisms for low-resource countries to enable them to comply with agreed guidance and international standards of sampling practices/diagnostic testing; 4) monitoring the implementation of agreed guidance using an extended set of indicators of diagnostic testing, including blood culture and CDI testing, but also indicators of other crucial diagnostic tests e.g. X-rays for suspicion of pneumonia or urine cultures.
- Increase the target staffing level for IPC nurses in EU/EEA acute care hospitals from 1 per 250 beds (SENIC study-based standard, [36]) to the recently recommended ratio of 1 IPC nurse per 100 occupied beds [22,59,60].
- Prioritise the placement of alcohol-based handrub dispensers at the point of care, i.e. aim for 100% of hospital beds with AHR dispensers within arm's reach.

- Ensure sufficient nursing staffing levels in accordance with workload to enhance compliance with hand hygiene protocols.
- Ensure sufficient isolation capacity for patients with alert microorganisms in acute care hospitals, especially when rebuilding hospitals.
- Develop or improve antimicrobial stewardship programmes to improve antimicrobial prescribing in acute care hospitals, in particular:
  - ensuring dedicated skilled personnel and time for antimicrobial stewardship consultancy;
  - promote the practice of post-prescription review of antimicrobial treatment and changing the prescribed treatment if appropriate, prioritising if possible changing the route of administration from parenteral to oral when possible and de-escalation of the antimicrobial spectrum;
  - rationalise the use of broad-spectrum antimicrobials (e.g. carbapenems);
  - reduce the excessive prolongation of surgical prophylaxis;
  - reduce the use of antimicrobials for medical prophylaxis;
  - improve the documentation of the reason for antimicrobial prescribing in the clinical notes.
- Implement standardised surveillance of HAIs, including surveillance of *C. difficile* infections at local, national and EU level.
- Enhance EU surveillance of HAIs with carbapenem-resistant gram-negative bacteria
- Support the timely detection of new epidemics with alert microorganisms and support the implementation of appropriate prevention and control measures accordingly.

Even though we did not find any results supporting the role of multimodal strategies in the prevention of HAIs and AMR in the 2016-2017 PPS, these findings were due to poor validity of the indicators used to measure the implementation of these strategies. Numerous other studies support the effectiveness of these strategies to improve IPC practices and reduce HAIs, particularly hand hygiene compliance, central line-associated bloodstream infections, ventilator-associated pneumonia and infections caused by MRSA and *C. difficile* [9,21,82]. The implementation of multimodal strategies is therefore crucial, and typically includes three to five of the following components: system change; education; awareness raising; bundle-based strategies; promotion of a patient safety culture, including leadership engagement and positive reinforcement strategies; and increased accountability via monitoring and timely feedback [21].

In addition to the recommendations for the prevention of HAIs and the improvement of antimicrobial prescribing in acute care hospitals, the experience of the ECDC PPS suggests the following recommendations for future repeated PPSs in Europe:

- EU-wide PPS initiatives can increase surveillance skills in Member States as well as enable countries to execute studies using a common protocol. However, considerable additional training of healthcare workers is needed to harmonise the interpretation of HAI case definitions, IPC and antimicrobial stewardship indicators and other key terms in the ECDC PPS protocol.
- National PPSs should be repeated at least once every five years. ECDC will organise a third coordinated PPS in European acute care hospitals in 2022, but will also support the organisation, data collection, validation and analysis of national PPSs during the years in between.
- The ECDC PPS protocol should be evaluated and adjusted where needed. Particular emphasis should be given to revising, replacing or removing indicators or variables with important validity problems (especially yes/no indicators), adding more indicators of the frequency of diagnostic testing and removing variables for which the added value is questioned.
- Develop a standardised indicator of HAI prevalence taking into account differences in patient case mix and type of hospital, differences in diagnostic (especially microbiological) testing and results of nationally representative validation studies.

Finally, a number of results from the 2016-2017 ECDC PPS support recommending electronic (automated) surveillance of HAIs and/or antimicrobial resistance in European hospitals:

- Automated data transmission from hospital microbiological laboratories improves the timeliness of detecting alert microorganisms at regional, national and European level and thereby enables timely national and international coordinated response to outbreaks.
- The main recommendation of the 2016-2017 PPS, i.e. the need to harmonise diagnostic stewardship and support access to adequate diagnostic testing, should also improve the availability of electronic data in European hospitals.
- Conventional surveillance of HAIs and/or AMR as part of surveillance networks is still only performed by approximately half of European hospitals (with 25% of hospitals not participating in any such surveillance network), despite the fact that surveillance has been recommended as an essential measure for HAI and AMR prevention since several decennia. Electronic surveillance could reduce the workload of surveillance and may increase the sustainability and coverage of surveillance systems at the longer term.
- The implementation of automated case detection algorithms will improve the comparability of HAI incidence rates because the case finding process of surveillance staff with variable specificity and sensitivity is replaced by standardised automated algorithms which do not vary between hospitals with similar availability of electronic (diagnostic, pharmaceutical, clinical, administrative) databases.

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Annex 1. Tables

Table A1.1. Distribution of patient risk factors by country, patient-based data only

Country	N of patients	Median age (years)	Age category						Sex ratio M:F	Median length of stay until day of th PPS (days)	% Surgery since admission	McCabe score				Invasive device use			
			% < 1 month	% 1–11months	% 1–17 years	% 18–64 years	% 65–84 years	% 85+ years				% Non-fatal	% Ultimately fatal	% Rapidly fatal	% Missing	% CVC	% PVC	% Urinary catheter	% Intubation
Austria	13 461	67	1.2	2.3	3.9	39.3	41.4	11.9	0.87:1	6	29.7	77.8	17.8	3.2	1.3	9.6	47.2	14.7	1.4
Belgium	11 800	67	3.0	2.1	4.1	37.1	39.3	14.4	0.81:1	7	30.3	61.8	15.9	5.8	16.5	12.1	36.7	12.3	1.8
Bulgaria	2 200	61	3.7	1.7	7.3	46.0	37.5	3.8	0.96:1	4	27.1	86.9	6.4	2.1	4.6	5.6	72.4	18.6	3.8
Croatia	5 806	63	2.9	1.2	4.2	44.2	40.2	7.3	1.02:1	7	21.3	74.0	19.1	4.8	2.2	5.3	51.6	20.2	2.3
Cyprus	1 036	63	6.5	1.4	5.5	39.4	38.5	8.8	0.95:1	6	32.0	70.9	10.4	6.9	11.8	6.9	72.2	30.3	3.6
Czechia	15 117	66	3.9	1.9	5.4	35.6	41.8	11.4	0.85:1	6	31.4	63.4	22.9	9.4	4.2	8.3	43.0	24.3	3.2
Estonia	3 287	63	2.9	2.0	6.6	40.7	36.1	11.7	0.87:1	8	20.5	71.4	20.5	6.7	1.4	6.8	36.4	11.1	2.3
Finland	9 079	66	5.5	1.7	4.3	36.7	40.3	11.6	0.91:1	4	26.1	62.1	27.7	5.0	5.1	6.5	51.1	19.5	2.1
France	16 522	69	4.4	0.9	3.2	34.8	36.7	20.1	0.95:1	8	22.9	51.1	18.3	8.2	22.4	5.2	27.1	11.8	1.7
Greece	9 401	64	2.7	2.3	5.7	39.5	39.8	9.9	1.15:1	6	26.3	60.3	18.0	6.5	15.2	13.0	72.8	35.1	4.5
Hungary	20 588	66	0.4	3.4	2.9	39.7	42.9	10.7	0.69:1	9	19.0	63.8	10.9	3.9	21.5	3.5	24.5	13.2	1.4
Iceland	633	66	3.6	1.6	4.7	36.8	37.1	16.1	0.85:1	10	26.0	74.4	19.4	3.8	2.4	7.1	32.1	16.5	1.9
Ireland	10 333	67	4.9	1.4	4.0	35.8	41.1	12.7	0.92:1	6	17.9	76.8	3.9	18.1	1.2	7.7	48.7	13.3	1.7
Italy	14 773	68	3.3	1.4	3.9	35.3	43.3	12.8	1.04:1	7	32.2	66.8	17.7	7.6	7.9	14.9	64.2	28.9	3.4
Latvia	3 807	63	2.4	1.8	8.0	41.1	39.6	7.1	0.84:1	5	25.0	59.4	3.9	2.1	34.6	4.1	55.6	10.5	0.7
Lithuania	12 415	66	1.6	1.2	8.1	36.7	40.2	12.2	0.77:1	7	18.2	69.7	1.2	5.9	23.3	3.2	36.3	5.6	0.6
Luxembourg	2 018	63	4.8	0.5	4.1	43.3	36.1	11.1	0.91:1	8	28.9	81.6	14.1	3.3	1.0	9.1	33.3	10.2	1.7
Malta	961	69	4.8	1.2	4.6	31.0	45.6	12.8	0.96:1	6	22.5	0.0	0.0	0.0	100.0	5.8	51.5	14.8	0.9
Netherlands	4 441	68	3.9	0.0	5.1	34.0	43.7	13.4	0.88:1	5	27.7	81.6	12.2	3.9	2.4	5.3	56.7	19.4	1.3
Poland	21 712	61	3.6	2.1	8.0	44.2	35.1	7.1	0.95:1	5	25.0	78.0	13.7	4.0	4.3	7.3	53.2	16.5	3.0
Portugal	16 982	67	3.9	0.9	2.9	37.9	41.1	13.3	1.07:1	8	27.4	69.9	23.1	5.7	1.2	8.2	64.8	21.1	2.6
Romania	11 443	60	4.9	1.9	5.9	47.3	36.3	3.6	0.90:1	4	27.8	74.4	9.7	8.6	7.3	4.7	68.1	13.6	3.5
Slovakia	7 990	61	4.1	2.1	6.4	43.1	37.5	6.8	0.84:1	5	17.1	82.1	12.5	2.8	2.6	4.7	46.2	15.9	1.7
Slovenia	5 720	65	3.2	1.3	5.5	39.0	40.9	10.2	0.95:1	6	32.0	72.0	19.7	6.9	1.4	9.4	48.3	19.2	3.1
Spain	19 546	67	3.1	1.4	3.8	37.6	40.7	13.4	1.08:1	6	29.7	72.7	21.0	6.3	0.0	11.4	72.1	19.1	2.0
UK-England	20 148	70	3.0	2.7	2.9	31.7	39.4	20.2	0.87:1	7	21.7	63.7	20.9	4.6	10.8	7.2	43.1	20.3	1.9
UK-Northern Ireland	3 813	68	4.0	0.0	5.0	35.4	41.1	14.5	0.86:1	6	16.0	65.0	19.3	4.8	11.0	5.4	52.8	17.8	2.0
UK-Scotland	11 623	71	2.9	1.3	2.6	32.6	42.5	18.1	0.82:1	8	19.8	59.6	28.7	11.0	0.8	4.9	35.9	19.7	1.2
UK-Wales	6 400	74	2.1	1.1	2.3	27.1	46.2	21.2	0.88:1	8	18.8	0.0	0.0	0.0	100.0	4.3	35.9	16.3	1.6
EU/EEA	**283 055**	**66**	**3.2**	**1.8**	**4.6**	**37.8**	**40.1**	**12.6**	**0.91:1**	**6**	**24.9**	**66.6**	**16.3**	**6.2**	**11.0**	**7.5**	**48.7**	**17.7**	**2.2**
EU/EEA P25	**3 810**	**63**	**2.9**	**1.2**	**3.8**	**35.4**	**37.5**	**9.4**	**0.85:1**	**6**	**20.1**	**62.0**	**10.1**	**3.5**	**1.4**	**5.1**	**36.4**	**13.3**	**1.5**
EU/EEA P50	**9 401**	**66**	**3.6**	**1.4**	**4.6**	**37.6**	**40.2**	**11.9**	**0.90:1**	**6**	**26.0**	**69.9**	**17.7**	**5.0**	**4.6**	**6.8**	**48.7**	**16.5**	**1.9**
EU/EEA P75	**14 945**	**68**	**4.2**	**2.0**	**5.8**	**40.9**	**41.6**	**13.9**	**0.96:1**	**8**	**29.3**	**75.6**	**20.1**	**6.9**	**15.8**	**8.7**	**60.4**	**19.9**	**3.1**
Serbia	14 982	61	4.5	3.2	6.6	43.6	38.8	3.3	0.92:1	6	26.4	80.1	11.8	4.9	3.1	4.9	60.0	19.8	2.2

CVC: central vascular catheter; PVC: peripheral vascular catheter; EU/EEA P25: 25th percentile of EU/EEA countries and the UK; P50: 50th percentiale (median); P75: 75th percentile.

Table A1.2. Distribution of patient/consultant specialty by country

Patient/consultant specialty	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czechia	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands	Norway	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	UK-England	UK-Northern Ireland	UK-Scotland	UK-Wales	EU/EEA	Serbia
N of patients, all specialties	13 461	11 800	2 200	10 466	1 036	15 117	4 220	9 079	16 522	11 324	9 401	20 588	633	10 333	14 773	3 807	12 415	2 018	961	4 441	9 628	21 712	16 982	11 443	9 145	5 720	19 546	20 148	3 813	11 623	6 400	310 755	14 982
Surgery	34.0	21.4	37.7	27.8	33.2	30.5	19.6	29.2	18.5	28.2	36.9	14.9	16.6	24.9	30.3	35.5	20.2	21.9	29.8	30.8	32.1	27.9	32.1	29.6	19.1	37.0	30.2	25.1	25.8	24.8	28.3	26.9	33.2
General surgery	6.5	2.5	8.5	1.5	10.4	9.3	6.8	1.7	0.3	4.8	11.8	3.9	3.9	7.9	7.2	9.6	5.0	1.2	9.5	11.7	10.6	6.3	11.7	11.9	6.9	2.0	6.9	6.8	8.6	9.2	9.7	6.7	8.6
Digestive tract surgery	1.8	3.3	2.0	4.2	0.0	0.7	0.5	8.2	3.7	2.4	0.1	0.1	0.0	2.3	0.7	1.6	1.0	2.0	0.0	5.3	5.1	0.6	0.4	0.0	0.4	5.7	1.7	1.2	2.9	0.6	0.5	1.8	1.1
Orthopaedics and traumatology	13.5	6.8	6.3	7.2	12.2	10.2	4.5	8.7	5.9	10.1	9.9	4.6	5.4	7.5	6.5	8.3	4.3	9.7	7.8	6.6	9.2	6.5	9.1	5.0	5.7	15.6	9.4	8.4	7.7	8.0	11.9	7.9	8.6
Cardiovascular surgery	2.5	2.3	2.1	2.8	1.5	1.6	1.7	2.9	2.3	2.6	2.2	1.2	2.2	1.9	3.6	2.1	1.8	2.8	5.9	0.3	1.2	2.5	2.2	1.7	0.7	2.9	3.1	2.3	1.0	2.0	2.0	2.2	2.3
Thoracic surgery	0.1	0.2	3.5	0.8	0.6	0.1	0.5	0.4	0.6	0.6	0.7	0.1	0.9	0.3	0.8	0.6	0.4	0.2	0.0	0.4	0.8	0.9	0.3	0.5	0.1	0.7	0.6	0.3	0.5	0.2	0.1	0.5	0.8
Neurosurgery	1.2	1.9	3.1	1.9	1.5	1.7	0.9	1.5	1.6	2.0	3.3	0.8	0.9	0.8	2.7	2.9	2.1	1.5	1.1	1.1	1.3	2.1	2.0	1.4	1.1	1.6	2.4	2.2	0.8	1.1	0.5	1.7	2.1
Transplantation surgery	0.2	0.2	0.0	0.4	0.3	0.1	0.0	0.2	0.1	0.0	0.2	0.1	0.0	0.1	0.9	0.2	0.1	0.0	0.0	0.0	0.0	0.6	0.4	0.3	0.0	0.0	0.0	0.1	0.2	0.1	0.2	0.2	0.0
Surgery for cancer	0.2	0.3	0.6	1.2	0.0	0.5	1.5	0.3	0.4	0.3	0.2	0.0	0.6	0.0	1.6	0.7	1.1	0.0	0.0	0.1	0.0	0.8	0.2	0.0	0.6	0.6	0.0	0.4	0.1	0.0	0.1	0.4	1.2
ENT	2.1	0.4	3.4	2.5	2.2	1.6	0.6	0.9	1.0	1.5	2.4	1.3	0.5	1.2	1.2	0.4	0.9	0.9	1.2	0.1	1.1	2.1	0.7	1.3	1.2	2.6	1.4	0.7	0.8	0.9	1.1	1.3	1.8
Ophthalmology	0.9	0.1	0.9	1.2	0.5	0.5	0.0	0.3	0.2	0.6	1.2	0.8	0.0	0.3	0.4	0.8	0.6	0.4	0.2	0.1	0.4	2.0	0.3	2.1	0.3	1.3	0.2	0.0	0.3	0.2	0.1	0.6	1.1
Maxillo-facial surgery	0.4	0.4	0.0	0.6	0.7	0.3	0.2	0.0	0.1	0.6	0.5	0.1	0.0	0.2	0.4	0.0	0.2	0.8	0.1	0.8	0.0	0.5	0.3	0.3	0.2	0.2	0.4	0.2	0.2	0.2	0.3	0.3	0.2
Stomatology/ Dentistry	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Burns care	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.0	1.0	0.3	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Urology	2.8	2.2	5.7	2.5	2.7	2.8	2.0	2.4	1.5	2.1	3.9	1.4	1.1	1.9	2.7	2.7	1.5	0.9	3.4	3.4	1.9	2.6	2.8	3.0	1.6	2.8	3.1	1.5	2.0	1.7	1.5	2.3	4.3
Plastic and reconstructive surgery	0.5	0.5	0.4	0.8	0.5	0.3	0.4	1.4	0.3	0.4	0.6	0.0	0.6	0.5	0.7	0.3	0.1	0.3	0.4	0.8	0.4	0.2	1.1	1.8	0.3	0.9	0.8	0.5	0.6	0.5	0.2	0.6	0.9
Other surgery	1.3	0.2	1.1	0.1	0.1	0.6	0.0	0.1	0.0	0.2	0.1	0.3	0.3	0.1	0.9	4.5	0.7	0.9	0.0	0.1	0.1	0.2	0.4	0.1	0.0	0.1	0.1	0.3	0.0	0.0	0.0	0.3	0.2
Medicine	38.9	30.5	42.5	36.3	38.8	39.0	36.1	39.1	26.1	35.3	40.1	41.7	30.5	50.1	44.0	46.2	39.9	28.7	48.8	47.6	40.1	39.9	42.5	45.5	39.1	39.1	47.5	43.1	47.1	39.5	50.2	40.4	37.6
General medicine	8.9	2.6	0.8	1.8	19.7	17.3	15.0	9.6	3.6	7.4	17.2	10.9	4.3	21.1	16.8	9.7	10.7	2.4	9.8	13.0	16.6	9.1	26.4	6.3	17.7	5.1	22.8	18.0	21.6	18.2	33.5	13.6	5.1
Gastro-enterology	2.9	4.6	6.9	4.5	0.2	0.6	0.6	1.2	0.0	3.9	1.2	2.5	2.2	3.5	1.8	1.5	1.2	2.5	2.4	4.4	1.9	2.1	1.6	5.4	1.0	3.0	3.7	3.6	3.5	3.6	2.5	2.5	2.7
Hepatology	0.1	0.1	0.1	0.0	0.0	0.3	0.0	0.2	0.0	0.1	0.0	0.2	0.0	0.2	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.3	0.4	0.7	0.5	0.0	0.0	0.2	0.1
Endocrinology	0.8	0.7	4.0	1.9	0.0	0.2	0.3	0.5	1.7	0.5	0.2	0.8	0.0	3.3	0.7	1.2	0.7	1.3	3.5	0.0	0.1	0.8	0.2	2.2	0.1	1.0	0.2	1.9	0.7	1.1	1.3	0.9	1.9
Nephrology	1.3	1.5	3.4	2.4	2.6	0.7	1.3	0.9	1.3	1.0	1.4	1.1	1.4	1.8	1.9	1.9	1.7	2.0	8.1	0.0	1.0	2.3	1.3	2.0	0.2	1.2	1.5	1.7	0.8	1.5	1.4	1.5	1.6
Cardiology	5.1	5.4	6.0	6.0	7.8	3.2	3.7	6.6	5.6	6.7	7.6	4.6	7.1	4.6	5.4	8.2	4.8	3.5	2.8	11.0	4.3	7.1	3.0	8.0	2.2	7.2	4.5	4.9	5.5	4.3	4.1	5.3	6.2
Dermatology	1.4	0.1	0.3	0.7	0.0	0.9	0.6	0.7	0.6	0.8	0.4	0.7	0.0	0.0	0.2	0.1	0.4	0.0	0.0	0.0	0.4	1.6	0.2	1.4	1.0	0.8	0.1	0.1	0.3	0.2	0.0	0.6	0.4
Haematology / BMT	0.4	1.2	4.5	2.1	2.0	0.8	1.5	2.0	1.3	0.7	2.9	1.3	1.9	1.7	2.3	2.6	1.1	0.6	2.3	0.7	1.1	2.1	1.3	0.7	0.4	1.3	2.4	1.9	2.4	1.3	0.8	1.5	2.0
Oncology	4.9	3.7	1.3	1.6	3.2	2.9	3.0	2.5	2.2	1.5	1.6	2.0	0.8	3.9	2.7	1.6	2.6	5.6	2.3	0.9	4.0	2.3	1.6	2.3	4.3	3.1	3.3	1.7	1.9	1.9	1.3	2.6	4.1
Neurology	6.1	4.6	9.0	5.6	0.2	7.0	4.4	6.8	3.3	7.3	2.9	4.8	3.3	1.4	5.1	8.6	7.4	2.7	2.0	7.1	4.1	5.5	2.5	6.3	8.4	5.3	3.2	2.8	1.7	0.6	0.8	4.6	5.4
Pneumology	2.6	4.8	4.5	4.6	2.6	2.7	3.0	4.3	2.9	2.7	3.4	2.7	3.8	4.8	3.4	2.4	1.0	3.5	6.5	9.2	3.3	4.5	2.6	2.0	2.4	5.5	3.7	3.8	6.6	5.3	1.2	3.5	5.0
Rheumatology	0.6	0.2	0.6	0.7	0.0	0.3	0.4	0.1	1.1	0.9	0.2	2.2	2.5	1.3	0.6	0.5	0.4	0.0	6.1	0.2	0.7	0.8	0.1	0.5	0.0	0.5	0.2	0.2	0.4	0.2	0.0	0.6	0.4
Infectious diseases	0.3	0.8	0.9	3.2	0.3	1.5	2.0	3.4	1.4	0.3	0.6	1.0	3.2	0.6	1.8	2.6	3.2	0.8	3.0	0.0	2.5	0.8	1.2	5.2	1.2	3.8	0.8	0.3	0.3	1.2	0.3	1.4	1.5
Medical traumatology	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.1	0.0	4.9	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
Other Medical	3.2	0.4	0.1	1.2	0.2	0.5	0.2	0.3	1.2	1.5	0.4	2.3	0.0	1.7	1.1	5.1	4.3	3.5	0.0	0.8	0.0	0.6	0.5	3.2	0.1	1.0	0.4	1.7	0.9	0.3	2.8	1.3	1.1
Intensive care	3.2	4.2	5.0	4.6	5.5	7.1	2.6	2.6	3.2	4.6	5.7	1.7	2.2	2.2	4.5	2.6	2.6	4.6	2.5	4.7	6.1	2.7	3.5	5.4	4.3	3.0	3.9	2.0	1.9	1.5	2.6	3.6	5.5
Medical ICU	0.8	1.2	1.4	1.2	1.2	2.6	1.1	1.1	0.7	1.8	1.3	0.3	0.8	1.2	0.9	0.9	0.6	1.6	0.9	1.7	2.3	0.8	0.5	0.9	1.5	1.4	0.9	0.4	0.4	0.3	0.8	1.0	2.0
Surgical ICU	1.7	0.7	2.4	0.9	0.4	2.3	0.6	1.1	1.3	2.0	0.6	0.4	1.4	1.0	0.9	0.7	0.3	0.8	0.9	1.5	2.2	0.3	0.6	1.1	0.6	1.2	0.5	0.6	0.9	0.3	0.8	0.9	2.5

Patient/consultant specialty	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czechia	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands	Norway	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	UK-England	UK-Northern Ireland	UK-Scotland	UK-Wales	EU/EEA	Serbia
Mixed/polyvalent ICU	0.5	1.9	1.2	1.3	1.4	1.4	0.9	0.4	1.0	0.3	3.0	0.8	0.0	0.1	1.8	0.8	1.3	1.6	0.1	1.5	0.0	1.3	1.6	2.8	1.7	0.2	2.2	0.9	0.6	0.7	1.0	1.2	0.9
Specialised ICU	0.2	0.3	0.0	1.2	2.6	0.8	0.0	0.0	0.1	0.4	0.9	0.1	0.0	0.0	1.0	0.2	0.4	0.6	0.5	0.0	0.0	0.5	0.8	0.5	0.6	0.2	0.3	0.2	0.0	0.1	0.0	0.4	0.1
Other ICU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Paediatrics/Neonates	4.7	7.1	9.5	7.7	10.7	9.1	4.4	7.2	5.4	4.0	8.5	4.6	7.7	7.2	5.7	6.6	5.8	6.3	9.5	8.1	6.6	9.9	6.1	9.2	10.4	8.8	6.1	7.1	5.3	3.9	4.1	6.7	10.9
Paediatric surgery	0.5	0.1	0.3	0.7	0.5	0.5	0.3	0.4	0.4	0.3	0.5	0.2	0.2	0.2	0.4	0.6	0.2	0.7	1.0	0.5	0.7	1.3	0.3	1.0	0.5	0.8	0.4	0.5	0.3	0.0	0.4	0.5	0.8
Healthy neonates	1.1	1.3	0.8	1.6	0.9	2.6	1.2	3.3	0.6	1.2	0.9	0.0	1.9	2.0	1.6	1.2	0.3	1.7	2.7	0.7	0.0	1.3	2.4	1.5	2.8	2.5	0.8	2.2	0.3	1.5	0.0	1.4	2.2
Neonatology	0.7	1.0	2.4	0.5	1.1	2.3	0.8	1.1	1.6	0.5	0.9	1.2	0.0	0.9	0.8	0.7	1.0	0.1	0.2	0.6	1.6	2.2	0.9	2.6	1.3	0.2	1.3	0.8	0.3	1.0	0.6	1.2	2.8
Paediatrics	1.7	3.9	4.2	3.5	4.2	2.8	1.4	1.2	2.3	1.7	4.3	2.1	2.7	3.3	1.4	3.2	4.1	2.5	3.2	4.9	4.1	4.0	1.7	3.1	4.8	4.6	2.5	2.1	3.1	0.2	2.0	2.7	4.1
Paediatric ICU	0.3	0.2	0.6	0.3	0.5	0.2	0.2	0.1	0.2	0.1	0.2	0.1	0.3	0.0	0.3	0.1	0.1	0.4	0.4	0.7	0.2	0.3	0.2	0.0	0.4	0.3	0.5	0.6	0.2	0.2	0.1	0.3	0.4
Neonatal ICU	0.4	0.6	1.2	1.1	3.6	0.7	0.5	1.1	0.4	0.3	1.7	1.0	2.7	0.8	1.2	0.8	0.1	0.9	1.9	0.6	0.0	0.8	0.6	1.0	0.5	0.4	0.7	0.8	1.0	1.1	1.1	0.8	0.6
Obstetrics and gynaecology	5.2	4.9	4.1	7.6	8.5	6.0	5.1	6.7	6.9	4.4	4.5	5.8	3.9	7.8	4.4	5.8	4.0	7.2	6.3	5.4	10.4	6.4	5.6	7.2	7.5	6.9	5.4	5.0	7.7	3.9	5.0	5.9	9.5
Obstetrics / Maternity	3.0	3.9	2.7	3.5	6.9	3.0	3.2	5.4	5.9	2.4	3.7	4.3	2.8	6.1	3.2	2.7	2.6	5.2	4.5	4.6	8.6	3.6	4.0	5.0	3.5	3.5	3.8	3.9	6.1	2.8	3.7	4.0	4.8
Gynaecology (incl. surgery)	2.2	1.0	1.4	4.1	1.5	2.9	2.0	1.3	1.0	2.1	0.8	1.5	1.1	1.7	1.2	3.1	1.4	2.0	1.9	0.8	1.8	2.8	1.6	2.2	4.0	3.4	1.5	1.1	1.5	1.1	1.3	1.8	4.7
Geriatrics	3.1	15.4	0.0	0.7	0.0	1.0	10.8	2.1	4.8	2.7	0.0	0.5	12.6	5.3	3.3	1.1	0.3	6.7	0.0	3.5	1.6	1.4	0.0	0.4	4.4	0.4	2.3	14.5	8.6	17.1	7.1	4.1	0.6
Geriatrics, care for the elderly	3.1	15.4	0.0	0.7	0.0	1.0	10.8	2.1	4.8	2.7	0.0	0.5	12.6	5.3	3.3	1.1	0.3	6.7	0.0	3.5	1.6	1.4	0.0	0.4	4.4	0.4	2.3	14.5	8.6	17.1	7.1	4.1	0.6
Psychiatry	8.1	7.0	0.0	10.1	1.9	2.8	12.8	7.0	6.6	16.8	3.9	13.2	17.7	0.6	2.9	0.0	8.0	16.9	1.9	0.0	0.0	5.2	8.4	0.5	8.3	2.9	3.8	0.0	0.0	3.8	0.0	5.6	1.0
Psychiatrics	8.1	7.0	0.0	10.1	1.9	2.8	12.8	7.0	6.6	16.8	3.9	13.2	17.7	0.6	2.9	0.0	8.0	16.9	1.9	0.0	0.0	5.2	8.4	0.5	8.3	2.9	3.8	0.0	0.0	3.8	0.0	5.6	1.0
Rehabilitation and long-term care	1.2	7.9	1.1	3.5	1.4	4.6	7.6	3.8	15.6	1.3	0.2	17.1	8.7	1.7	4.4	1.9	17.8	7.6	0.0	0.0	2.8	4.8	1.0	1.3	5.3	0.9	0.8	2.7	1.8	2.9	2.7	5.1	1.2
Rehabilitation	1.0	7.7	1.1	2.7	1.4	2.4	2.3	2.6	7.2	1.3	0.2	6.9	8.7	1.7	3.5	0.3	5.4	7.6	0.0	0.0	2.8	3.4	0.9	1.3	2.6	0.1	0.8	2.7	1.8	2.6	2.7	3.0	0.6
Long-term care	0.2	0.3	0.0	0.8	0.0	2.1	5.3	1.2	8.4	0.0	0.0	10.2	0.0	0.0	1.0	1.6	12.4	0.0	0.0	0.0	0.0	1.4	0.1	0.0	2.7	0.8	0.0	0.0	0.0	0.3	0.0	2.2	0.6
Mixed/Other/Unknown	1.6	1.6	0.0	1.6	0.0	0.1	1.1	2.3	13.0	2.6	0.2	0.4	0.0	0.2	0.5	0.3	1.3	0.0	1.2	0.0	0.3	1.7	0.9	0.9	1.7	1.0	0.2	0.5	1.8	2.6	0.1	1.6	0.4
Others not listed	1.0	1.4	0.0	1.1	0.0	0.1	0.2	0.6	10.8	1.0	0.2	0.4	0.0	0.2	0.4	0.0	0.0	0.0	1.2	0.0	0.3	0.4	0.7	0.9	1.6	0.9	0.2	0.5	1.2	2.6	0.1	1.1	0.3

Table A1.3. Distribution of types of HAI, by country

Type of HAI (code)	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czechia	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands	Norway	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	UK-England	UK-Northern Ireland	UK-Scotland	UK-Wales	EU/EEA	Serbia
Number of HAIs	554	911	78	584	94	1 098	202	859	1 020	437	1 083	881	44	677	1 296	146	377	110	64	182	503	1 337	1662	455	391	404	1 671	1 354	241	534	375	19 624	687
Pneumonia	20.8	21.6	20.5	19.5	8.5	18.1	21.3	19.3	19.6	23.3	25.9	17.1	27.3	29.0	20.3	21.2	36.6	18.2	17.2	15.9	20.9	27.6	18.8	17.6	15.1	27.0	14.1	27.8	29.5	22.5	18.7	22.1	20.8
Pneumonia, positive quantitative culture, minimally contaminated LRT specimen (PN1)	1.6	2.2	11.5	3.4	0.0	2.2	0.0	0.5	5.6	2.1	2.3	1.2	0.0	0.9	2.9	1.4	1.9	0.9	0.0	0.0	0.0	3.4	0.5	2.2	0.8	0.7	2.0	0.4	0.4	1.5	0.8	2.0	3.3
Pneumonia, positive quantitative culture, possibly contaminated LRT specimen (PN2)	0.4	1.1	6.4	2.2	1.1	2.3	0.0	0.1	3.7	0.7	2.1	0.7	0.0	0.3	1.1	0.0	0.5	0.0	0.0	0.0	0.0	1.9	0.1	2.4	0.5	0.2	0.9	0.4	0.0	0.4	1.1	1.1	1.0
Pneumonia, microbiological diagnosis by alternative microbiology methods (PN3)	0.7	1.2	1.3	0.9	0.0	0.8	1.0	1.2	0.3	1.6	0.4	0.7	0.0	0.7	0.8	0.0	1.1	0.0	0.0	3.8	0.0	1.0	0.8	0.0	0.8	0.5	0.5	0.5	0.0	0.9	1.1	0.8	1.9
Pneumonia, positive sputum culture or non-quantitative culture, LRT specimen (PN4)	2.0	5.8	0.0	1.0	0.0	4.5	10.9	2.0	2.2	3.4	3.7	1.5	4.5	2.7	3.2	8.2	4.0	2.7	3.1	2.2	0.0	3.8	4.3	5.1	5.4	9.7	2.6	3.8	2.5	2.1	1.6	3.6	5.4
Pneumonia - Clinical signs of pneumonia without positive microbiology (PN5)	15.9	10.0	1.3	10.6	7.4	8.1	8.9	15.1	7.8	15.6	16.7	13.1	22.7	24.4	11.8	11.6	29.2	14.5	12.5	9.9	0.0	14.2	13.0	7.9	6.6	15.3	8.2	21.7	26.1	17.4	14.1	13.5	6.8
Pneumonia in neonates (NEO-PNEU)	0.2	0.0	0.0	0.7	0.0	0.0	0.0	0.5	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.6	0.0	0.0	0.8	0.0	0.0	0.3	0.5	0.0	0.0	0.4	0.2	0.0	0.2	2.0
Pneumonia, not specified (PN-NOS)	0.0	1.3	0.0	0.7	0.0	0.3	0.5	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	20.9	2.5	0.1	0.0	0.8	0.0	0.0	0.9	0.0	0.0	0.0	1.0	0.3
Other lower respiratory tract inf.	2.0	4.9	2.6	3.3	10.6	5.6	4.0	1.4	5.9	3.4	3.3	7.9	4.5	2.4	2.5	2.1	8.8	6.4	1.6	1.1	0.0	4.8	6.6	2.0	4.9	1.7	6.1	3.0	2.5	1.3	7.7	4.3	0.7
Bronchitis, tracheobronchitis, etc. without evidence of pneumonia (LRI-BRON)	1.8	4.0	2.6	2.6	9.6	5.3	4.0	1.2	1.6	2.7	2.3	7.4	4.5	1.8	2.1	0.0	6.6	2.7	1.6	1.1	0.0	4.6	5.8	2.0	4.9	1.7	3.0	1.3	2.5	1.1	2.7	3.2	0.6
Other infections of the lower respiratory tract (LRI-LUNG)	0.2	1.0	0.0	0.7	1.1	0.2	0.0	0.2	4.3	0.7	1.0	0.6	0.0	0.6	0.4	1.4	2.1	3.6	0.0	0.0	0.0	0.1	0.7	0.0	0.0	0.0	3.1	0.9	0.0	0.2	5.1	1.0	0.1
Lower respiratory tract infection, other than pneumonia, not specified (LRI-NOS)	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.1	0.0
Surgical site infections	24.7	16.9	28.2	15.8	10.6	18.9	20.3	20.7	18.3	20.4	11.7	15.2	15.9	18.0	14.4	24.0	13.8	30.0	39.1	35.2	37.8	15.9	17.2	13.0	12.5	20.8	25.6	16.5	17.0	15.9	10.9	19.0	19.2
Surgical site infection, Superficial incisional (SSI-S)	6.9	4.0	11.5	7.0	4.3	6.6	4.0	5.4	2.4	5.5	3.0	5.4	6.8	5.9	4.2	6.2	6.1	12.7	18.8	11.0	5.6	5.7	3.2	7.0	6.9	6.7	4.7	4.9	4.6	7.1	4.8	5.4	7.1
Surgical site infection, Deep incisional (SSI-D)	9.6	6.0	6.4	4.5	3.2	6.8	6.9	6.5	8.5	8.0	4.4	7.8	6.8	6.6	5.2	11.6	5.6	7.3	9.4	20.3	17.1	6.2	5.3	2.9	4.1	6.7	9.0	6.6	4.1	5.2	4.5	7.1	7.4
Surgical site infection, Organ/Space (SSI-O)	8.3	6.6	9.0	3.8	3.2	5.5	9.4	8.8	7.5	6.9	4.2	1.9	2.3	5.5	4.9	6.2	2.1	10.0	10.9	3.8	15.1	3.7	8.7	3.1	1.5	7.4	11.8	4.7	8.3	3.6	1.6	6.4	4.4
Surgical site infection, not specified (SSI-NOS)	0.0	0.3	1.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.1	0.3
Urinary tract infections	22.2	21.3	7.7	27.9	17.0	27.6	22.3	11.5	18.4	19.5	14.6	19.9	29.5	14.5	18.0	11.0	13.3	14.5	9.4	23.6	14.1	16.5	24.2	18.0	25.8	17.1	19.6	15.3	6.2	23.4	16.0	19.6	21.3
Urinary tract infection, microbiologically confirmed (UTI-A)	13.4	17.3	6.4	18.7	12.8	18.9	13.4	10.4	16.5	11.0	9.7	8.7	13.6	9.2	12.0	3.4	8.2	11.8	6.3	19.2	0.0	9.6	18.7	7.3	20.2	12.1	15.2	9.5	3.7	13.3	10.1	13.2	15.6
Urinary tract infection, not microbiologically confirmed (UTI-B)	8.8	3.1	1.3	8.2	4.3	8.6	8.9	1.2	2.0	8.5	4.6	11.1	15.9	5.3	5.8	7.5	5.0	2.7	3.1	3.3	0.0	6.2	5.5	10.8	5.1	5.0	4.4	5.6	2.5	10.1	5.3	5.8	4.7
Urinary tract infection, not specified (UTI-NOS)	0.0	0.9	0.0	1.0	0.0	0.2	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	1.1	14.1	0.6	0.1	0.0	0.5	0.0	0.0	0.1	0.0	0.0	0.5	0.6	1.0
Bloodstream infections (a)	9.6	12.5	14.1	10.1	17.0	7.6	9.9	10.6	15.6	8.9	17.8	4.9	2.3	10.0	18.3	7.5	6.6	12.7	14.1	14.3	10.5	7.0	10.2	8.1	6.6	5.7	13.5	7.1	10.0	11.0	9.6	11.2	11.5
Bloodstream infection (laboratory-confirmed) , other than CRI3 (BSI)	6.3	11.5	12.8	7.2	9.6	5.6	8.4	9.3	8.2	7.1	12.7	3.6	2.3	8.7	12.6	2.1	3.7	9.1	10.9	11.5	10.5	4.0	8.5	7.3	4.9	4.5	8.2	6.4	8.3	9.2	9.3	8.3	8.2
Microbiologically confirmed CVC-related bloodstream infection (CRI3-CVC)	2.5	0.9	0.0	1.4	3.2	1.4	1.5	0.9	6.0	1.6	4.1	1.1	0.0	0.9	4.6	5.5	1.3	2.7	0.0	1.1	0.0	2.3	1.2	0.4	1.0	0.5	4.3	0.4	0.4	0.9	0.3	2.1	1.7
Microbiologically confirmed PVC-related bloodstream infection (CRI3-PVC)	0.7	0.1	0.0	0.3	0.0	0.6	0.0	0.2	1.0	0.2	0.7	0.1	0.0	0.1	0.9	0.0	1.3	0.9	0.0	0.0	0.0	0.2	0.2	0.0	0.5	0.0	0.7	0.1	0.0	0.9	0.0	0.4	0.1
Laboratory-confirmed bloodstream infection in neonates, non-CNS (NEO-LCBI)	0.0	0.0	1.3	0.7	0.0	0.0	0.0	0.1	0.2	0.0	0.1	0.0	0.0	0.3	0.1	0.0	0.3	0.0	1.6	0.5	0.0	0.3	0.1	0.4	0.3	0.2	0.2	0.1	0.8	0.0	0.0	0.2	1.0

Type of HAI (code)	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czechia	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands	Norway	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	UK-England	UK-Northern Ireland	UK-Scotland	UK-Wales	EU/EEA	Serbia
Laboratory-confirmed BSI with CNS in neonates (NEO-CNSB)	0.0	0.0	0.0	0.5	4.3	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0	1.6	1.1	0.0	0.1	0.2	0.0	0.0	0.5	0.1	0.1	0.4	0.0	0.0	0.2	0.4
Catheter-related infections w/o BSI	2.9	0.5	1.3	1.4	2.1	0.5	0.5	0.7	1.6	0.9	2.9	1.6	0.0	0.3	1.2	2.1	1.9	0.0	0.0	0.0	0.0	1.9	0.8	1.1	2.6	0.7	0.6	0.7	0.0	1.1	1.6	1.2	2.6
Local CVC-related infection (CRI1-CVC)	0.7	0.2	1.3	0.0	1.1	0.1	0.5	0.2	0.4	0.7	0.2	0.0	0.0	0.0	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.6	0.1	0.2	0.8	0.7	0.1	0.4	0.0	0.2	0.0	0.3	0.6
General CVC-related infection (CRI2-CVC)	0.7	0.2	0.0	0.9	0.0	0.0	0.0	0.3	0.3	0.2	1.0	0.2	0.0	0.1	0.5	1.4	1.6	0.0	0.0	0.0	0.0	0.9	0.5	0.2	0.5	0.0	0.2	0.2	0.0	0.0	0.3	0.4	0.9
Local PVC-related infection (CRI1-PVC)	1.4	0.1	0.0	0.5	0.0	0.4	0.0	0.1	0.6	0.0	1.5	1.0	0.0	0.1	0.3	0.7	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.8	0.0	0.2	0.1	0.0	0.7	1.3	0.4	0.4
General PVC-related infection (CRI2-PVC)	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.3	0.0	0.2	0.3	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.7	0.5	0.0	0.2	0.0	0.0	0.2	0.0	0.2	0.7
Cardiovascular system infections	0.5	1.0	0.0	0.0	0.0	0.3	0.0	0.9	1.5	1.8	1.0	1.4	0.0	1.0	1.3	1.4	1.6	0.0	0.0	0.5	1.8	0.9	1.1	1.5	1.3	1.2	1.1	0.9	0.4	0.7	0.5	1.0	0.7
Arterial or venous infection (CVS-VASC)	0.2	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.5	0.5	0.6	0.0	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.2	1.3	1.0	0.4	0.4	0.0	0.4	0.0	0.3	0.7
Endocarditis (CVS-ENDO)	0.0	0.7	0.0	0.0	0.0	0.1	0.0	0.7	0.9	1.4	0.5	0.5	0.0	0.6	0.7	0.0	0.0	0.0	0.0	0.5	0.0	0.4	0.6	0.4	0.0	0.2	0.6	0.4	0.4	0.4	0.5	0.5	0.0
Myocarditis or pericarditis (CVS-CARD)	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.7	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Mediastinitis (CVS-MED)	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.0	0.1	0.2	0.0	0.0	0.1	0.7	1.6	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0
Cardiovascular system infection, not specified (CVS-NOS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.1	0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Gastro-intestinal system infections	6.5	9.5	1.3	8.7	12.8	10.7	8.4	9.9	3.9	13.5	6.4	16.2	11.4	8.1	8.5	13.7	7.2	5.5	1.6	3.3	6.2	13.5	5.9	21.3	16.9	6.2	6.0	7.5	10.8	5.4	10.9	9.3	11.1
Clostridioides difficile infection (GI-CDI)	5.1	3.2	1.3	4.8	7.4	7.7	6.9	5.0	1.4	9.4	2.3	9.9	9.1	4.4	4.2	11.6	4.2	2.7	1.6	1.6	0.0	7.6	2.0	17.6	14.1	3.0	2.1	3.5	5.8	2.8	7.2	5.2	9.0
Gastroenteritis (excluding CDI) (GI-GE)	0.0	1.2	0.0	0.9	0.0	0.7	0.5	0.7	0.3	1.1	0.4	4.8	0.0	0.3	0.6	0.0	0.8	0.0	0.0	0.0	0.0	1.3	0.1	0.9	1.5	0.5	0.6	0.3	0.0	0.6	0.0	0.8	1.2
Gastrointestinal tract, excluding GE, CDI (GI-GIT)	0.7	2.2	0.0	0.0	0.0	0.6	0.5	1.9	0.6	1.6	1.4	0.3	2.3	0.9	1.6	0.0	0.3	0.9	0.0	0.0	0.0	0.8	0.8	0.4	0.8	0.2	1.1	0.9	2.1	0.4	0.5	0.9	0.6
Hepatitis (GI-HEP)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0
Intraabdominal infection, not specified elsewhere (GI-IAB)	0.7	2.6	0.0	2.6	4.3	1.6	0.5	2.3	1.6	1.4	1.8	1.2	0.0	2.2	1.9	0.7	1.9	1.8	0.0	1.6	0.0	3.6	2.8	1.8	0.5	2.2	2.0	2.6	2.5	1.5	2.9	2.0	0.1
Necrotising enterocolitis (NEO-NEC)	0.0	0.1	0.0	0.5	1.1	0.0	0.0	0.0	0.1	0.0	0.6	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.2	0.0	0.1	0.4	0.2	0.3	0.1	0.1
Gastro-intestinal system infection, not specified (GI-NOS)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	6.2	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Skin and soft tissue infections	2.3	3.8	5.1	5.0	5.3	3.3	3.5	5.5	3.4	2.1	5.3	7.2	4.5	3.8	3.2	6.8	2.7	4.5	1.6	1.6	2.8	4.0	4.8	5.1	3.6	2.5	3.8	4.0	4.6	6.9	7.2	4.3	3.5
Skin infection (SST-SKIN)	1.3	1.3	0.0	1.5	1.1	0.5	0.0	2.4	2.1	1.4	1.2	1.6	0.0	2.5	0.8	0.7	0.0	0.9	0.0	1.6	0.0	1.1	1.6	1.1	1.5	1.5	1.8	2.4	4.1	0.7	4.0	1.5	0.4
Soft tissue (SST-ST)	1.1	1.5	2.6	1.9	3.2	1.1	1.0	2.1	0.9	0.5	2.9	1.5	0.0	1.2	1.0	0.0	1.3	2.7	0.0	0.0	0.0	1.9	2.1	2.2	0.3	0.5	1.3	0.4	0.4	4.9	3.2	1.5	1.9
Decubitus ulcer (SST-DECU)	0.0	0.8	2.6	0.9	0.0	1.5	2.5	0.8	0.2	0.2	0.6	4.0	4.5	0.1	0.8	0.7	1.3	0.9	0.0	0.0	0.0	0.7	0.8	1.3	1.5	0.5	0.7	0.3	0.0	1.1	0.0	0.9	0.9
Burn (SST-BURN)	0.0	0.0	0.0	0.2	1.1	0.2	0.0	0.0	0.2	0.0	0.4	0.1	0.0	0.0	0.4	4.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Breast abscess or mastitis (SST-BRST)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.0	0.0
Skin and soft tissue infections, not specified (SST-NOS)	0.0	0.1	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2	1.4	0.0	0.0	1.6	0.0	2.8	0.1	0.1	0.4	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.2	0.1
Bone and joint infections	1.4	0.7	10.3	0.7	0.0	1.1	0.5	0.2	1.7	1.1	2.2	0.7	2.3	1.3	1.0	2.7	1.6	0.9	1.6	1.1	1.4	1.0	1.4	1.8	0.8	1.5	1.7	1.4	1.2	0.7	3.5	1.3	0.4
Osteomyelitis (BJ-BONE)	0.5	0.4	0.0	0.3	0.0	0.6	0.5	0.0	0.7	0.7	1.3	0.6	0.0	0.4	0.5	2.1	0.3	0.9	1.6	0.0	0.0	0.7	0.7	1.1	0.3	1.0	0.6	0.7	0.8	0.4	0.8	0.6	0.1
Joint or bursa (BJ-JNT)	0.9	0.1	9.0	0.3	0.0	0.2	0.0	0.2	0.2	0.2	0.6	0.1	0.0	0.7	0.2	0.7	0.8	0.0	0.0	0.5	0.0	0.1	0.5	0.7	0.5	0.5	1.1	0.6	0.0	0.2	2.4	0.5	0.3
Disc space infection (BJ-DISC)	0.0	0.1	0.0	0.0	0.0	0.3	0.0	0.0	0.8	0.2	0.2	0.0	0.0	0.1	0.0	0.0	0.5	0.0	0.0	0.5	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.4	0.2	0.0	0.1	0.0
Bone and joint infection, not specified (BJ-NOS)	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	2.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.3	0.1	0.0
Central nervous system infections	0.4	0.4	1.3	1.2	2.1	0.5	0.0	1.3	0.7	0.2	1.1	0.7	0.0	0.4	0.9	0.7	1.1	0.0	0.0	0.5	0.4	0.7	1.2	1.3	0.8	2.0	0.6	1.8	0.8	0.4	0.3	0.9	0.1
Intracranial infection (CNS-IC)	0.2	0.0	0.0	0.7	1.1	0.3	0.0	0.2	0.1	0.0	0.2	0.3	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	1.0	0.2	0.7	0.4	0.2	0.3	0.2	0.0
Meningitis or ventriculitis (CNS-MEN)	0.2	0.3	1.3	0.2	1.1	0.1	0.0	0.6	0.6	0.2	0.7	0.3	0.0	0.4	0.5	0.7	0.8	0.0	0.0	0.5	0.0	0.4	1.0	0.4	0.5	1.0	0.4	1.0	0.4	0.0	0.0	0.5	0.1
Spinal abscess without meningitis (CNS-SA)	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.1	0.0

Type of HAI (code)	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czechia	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands	Norway	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	UK-England	UK-Northern Ireland	UK-Scotland	UK-Wales	EU/EEA	Serbia
Central nervous system infection, not specified (CNS-NOS)	0.0	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.1	0.0	0.7	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Eye, ear, nose or mouth infection	2.0	2.1	6.4	0.9	2.1	1.8	1.0	3.8	3.0	1.8	0.7	3.9	2.3	3.5	3.1	1.4	2.4	3.6	3.1	1.6	2.0	2.2	3.1	3.3	6.6	2.0	3.5	3.0	6.6	5.4	2.7	2.9	2.0
Conjunctivitis (EENT-CONJ)	0.2	0.3	0.0	0.2	0.0	0.6	0.5	0.7	0.2	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.9	1.6	0.0	0.0	0.1	0.5	0.0	0.3	0.5	0.4	0.1	0.0	0.0	0.3	0.3	0.4
Eye, other than conjunctivitis (EENT-EYE)	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.5	0.3	0.2	0.0	0.0	0.0	0.7	0.5	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.2	0.2	0.1	0.0	0.7	0.3	0.2	0.0
Ear mastoid (EENT-EAR)	0.0	0.1	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.2	0.3	0.0	0.0	0.1	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.1	0.2	0.0	0.2	0.0	0.1	0.0
Oral cavity (mouth, tongue, or gums) (EENT-ORAL)	1.3	0.5	0.0	0.2	1.1	0.6	0.0	1.9	2.5	0.5	0.1	1.5	0.0	3.0	2.0	0.0	0.3	2.7	1.6	1.6	0.0	0.9	1.6	0.4	1.5	1.0	2.2	2.3	6.6	4.1	2.1	1.5	0.3
Sinusitis (EENT-SINU)	0.2	0.4	0.0	0.2	0.0	0.1	0.0	0.3	0.2	0.2	0.0	0.1	0.0	0.0	0.1	0.0	0.5	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.1	0.0
Upper respiratory tract, pharyngitis, laryngitis, epiglottitis (EENT-UR)	0.2	0.4	6.4	0.3	0.0	0.3	0.5	0.6	0.1	0.5	0.1	1.9	2.3	0.4	0.8	0.0	0.8	0.0	0.0	0.0	0.0	0.7	0.8	1.5	4.6	0.2	0.7	0.2	0.0	0.2	0.0	0.7	1.3
Eye, ear, nose or mouth infection, not specified (EENT-NOS)	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	2.0	0.1	0.0	1.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Reproductive tract infections	0.0	0.2	0.0	0.2	0.0	0.5	1.0	2.4	1.2	0.7	0.1	0.8	0.0	0.4	0.5	0.7	0.5	0.0	0.0	0.5	0.8	0.4	0.6	1.5	0.3	0.5	0.4	0.4	0.0	0.4	0.5	0.6	1.0
Endometritis (REPR-EMET)	0.0	0.0	0.0	0.2	0.0	0.2	1.0	0.9	0.3	0.2	0.0	0.3	0.0	0.1	0.0	0.7	0.3	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.4
Episiotomy (REPR-EPIS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vaginal cuff (REPR-VCUF)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Other infections of the male or female reproductive tract (REPR-OREP)	0.0	0.2	0.0	0.0	0.0	0.4	0.0	1.2	0.7	0.5	0.1	0.3	0.0	0.3	0.5	0.0	0.3	0.0	0.0	0.5	0.0	0.4	0.3	0.7	0.3	0.2	0.4	0.1	0.0	0.2	0.3	0.4	0.4
Reproductive tract infections, not specified (REPR-NOS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.7	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.1	0.1
Systemic infections	4.7	4.4	1.3	5.5	11.7	3.6	7.4	11.6	5.2	2.3	6.9	2.3	0.0	7.1	6.9	4.8	2.1	3.6	10.9	0.5	1.4	3.7	3.9	4.4	2.3	11.1	3.4	10.8	10.4	4.7	8.8	5.6	4.9
Disseminated infection (SYS-DI)	1.3	0.4	0.0	0.3	1.1	0.1	0.0	3.0	1.4	0.7	0.2	0.0	0.0	0.1	0.6	0.0	0.0	0.0	3.1	0.0	0.0	0.1	0.9	0.2	0.5	0.0	0.6	0.1	0.8	0.0	0.8	0.5	0.0
Treated unidentified severe infection in adults and children (SYS-CSEP)	2.9	3.0	1.3	1.9	9.6	2.9	6.9	6.1	3.5	1.1	4.4	1.9	0.0	6.2	5.9	0.0	2.1	3.6	7.8	0.5	0.0	2.3	2.2	0.7	1.5	9.9	2.6	9.2	5.4	3.4	6.7	3.8	0.0
Clinical sepsis in neonates (NEO-CSEP)	0.5	0.1	0.0	1.5	1.1	0.0	0.5	2.6	0.3	0.5	0.4	0.3	0.0	0.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.8	1.1	0.3	1.2	0.2	0.7	4.1	1.3	0.5	0.8	4.9
Systemic infections, not specified (SYS-NOS)	0.0	0.9	0.0	1.7	0.0	0.6	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.3	4.8	0.0	0.0	0.0	0.0	1.4	0.6	0.0	2.4	0.0	0.0	0.0	0.7	0.0	0.0	0.8	0.5	0.0

(a) Bloodstream infections: the origin of bloodstream infections (catheter-related, secondary to another infection or unknown origin) was recorded in a separate variable and is not given in this table. Catheter-related bloodstream infections reported under Figure 1 in the country summary sheets (Annex 2) include bloodstream infections (BSI, NEO-CNBC and NEO-LCBI) with origin C-CVC and C-PVC and microbiologically confirmed catheter-related bloodstream infections (CRI3-CVC and CRI3-PVC). Norway used a national protocol which grouped different subtypes of HAI in a single category, e.g. a single category for pneumonia and lower respiratory tract infections.

Table A1.4. Microorganisms isolated in HAIs, by country

Microorganism	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czechia	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands	Norway	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	UK-England	UK-Northern Ireland	UK-Scotland	UK-Wales	EU/EEA	Serbia
Number of microorganism codes, incl. negative	646	1 067	89	656	104	1 352	236	976	1 332	499	1 241	998	46	751	1 475	162	408	135	71	214	503	1 473	1862	496	440	491	1 991	1 442	255	579	395	22 385	799
Number of HAIs	554	911	78	584	94	1 098	202	859	1 020	437	1 083	881	44	677	1296	146	377	110	64	182	503	1 337	1 662	455	391	404	1 671	1 354	241	534	375	19 624	687
% of HAIs with microorganisms	55.4	62	73.1	56.5	52.1	60.9	63.4	45.5	71.1	59.7	51.2	43.8	56.8	45.9	54	41.8	39.5	60	53.1	70.9	0	49.1	54.2	58.7	71.4	52.7	67.6	38.3	35.3	44.6	36.8	52.6	70.9
Number of isolates	399	721	68	402	59	923	162	508	1 037	323	713	503	27	385	879	77	180	91	41	161	0	792	1 100	308	328	300	1 449	607	99	283	158	13 083	599
Gram-positive cocci	37.8	30.0	23.5	27.1	30.5	27.8	29.0	42.5	36.5	39.6	22.6	30.2	29.6	37.9	30.5	31.2	35.0	34.1	17.1	38.5	-	27.8	33.1	19.8	23.8	31.0	33.5	32.5	38.4	37.8	31.6	31.7	22.7
Staphylococcus aureus	10.5	11.2	7.4	8.0	8.5	9.3	11.1	19.7	14.8	13.3	4.8	11.5	14.8	14.5	8.9	14.3	14.4	11.0	9.8	16.8	-	9.5	13.2	9.4	9.5	10.0	9.5	16.8	19.2	20.1	14.6	11.6	6.5
Staphylococcus epidermidis	8.0	5.1	1.5	2.2	1.7	3.6	1.2	6.3	6.0	3.7	4.2	1.6	3.7	4.2	6.3	1.3	6.1	4.4	2.4	4.3	-	4.9	4.3	1.9	0.9	5.0	7.2	1.5	3.0	2.8	0.6	4.5	0.8
Staphylococcus haemolyticus	0.8	0.6	1.5	0.2	3.4	0.3	1.2	1.2	1.3	1.9	1.5	0.2	0.0	1.0	1.8	1.3	0.6	0.0	0.0	1.2	-	1.5	0.4	0.0	1.8	1.7	1.0	0.7	0.0	1.1	0.0	1.0	0.2
Coagulase-negative stafylococci, not specified	2.0	0.1	2.9	3.0	6.8	1.1	0.0	1.0	0.1	0.6	0.1	0.8	0.0	1.8	0.7	2.6	1.7	0.0	0.0	0.0	-	0.5	0.1	2.6	0.9	0.3	0.9	0.8	1.0	0.7	1.9	0.8	4.2
Coagulase-negative stafylococci, other	1.0	0.7	4.4	0.2	0.0	0.7	0.6	0.6	1.5	0.3	0.6	0.4	0.0	1.0	1.3	0.0	0.6	1.1	0.0	0.6	-	0.9	0.1	0.3	1.2	0.7	1.7	0.2	1.0	0.7	0.0	0.8	0.0
Staphylococcus sp., not specified	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.6	2.1	0.2	0.0	0.5	0.6	1.3	0.6	0.0	0.0	0.0	-	0.4	0.3	0.0	0.3	0.3	0.2	0.7	0.0	0.0	1.3	0.4	0.7
Streptococcus pneumoniae	0.0	0.7	0.0	0.5	0.0	0.5	1.2	0.6	0.6	1.2	0.3	0.0	3.7	1.0	0.0	0.0	0.6	0.0	0.0	0.0	-	0.1	0.6	0.3	0.3	0.3	0.1	0.2	1.0	0.0	1.3	0.4	0.5
Streptococcus agalactiae (b)	0.0	0.6	0.0	0.2	0.0	0.4	1.2	0.6	0.1	0.6	0.4	0.8	0.0	0.8	0.2	0.0	0.0	0.0	2.4	0.6	-	0.1	0.4	0.3	0.6	1.0	0.4	1.6	1.0	1.4	0.6	0.5	0.3
Streptococcus pyogenes (a)	1.0	0.0	0.0	0.2	0.0	0.2	0.0	0.8	0.1	0.3	0.1	0.2	0.0	0.8	0.2	0.0	0.6	0.0	0.0	0.0	-	0.1	0.0	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.6	0.2	0.3
Other haemol. streptococcae (c, g)	0.8	0.4	0.0	0.0	0.0	0.1	0.6	1.2	0.4	0.9	0.3	0.2	3.7	0.3	0.0	0.0	0.0	0.0	0.0	0.6	-	0.1	0.3	0.3	0.0	0.0	0.1	0.7	0.0	0.7	0.0	0.3	0.0
Streptococcus sp., other	1.5	0.8	0.0	0.5	0.0	1.4	0.6	2.0	1.2	2.2	0.7	1.2	0.0	2.6	0.7	0.0	0.0	1.1	0.0	1.2	-	0.1	0.8	0.0	1.2	1.3	0.6	0.8	0.0	1.4	2.5	1.0	0.5
Streptococcus sp., not specified	0.0	0.6	0.0	0.2	0.0	0.0	0.0	0.2	0.3	0.0	0.3	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	-	0.0	0.1	0.0	0.0	0.0	0.4	0.5	1.0	0.0	1.3	0.2	0.0
Enterococcus faecalis	6.5	6.1	2.9	7.5	3.4	6.4	1.9	4.7	7.8	7.4	2.9	8.0	0.0	2.1	4.9	5.2	3.9	11.0	2.4	8.1	-	4.7	7.5	2.3	4.3	6.7	7.1	3.0	2.0	3.9	3.2	5.7	1.2
Enterococcus faecium	3.5	1.5	0.0	2.2	3.4	2.6	8.6	2.6	1.6	5.3	3.4	2.8	0.0	5.2	3.5	1.3	4.4	4.4	0.0	2.5	-	4.3	3.8	1.3	1.8	2.7	3.7	2.6	7.1	2.8	3.2	3.1	0.3
Enterococcus sp., other	0.5	0.4	2.9	0.5	1.7	0.3	0.0	0.2	0.4	0.3	0.0	0.2	0.0	0.3	0.5	0.0	0.6	0.0	0.0	1.9	-	0.4	0.8	0.6	0.3	0.7	0.1	0.3	0.0	0.7	0.6	0.4	3.2
Enterococcus sp., not specified	0.3	0.7	0.0	1.0	0.0	0.7	0.6	0.0	0.2	0.6	0.8	1.8	0.0	1.8	0.3	3.9	1.1	0.0	0.0	0.0	-	0.1	0.0	0.0	0.3	0.0	0.3	1.6	1.0	1.1	0.0	0.5	4.0
Gram-positive cocci, not specified	0.0	0.0	0.0	0.5	1.7	0.1	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.6	-	0.0	0.4	0.0	0.0	0.0	0.2	0.5	1.0	0.4	0.0	0.2	0.0
Gram-positive cocci, other	0.3	0.4	0.0	0.0	0.0	0.1	0.0	0.6	0.3	0.3	0.0	0.2	3.7	0.0	0.2	0.0	0.0	1.1	0.0	0.0	-	0.0	0.1	0.0	0.3	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.0
Gram-negative cocci	0.5	1.1	0.0	0.0	0.0	0.1	0.0	0.2	0.4	0.6	0.4	0.0	0.0	0.3	0.2	0.0	0.0	0.0	0.0	0.6	-	0.0	0.1	0.6	0.3	0.0	0.3	0.8	0.0	0.4	0.6	0.3	0.0
Moraxella catharralis	0.0	1.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.6	-	0.0	0.1	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.1	0.0
Moraxella sp., other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Moraxella sp., not specified	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.1	0.0
Neisseria meningitidis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neisseria sp., other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Neisseria sp., not specified	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gram-negative cocci, not specified	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.6	0.1	0.0
Gram-negative cocci, other	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	0.0	0.0	0.0
Gram-positive bacilli	1.5	0.6	1.5	0.0	0.0	0.4	1.2	0.4	0.9	0.0	0.3	0.2	0.0	1.0	1.5	0.0	0.6	1.1	0.0	0.0	-	0.3	0.5	1.0	0.0	0.0	0.8	1.3	0.0	2.1	3.8	0.7	0.3
Corynebacterium species	1.3	0.4	1.5	0.0	0.0	0.3	0.6	0.2	0.8	0.0	0.3	0.2	0.0	0.5	1.0	0.0	0.6	1.1	0.0	0.0	-	0.1	0.3	0.6	0.0	0.0	0.4	0.7	0.0	0.7	2.5	0.5	0.3
Bacillus species	0.3	0.1	0.0	0.0	0.0	0.1	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	-	0.0	0.2	0.0	0.0	0.0	0.1	0.3	0.0	1.1	0.0	0.1	0.0
Lactobacillus species	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.6	0.1	0.0

Microorganism	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czechia	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands	Norway	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	UK-England	UK-Northern Ireland	UK-Scotland	UK-Wales	EU/EEA	Serbia
Listeria monocytogenes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gram-positive bacilli, not specified	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.6	0.0	0.0
Gram-positive bacilli, other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Enterobacterales	35.8	46.0	45.6	30.3	28.8	44.5	39.5	32.1	41.7	30.3	32.0	33.8	37.0	36.9	37.1	26.0	37.2	44.0	61.0	46.0	-	38.1	44.5	27.6	39.0	41.0	38.4	39.2	31.3	36.7	27.2	38.3	37.9
Citrobacter freundii	1.5	0.7	1.5	0.0	0.0	0.3	0.6	0.0	0.6	0.3	0.1	0.0	3.7	0.3	0.3	0.0	0.6	0.0	2.4	0.6	-	0.5	0.6	0.0	0.9	1.3	0.3	0.7	0.0	0.4	0.0	0.5	0.2
Citrobacter koseri (ex. diversus)	1.0	1.0	0.0	0.0	0.0	0.0	1.2	0.2	0.8	0.6	0.7	0.0	0.0	0.3	0.5	0.0	0.6	0.0	0.0	1.2	-	0.3	0.5	0.0	0.3	1.7	0.3	0.5	0.0	0.4	0.6	0.5	0.0
Citrobacter sp., other	0.5	0.1	0.0	0.0	0.0	0.0	0.6	0.2	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	-	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.2
Citrobacter sp., not specified	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.1	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.1	0.2
Enterobacter cloacae	4.3	5.3	1.5	1.5	5.1	2.0	3.7	3.9	6.2	0.9	2.5	1.4	3.7	1.6	3.2	5.2	0.6	4.4	0.0	9.3	-	3.8	2.2	1.0	2.7	6.3	3.6	3.5	1.0	1.1	0.6	3.2	0.2
Enterobacter aerogenes	0.5	1.4	0.0	0.0	0.0	0.2	1.2	0.2	1.3	0.6	0.0	0.2	0.0	0.5	1.1	0.0	0.6	2.2	2.4	1.2	-	0.1	1.0	0.0	0.0	2.3	0.9	1.2	0.0	0.7	0.0	0.7	0.0
Enterobacter agglomerans	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Enterobacter sakazakii	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Enterobacter sp., other	0.3	0.0	0.0	0.2	0.0	0.2	0.6	0.2	0.4	0.3	0.1	0.2	0.0	1.0	0.0	0.0	0.6	0.0	0.0	0.0	-	0.3	0.0	0.0	0.6	0.7	0.0	0.2	0.0	0.4	0.0	0.2	0.7
Enterobacter sp., not specified	0.0	0.0	0.0	0.5	1.7	0.0	1.9	0.2	0.0	0.3	0.4	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.2	0.0	0.6	0.0	0.2	0.2	0.0	0.0	1.9	0.2	2.2
Escherichia coli	16.0	22.5	13.2	11.4	10.2	16.4	16.0	17.1	21.2	16.4	5.9	13.9	22.2	23.4	13.0	5.2	10.6	16.5	39.0	20.5	-	14.1	17.0	6.5	15.2	13.3	16.0	19.4	21.2	23.0	17.7	16.1	8.8
Klebsiella pneumoniae	5.3	5.3	14.7	8.7	6.8	13.7	6.8	2.8	3.9	3.4	15.3	8.2	0.0	4.2	10.4	7.8	13.3	8.8	4.9	3.7	-	13.0	16.2	11.4	11.0	6.3	7.6	6.3	3.0	3.2	2.5	8.8	7.2
Klebsiella oxytoca	1.0	1.8	1.5	0.0	0.0	1.3	1.2	1.6	0.8	1.9	0.4	0.6	3.7	0.8	1.4	0.0	1.1	3.3	0.0	3.1	-	0.6	1.1	0.3	1.5	1.0	1.5	0.8	2.0	3.2	0.6	1.2	0.2
Klebsiella sp., other	0.3	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.3	0.3	0.1	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	-	0.1	0.1	1.3	0.0	0.7	0.1	0.0	0.0	0.0	0.0	0.2	4.0
Klebsiella sp., not specified	0.3	0.3	0.0	0.0	0.0	0.8	0.0	0.2	0.2	0.0	0.4	1.0	0.0	0.3	0.5	0.0	0.0	0.0	0.0	0.0	-	0.3	0.0	2.3	0.6	0.0	0.1	0.5	0.0	0.4	1.3	0.3	5.3
Proteus mirabilis	1.8	2.8	8.8	6.7	0.0	5.6	2.5	2.0	2.0	3.1	2.9	4.4	3.7	2.6	2.6	5.2	5.6	6.6	2.4	5.0	-	2.9	2.8	1.9	4.6	3.0	3.7	1.8	2.0	2.1	0.0	3.2	4.8
Proteus vulgaris	0.3	0.4	0.0	0.0	0.0	0.2	0.0	0.6	0.5	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.1	0.6	0.0	0.7	0.1	0.0	0.0	0.0	0.0	0.2	0.5
Proteus sp., other	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	2.4	0.0	-	0.0	0.0	0.3	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.1	0.2
Proteus sp., not specified	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.6	0.0	0.3	0.1	0.0	0.6	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.7	0.1	0.7	1.0	0.4	1.9	0.2	1.3
Serratia marcescens	1.3	1.8	2.9	0.2	3.4	1.3	1.9	1.4	0.9	0.9	1.3	0.8	0.0	0.8	1.5	1.3	1.1	1.1	7.3	0.0	-	0.8	0.9	1.0	0.0	1.3	1.2	1.2	1.0	0.4	0.0	1.1	0.3
Serratia liquefaciens	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	-	0.1	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.1	0.0
Serratia sp., other	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Serratia sp., not specified	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.5
Hafnia species	0.3	0.1	0.0	0.0	0.0	0.1	0.0	0.2	0.6	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0	-	0.3	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.1	0.0
Morganella species	0.5	1.8	0.0	0.0	1.7	1.5	1.2	0.6	1.5	0.9	0.4	0.6	0.0	0.5	0.8	0.0	0.6	1.1	0.0	0.6	-	0.4	1.3	0.0	0.9	1.0	1.8	1.0	0.0	1.1	0.0	1.0	0.7
Providencia species	0.0	0.1	1.5	0.2	0.0	0.2	0.0	0.2	0.0	0.0	0.8	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	-	0.1	0.1	0.6	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.2	0.5
Salmonella enteritidis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salmonella typhi or *paratyphi*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shigella species	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Enterobacterales, not specified	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0	-	0.0	0.1	0.0	0.0	0.0	0.1	0.8	0.0	0.0	0.0	0.1	0.0
Enterobacterales, other	0.0	0.3	0.0	0.5	0.0	0.1	0.0	0.2	0.4	0.0	0.0	0.6	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.6	-	0.1	0.2	0.3	0.0	0.0	0.0	0.2	0.0	0.4	0.0	0.2	0.0
Other gram-negative bacilli	8.5	11.5	27.9	28.4	22.0	9.4	14.2	6.7	12.6	10.2	31.7	13.9	7.4	6.2	14.0	18.2	15.0	7.7	9.8	8.1	-	15.2	12.2	21.1	11.9	11.0	15.1	11.9	4.0	6.0	13.9	13.8	27.0
Acinetobacter baumannii	0.3	0.6	10.3	9.5	3.4	0.5	0.0	1.2	1.2	0.3	16.3	2.8	0.0	0.3	3.0	15.6	4.4	0.0	0.0	0.0	-	6.1	1.0	7.1	1.8	1.0	1.9	0.2	1.0	0.0	0.6	2.9	10.2
Acinetobacter calcoaceticus	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Microorganism	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czechia	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands	Norway	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	UK-England	UK-Northern Ireland	UK-Scotland	UK-Wales	EU/EEA	Serbia
Acinetobacter haemolyticus	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Acinetobacter lwoffi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.3	0.0	0.0	0.1	0.0	0.0	0.0	0.6	0.0	0.0
Acinetobacter sp., other	0.5	0.4	1.5	0.2	0.0	0.1	0.6	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.1	1.6	0.9	0.0	0.0	0.2	0.0	0.4	0.0	0.2	2.0
Acinetobacter sp., not specified	0.0	0.1	1.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.1	0.0	1.7	0.0	0.0	0.0	-	0.0	0.0	1.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.8
Pseudomonas aeruginosa	6.8	6.5	13.2	16.2	18.6	6.9	10.5	4.5	7.2	6.2	12.5	9.1	3.7	3.4	8.1	1.3	5.6	6.6	7.3	3.7	-	7.2	9.7	9.4	7.3	7.0	9.9	7.9	2.0	2.1	4.4	8.0	10.5
Stenotrophomonas maltophilia	0.8	1.1	1.5	1.2	0.0	0.5	0.6	0.4	1.6	1.2	1.4	0.2	0.0	1.0	1.6	0.0	0.0	0.0	2.4	1.2	-	1.5	0.4	0.6	0.3	2.0	1.3	0.2	0.0	0.0	1.3	1.0	1.2
Burkholderia cepacia	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	-	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0
Pseudomonadaceae family, other	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.3	0.3	0.7	1.0	0.0	0.6	0.2	0.0
Pseudomonadaceae family, not specified	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.0	0.3	1.2	0.0	0.3	0.0	0.0	0.6	0.0	0.0	0.0	-	0.0	0.1	0.0	0.0	0.0	0.2	0.8	0.0	0.0	3.2	0.2	0.3
Haemophilus influenzae	0.0	0.7	0.0	0.0	0.0	0.3	1.9	0.0	1.0	0.3	0.0	0.4	0.0	1.0	0.2	0.0	0.0	1.1	0.0	0.0	-	0.1	0.7	0.0	0.6	0.7	1.0	1.2	0.0	2.1	2.5	0.6	0.0
Haemophilus parainfluenzae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.4	0.0	0.0	0.0
Haemophilus sp., not specified	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Legionella species	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Achromobacter species	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.3	0.0	3.7	0.0	0.3	0.0	2.2	0.0	0.0	0.0	-	0.0	0.0	0.0	0.3	0.0	0.1	0.2	0.0	0.0	0.0	0.1	0.0
Aeromonas species	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.6	-	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0
Agrobacterium sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Alcaligenes species	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Campylobacter species	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.6	-	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Flavobacterium species	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Helicobacter pylori	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0
Pasteurella species	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gram-negative bacilli, not specified	0.0	0.4	0.0	0.2	0.0	0.0	0.6	0.4	0.0	0.9	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	-	0.1	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.4	0.0	0.1	0.0
Gram-negative bacilli, other	0.0	0.1	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.7	0.0	0.1	0.0
Anaerobic bacilli	9.3	5.1	1.5	7.5	11.9	10.2	10.5	10.8	2.9	13.3	3.8	18.1	14.8	10.6	7.1	23.4	8.9	4.4	7.3	1.9	-	13.3	3.6	26.0	17.7	7.3	4.5	9.1	19.2	8.8	17.1	8.5	11.0
Bacteroides fragilis	0.0	0.3	0.0	0.0	0.0	0.1	0.0	1.2	0.5	0.0	0.1	0.4	0.0	0.0	0.6	1.3	0.0	0.0	2.4	0.0	-	0.0	0.1	0.0	0.0	1.0	0.6	0.2	1.0	0.0	0.0	0.3	0.0
Bacteroides sp., other	0.3	0.3	0.0	0.0	0.0	0.3	0.6	0.0	0.3	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.1	0.0	0.0	0.3	0.3	0.0	1.0	0.7	0.0	0.2	0.0
Bacteroides sp., not specified	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Clostridioides difficile	7.0	4.2	1.5	7.0	11.9	9.2	8.6	8.7	1.4	12.7	3.6	17.3	14.8	7.8	6.3	22.1	8.9	3.3	2.4	1.9	-	13.0	3.1	26.0	17.4	4.0	2.4	7.9	15.2	5.3	17.1	7.4	11.0
Clostridioides species, other	0.3	0.0	0.0	0.2	0.0	0.2	0.6	0.2	0.1	0.3	0.0	0.2	0.0	0.8	0.2	0.0	0.0	1.1	0.0	0.0	-	0.0	0.1	0.0	0.3	0.3	0.5	0.3	2.0	0.0	0.0	0.2	0.0
Propionibacterium species	0.8	0.3	0.0	0.2	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.2	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.1	0.0
Prevotella species	0.5	0.1	0.0	0.0	0.0	0.2	0.0	0.6	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.1	0.0	0.0	0.0	0.7	0.1	0.0	0.0	0.4	0.0	0.1	0.0
Anaerobes, not specified	0.3	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.1	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	2.4	0.0	-	0.0	0.1	0.0	0.0	0.0	0.1	0.5	0.0	2.5	0.0	0.2	0.0
Other anaerobes	0.3	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.3	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	-	0.1	0.0	0.0	0.0	0.7	0.1	0.2	0.0	0.0	0.0	0.1	0.0
Other bacteria	0.3	0.6	0.0	0.0	0.0	0.5	0.0	0.2	0.8	0.0	0.1	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	1.2	-	0.0	0.3	0.0	0.3	0.0	0.2	0.2	1.0	0.0	0.0	0.2	0.0
Chlamydia species	0.0	0.3	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Actinomyces species	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0
Nocardia species	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other bacteria	0.3	0.1	0.0	0.0	0.0	0.3	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	1.2	-	0.0	0.2	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.1	0.0

Microorganism	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czechia	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands	Norway	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	UK-England	UK-Northern Ireland	UK-Scotland	UK-Wales	EU/EEA	Serbia
Other bacteria, not specified	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Fungi	6.3	4.9	0.0	6.7	6.8	6.7	4.9	5.3	4.0	5.3	9.1	3.0	7.4	6.8	8.3	1.3	2.2	8.8	4.9	3.7	-	4.9	5.6	3.2	5.5	9.0	6.6	5.1	6.1	8.1	5.1	5.9	1.0
Candida albicans	3.3	2.6	0.0	2.2	1.7	3.8	1.9	3.9	1.6	2.8	2.9	1.4	3.7	3.9	4.0	0.0	1.7	7.7	2.4	1.2	-	2.8	3.5	1.6	2.7	5.0	3.0	2.5	1.0	1.1	1.9	2.9	0.0
Candida glabrata	0.5	0.4	0.0	0.7	0.0	0.5	0.6	0.2	0.4	1.2	0.3	0.4	0.0	0.5	0.8	0.0	0.0	0.0	2.4	0.6	-	1.4	0.4	0.0	0.9	2.0	1.4	0.5	3.0	1.1	0.0	0.7	0.0
Candida krusei	0.8	0.0	0.0	0.0	0.0	0.0	0.6	0.2	0.0	0.3	0.0	0.4	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	-	0.0	0.1	0.6	0.0	0.7	0.3	0.0	0.0	0.0	0.0	0.2	0.0
Candida parapsilosis	0.0	0.3	0.0	1.7	0.0	0.3	0.0	0.4	0.5	0.3	1.5	0.0	0.0	0.3	1.5	0.0	0.0	1.1	0.0	0.6	-	0.0	0.3	0.0	0.3	0.0	0.6	0.0	0.0	0.0	0.0	0.5	0.2
Candida tropicalis	0.0	0.1	0.0	0.2	1.7	0.2	0.6	0.0	0.0	0.0	0.6	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	-	0.3	0.2	0.0	0.3	0.0	0.5	0.3	0.0	0.0	0.0	0.2	0.0
Candida sp., other	0.5	0.4	0.0	0.2	0.0	0.7	0.0	0.0	0.4	0.3	1.0	0.0	0.0	0.0	0.5	0.0	0.6	0.0	0.0	0.6	-	0.1	0.5	0.0	0.0	0.7	0.1	0.5	0.0	0.0	0.0	0.3	0.3
Candida sp., not specified	0.8	0.0	0.0	0.5	3.4	0.7	0.0	0.0	0.2	0.0	2.0	0.4	0.0	0.8	0.5	1.3	0.0	0.0	0.0	0.0	-	0.1	0.2	1.0	0.6	0.0	0.3	0.7	0.0	2.5	3.2	0.5	0.3
Aspergillus fumigatus	0.3	0.7	0.0	1.0	0.0	0.2	1.2	0.0	0.2	0.0	0.0	0.2	0.0	0.5	0.1	0.0	0.0	0.0	0.0	0.6	-	0.1	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.2	0.0
Aspergillus niger	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	2.8	0.0	0.1	0.0
Aspergillus sp., other	0.3	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.3	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0
Aspergillus sp., not specified	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.3	0.2	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	-	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Other yeasts	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.0	0.7	0.0	0.1	0.0
Fungi, other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.4	0.0	0.0	0.3	0.2	0.0	0.0	0.0	0.0	0.0	-	0.1	0.5	0.0	0.3	0.3	0.1	0.0	1.0	0.0	0.0	0.1	0.2
Fungi, not specified	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Filaments other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other fungi/parasites	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0
Virus	0.0	0.3	0.0	0.0	0.0	0.2	0.6	1.8	0.3	0.6	0.0	0.8	3.7	0.0	1.4	0.0	1.1	0.0	0.0	0.0	-	0.5	0.1	0.6	1.5	0.7	0.6	0.0	0.0	0.0	0.6	0.5	0.0
Adenovirus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	-	0.1	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0
Cytomegalovirus (CMV)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	-	0.1	0.1	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.6	0.1	0.0
Hepatitis c virus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Herpes simplex virus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.3	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Human immunodeficiency virus (HIV)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Norovirus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.3	0.0	0.8	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Parainfluenzavirus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	0.1	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Respiratory syncytial virus (RSV)	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Rhinovirus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rotavirus	0.0	0.0	0.0	0.0	0.0	0.2	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	1.1	0.0	0.0	0.0	-	0.1	0.0	0.3	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Varicella-zoster virus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other virus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0
Negative codes	44.6	38.0	26.9	43.5	47.9	39.1	36.6	54.5	28.9	40.3	48.8	56.2	43.2	54.1	46.0	58.2	60.5	40.0	46.9	29.1	100.0	50.9	45.8	41.3	28.6	47.3	32.4	61.7	64.7	55.4	63.2	47.4	29.1
Micro-organism not identified	0.9	8.0	2.6	7.9	0.0	11.6	1.5	0.5	4.7	1.1	1.2	0.3	2.3	8.9	2.9	2.1	0.3	1.8	1.6	5.5	0.0	1.9	5.7	4.0	3.8	0.7	2.9	18.5	6.2	2.8	1.6	4.8	6.0
Examination not done	28.7	8.5	0.0	3.8	0.0	5.7	7.9	1.2	17.9	1.4	21.8	44.0	29.5	5.5	11.0	11.0	3.4	0.0	18.8	19.2	0.0	9.1	9.8	1.1	7.2	21.5	14.1	13.2	29.9	21.5	5.9	12.5	3.1
Sterile examination	6.5	2.3	0.0	1.2	0.0	0.3	7.4	0.8	6.3	0.9	8.5	4.9	4.5	1.6	1.7	0.0	4.5	0.0	15.6	4.4	0.0	1.5	2.8	0.9	0.8	11.9	6.9	1.1	0.4	5.1	1.1	3.3	0.3
Result not (yet) available or missing	8.5	19.2	24.4	30.7	47.9	21.5	19.8	52.0	0.0	36.8	17.3	6.9	6.8	38.1	30.4	45.2	52.3	38.2	10.9	0.0	100.0	38.4	27.6	35.4	16.9	13.1	8.6	28.8	28.2	26.0	54.7	26.8	19.8

Table A1.5. Prevalence of HAIs and antimicrobial use, by patient specialty

Specialty	Number of patients	% of total	N pts HAI	HAI%	N pts AU	AU%
All specialties	325 737	100.0	18937	5.8	108 285	33.2
Surgery (SUR)	90 219	30.6	5981	6.6	37 185	41.2
General surgery	22 007	6.8	1475	6.7	10 231	46.5
Digestive tract surgery	5 694	1.7	562	9.9	2 506	44.0
Orthopaedics and surgical traumatology	21 616	6.6	1254	5.8	7 525	34.8
Cardiovascular surgery	2 160	0.7	291	13.5	746	34.5
Thoracic surgery	1 566	0.5	113	7.2	610	39.0
Neurosurgery	5 718	1.8	508	8.9	1 746	30.5
Paediatric surgery	1 602	0.5	44	2.7	681	42.5
Transplantation surgery	641	0.2	86	13.4	384	59.9
Surgery for cancer	1 494	0.5	106	7.1	567	38.0
ENT	4 302	1.3	128	3.0	1 765	41.0
Ophthalmology	2 071	0.6	17	0.8	350	16.9
Maxillo-facial surgery	958	0.3	47	4.9	573	59.8
Stomatology/ Dentistry	72	<0.1	3	4.2	41	56.9
Burns care	279	0.1	35	12.5	108	38.7
Urology	7 812	2.4	451	5.8	4 621	59.2
Plastic and reconstructive surgery	1 838	0.6	121	6.6	950	51.7
Other surgery	1 084	0.3	50	4.6	440	40.6
Medicine (MED)	131 202	40.3	7378	5.6	47 332	36.1
General medicine	43 066	13.2	2460	5.7	17 815	41.4
Gastro-enterology	8 305	2.5	377	4.5	3 028	36.5
Hepatology	494	0.2	41	8.3	232	47.0
Endocrinology	3 187	1.0	97	3.0	861	27.0
Nephrology	4 806	1.5	452	9.4	2 309	48.0
Cardiology	17 323	5.3	673	3.9	3 488	20.1
Dermatology	1 789	0.5	35	2.0	576	32.2
Haematology / BMT	4 721	1.4	735	15.6	2 943	62.3
Oncology	8 548	2.6	562	6.6	2 516	29.4
Neurology	15 068	4.6	783	5.2	2 383	15.8
Pneumology	11 595	3.6	495	4.3	6 251	53.9
Rheumatology	1 931	0.6	38	2.0	369	19.1
Infectious diseases	4 674	1.4	377	8.1	3 178	68.0
Medical traumatology	1 131	0.3	29	2.6	61	5.4
Other Medical	4 279	1.3	166	3.9	1 099	25.7
Paediatrics (PED)	14 384	4.4	337	2.3	4 101	28.5
Neonatology	5 324	1.6	160	3.0	707	13.3
Paediatrics	9 060	2.8	177	2.0	3 394	37.5
Intensive care unit (ICU)	15 336	4.7	2934	19.1	8 660	56.5
Medical ICU	3 526	1.1	582	16.5	1 913	54.3
Surgical ICU	3 246	1.0	741	22.8	2 248	69.3
Paediatric ICU	845	0.3	133	15.7	435	51.5
Neonatal ICU	2 453	0.8	256	10.4	782	31.9
Mixed/polyvalent ICU	3 591	1.1	970	27.0	2 458	68.4
Specialised ICU	1 208	0.4	204	16.9	617	51.1
Other ICU	467	0.1	48	10.3	207	44.3
Gynaecology/obstetrics (GO)	22 980	7.1	365	1.6	4 454	19.4
Obstetrics / Maternity	16 563	5.1	169	1.0	2 423	14.6
Gynaecology (incl. surgery)	6 417	2.0	196	3.1	2 031	31.7
Geriatrics (GER)	12 913	4.0	797	6.2	3 748	29.0
Geriatrics, care for the elderly	12 913	4.0	797	6.2	3 748	29.0
Psychiatrics (PSY)	17 499	5.4	173	1.0	430	2.5
Psychiatrics	17 499	5.4	173	1.0	430	2.5
Other (OTH)	19 691	6.0	875	4.4	1 942	9.9

Specialty	Number of patients	% of total	N pts HAI	HAI%	N pts AU	AU%
Rehabilitation	9 301	2.9	415	4.5	768	8.3
Long-term care	6 780	2.1	267	3.9	453	6.7
Others not listed	3 317	1.0	179	5.4	654	19.7
Unknown	293	0.1	14	4.8	67	22.9
Mixed (MIX)	1 513	0.5	97	6.4	433	28.6
Combination of specialties	1 513	0.5	97	6.4	433	28.6

Table A1.6. Antimicrobial agents (4th and 5th ATC levels), by indication

Antimicrobial agent (ATC code)	Total	%	Treatment (%)	Surgical prophyl-axis (%)	Medical prophyl-axis (%)
Total number of antimicrobial agents	139 591	100.0	98 984	19 792	14 977
Intestinal antiinfectives, antibiotics (A07AA)	1 862	1.3	1.3	0.1	2.9
Neomycin (oral) (A07AA01)	29	0.0	<0.1	<0.1	0.1
Nystatin (A07AA02)	600	0.4	0.4	0.0	1.2
Natamycin (A07AA03)	1	<0.1	<0.1	0.0	0.0
Streptomycin (oral) (A07AA04)	11	<0.1	<0.1	0.0	0.0
Polymyxin B (A07AA05)	1	<0.1	0.0	0.0	0.0
Paromomycin (A07AA06)	11	<0.1	<0.1	<0.1	<0.1
Amphotericin B (oral) (A07AA07)	26	<0.1	<0.1	<0.1	0.1
Kanamycin (A07AA08)	22	<0.1	<0.1	0.0	0.0
Vancomycin (oral) (A07AA09)	657	0.5	0.6	<0.1	0.1
Colistin (oral) (A07AA10)	71	0.1	<0.1	0.0	0.2
Rifaximin (A07AA11)	391	0.3	0.2	<0.1	1.1
Fidaxomicin (A07AA12)	40	<0.1	<0.1	0.0	0.0
Neomycin, combinations (oral) (A07AA51)	1	<0.1	0.0	0.0	0.0
Intestinal antiinfectives, antibiotics, unclassified (A07AA99)	1	<0.1	<0.1	0.0	0.0
Antifungals for systemic use (D01BA)	18	<0.1	<0.1	0.0	<0.1
Griseofulvin (D01BA01)	1	<0.1	0.0	0.0	0.0
Terbinafine (D01BA02)	17	<0.1	<0.1	0.0	<0.1
Tetracyclines (J01AA)	2 224	1.6	1.9	0.4	0.8
Demeclocycline (J01AA01)	16	<0.1	<0.1	0.0	<0.1
Doxycycline (J01AA02)	1 637	1.2	1.4	0.3	0.5
Lymecycline (J01AA04)	21	<0.1	<0.1	0.0	0.1
Metacycline (J01AA05)	3	<0.1	<0.1	0.0	0.0
Oxytetracycline (J01AA06)	10	<0.1	<0.1	0.0	<0.1
Tetracycline (J01AA07)	13	<0.1	<0.1	0.0	<0.1
Minocycline (J01AA08)	27	<0.1	<0.1	<0.1	<0.1
Clomocycline (J01AA11)	2	<0.1	<0.1	0.0	0.0
Tigecycline (J01AA12)	492	0.4	0.4	0.1	0.1
Combinations of tetracyclines (J01AA20)	2	<0.1	<0.1	<0.1	0.0
Oxytetracycline, combinations (J01AA56)	1	<0.1	<0.1	0.0	0.0
Amphenicols (J01BA)	33	<0.1	<0.1	<0.1	<0.1
Chloramphenicol (J01BA01)	32	<0.1	<0.1	<0.1	<0.1
Thiamphenicol (J01BA02)	1	<0.1	0.0	<0.1	0.0
Penicillins, extended spectrum without anti-pseudomonal activity (J01CA)	6 727	4.8	5.1	2.6	5.3
Ampicillin (J01CA01)	2 090	1.5	1.3	1.1	3.1
Pivampicillin (J01CA02)	3	<0.1	<0.1	0.0	0.0
Amoxicillin (J01CA04)	3 601	2.6	3.0	1.1	1.6
Carindacillin (J01CA05)	1	<0.1	<0.1	0.0	0.0
Epicillin (J01CA07)	1	<0.1	<0.1	0.0	0.0
Pivmecillinam (J01CA08)	217	0.2	0.2	0.1	0.1
Azlocillin (J01CA09)	2	<0.1	<0.1	0.0	0.0
Mecillinam (J01CA11)	20	<0.1	<0.1	0.0	0.0
Piperacillin (J01CA12)	411	0.3	0.3	0.1	0.4
Ticarcillin (J01CA13)	1	<0.1	<0.1	0.0	0.0
Metampicillin (J01CA14)	1	<0.1	<0.1	0.0	0.0
Sulbenicillin (J01CA16)	2	<0.1	<0.1	0.0	<0.1
Temocillin (J01CA17)	187	0.1	0.2	<0.1	0.0
Combinations of penicillins with extended spectrum (J01CA20)	34	<0.1	<0.1	<0.1	<0.1
Ampicillin, combinations (J01CA51)	144	0.1	0.1	0.2	0.2
Penicillins, extended spectrum without anti-pseudomonal activity, unclassified (J01CA99)	12	<0.1	<0.1	<0.1	<0.1

Antimicrobial agent (ATC code)	Total	%	Treatment (%)	Surgical prophyl-axis (%)	Medical prophyl-axis (%)
Beta-lactamase sensitive penicillins (J01CE)	2 195	1.6	1.7	0.3	2.3
Benzylpenicillin (J01CE01)	1 682	1.2	1.4	0.3	1.1
Phenoxymethylpenicillin (J01CE02)	374	0.3	0.2	0.1	1.1
Propicillin (J01CE03)	1	<0.1	0.0	0.0	<0.1
Azidocillin (J01CE04)	3	<0.1	<0.1	0.0	0.0
Pheneticillin (J01CE05)	4	<0.1	<0.1	0.0	<0.1
Penamecillin (J01CE06)	3	<0.1	<0.1	<0.1	0.0
Benzathine benzylpenicillin (J01CE08)	75	0.1	0.1	0.0	0.1
Procaine benzylpenicillin (J01CE09)	28	<0.1	<0.1	<0.1	<0.1
Benzathine phenoxymethylpenicillin (J01CE10)	16	<0.1	<0.1	0.0	<0.1
Combinations of beta-lactamase sensitive penicillins (J01CE30)	5	<0.1	<0.1	0.0	<0.1
Beta-lactamase sensitive penicillins, unclassified (J01CE99)	4	<0.1	<0.1	0.0	<0.1
Beta-lactamase resistant penicillins (J01CF)	3 052	2.2	2.7	1.2	0.3
Dicloxacillin (J01CF01)	112	0.1	0.1	0.1	<0.1
Cloxacillin (J01CF02)	489	0.4	0.4	0.2	<0.1
Oxacillin (J01CF04)	336	0.2	0.3	0.3	0.1
Flucloxacillin (J01CF05)	2 113	1.5	1.9	0.7	0.2
Nafcillin (J01CF06)	1	<0.1	<0.1	0.0	0.0
Beta-lactamase resistant penicillins, unclassified (J01CF99)	1	<0.1	<0.1	0.0	<0.1
Beta-lactamase inhibitors (J01CG)	369	0.3	0.2	0.3	0.4
Sulbactam (J01CG01)	40	<0.1	<0.1	0.1	0.1
Tazobactam (J01CG02)	328	0.2	0.2	0.2	0.4
Beta-lactamase inhibitors, unclassified (J01CG99)	1	<0.1	<0.1	0.0	0.0
Combinations of penicillins, incl. beta-lactamase inhibitors (J01CR)	28 581	20.5	22.4	15.1	14.5
Ampicillin and enzyme inhibitor (J01CR01)	2 233	1.6	1.4	2.4	1.8
Amoxicillin and enzyme inhibitor (J01CR02)	15 488	11.1	11.6	10.5	8.0
Ticarcillin and enzyme inhibitor (J01CR03)	2	<0.1	<0.1	<0.1	0.0
Sultamicillin (J01CR04)	302	0.2	0.2	0.3	0.3
Piperacillin and enzyme inhibitor (J01CR05)	10 461	7.5	9.2	2.0	4.3
Combinations of penicillins (J01CR50)	95	0.1	0.1	<0.1	<0.1
First-generation cephalosporins (J01DB)	6 729	4.8	1.0	26.6	2.3
Cefalexin (J01DB01)	511	0.4	0.3	0.3	0.6
Cefaloridine (J01DB02)	3	<0.1	0.0	<0.1	<0.1
Cefalotin (J01DB03)	228	0.2	<0.1	1.1	<0.1
Cefazolin (J01DB04)	5 910	4.2	0.6	25.1	1.7
Cefadroxil (J01DB05)	26	<0.1	<0.1	<0.1	<0.1
Cefazedone (J01DB06)	13	<0.1	<0.1	0.1	<0.1
Cefatrizine (J01DB07)	2	<0.1	<0.1	0.0	0.0
Cefapirin (J01DB08)	3	<0.1	0.0	<0.1	0.0
Cefradine (J01DB09)	26	<0.1	<0.1	0.1	0.1
Cefroxadine (J01DB11)	3	<0.1	<0.1	<0.1	0.0
Ceftezole (J01DB12)	4	<0.1	<0.1	0.0	0.0
Second-generation cephalosporins (J01DC)	9 038	6.5	4.6	17.9	4.4
Cefoxitin (J01DC01)	836	0.6	0.1	3.1	0.4
Cefuroxime (J01DC02)	7 902	5.7	4.4	13.8	3.7
Cefamandole (J01DC03)	29	<0.1	<0.1	0.1	<0.1
Cefaclor (J01DC04)	64	<0.1	<0.1	0.2	0.1
Cefonicide (J01DC06)	7	<0.1	<0.1	<0.1	<0.1
Cefotiam (J01DC07)	1	<0.1	0.0	<0.1	0.0
Loracarbef (J01DC08)	1	<0.1	0.0	<0.1	0.0
Cefprozil (J01DC10)	19	<0.1	<0.1	0.1	<0.1
Ceforanide (J01DC11)	174	0.1	<0.1	0.6	0.2
Cefminox (J01DC12)	4	<0.1	0.0	<0.1	0.0

Antimicrobial agent (ATC code)	Total	%	Treatment (%)	Surgical prophyl-axis (%)	Medical prophyl-axis (%)
Cefbuperazone (J01DC13)	1	<0.1	<0.1	0.0	0.0
Third-generation cephalosporins (J01DD)	13 794	9.9	10.2	9.2	9.1
Cefotaxime (J01DD01)	2 219	1.6	1.7	1.2	1.4
Ceftazidime (J01DD02)	1 560	1.1	1.2	1.0	1.0
Cefsulodin (J01DD03)	1	<0.1	0.0	<0.1	0.0
Ceftriaxone (J01DD04)	9 303	6.7	6.9	6.3	6.2
Cefmenoxime (J01DD05)	1	<0.1	0.0	<0.1	0.0
Latamoxef (J01DD06)	4	<0.1	<0.1	0.0	<0.1
Ceftizoxime (J01DD07)	31	<0.1	<0.1	<0.1	<0.1
Cefixime (J01DD08)	144	0.1	0.1	0.1	0.1
Cefodizime (J01DD09)	3	<0.1	<0.1	0.0	0.0
Cefpiramide (J01DD11)	2	<0.1	0.0	0.0	<0.1
Cefoperazone (J01DD12)	142	0.1	0.1	0.2	0.1
Cefpodoxime (J01DD13)	41	<0.1	<0.1	<0.1	<0.1
Cefditoren (J01DD16)	16	<0.1	<0.1	0.0	<0.1
Cefotaxime, combinations (J01DD51)	14	<0.1	<0.1	<0.1	<0.1
Ceftazidime, combinations (J01DD52)	25	<0.1	<0.1	<0.1	<0.1
Ceftriaxone, combinations (J01DD54)	86	0.1	0.1	0.1	<0.1
Cefoperazone, combinations (J01DD62)	202	0.1	0.1	0.3	0.1
Fourth-generation cephalosporins (J01DE)	525	0.4	0.4	0.1	0.3
Cefepime (J01DE01)	523	0.4	0.4	0.1	0.3
Cefpirome (J01DE02)	2	<0.1	<0.1	<0.1	0.0
Monobactams (J01DF)	138	0.1	0.1	<0.1	0.1
Aztreonam (J01DF01)	137	0.1	0.1	<0.1	0.1
Carumonam (J01DF02)	1	<0.1	0.0	<0.1	0.0
Carbapenems (J01DH)	6 823	4.9	6.0	1.0	2.6
Meropenem (J01DH02)	5 072	3.6	4.5	0.6	2.1
Ertapenem (J01DH03)	503	0.4	0.5	0.1	0.1
Doripenem (J01DH04)	1	<0.1	<0.1	0.0	0.0
Biapenem (J01DH05)	1	<0.1	<0.1	0.0	0.0
Imipenem and enzyme inhibitor (J01DH51)	1 246	0.9	1.1	0.2	0.4
Other cephalosporins and penems (J01DI)	48	<0.1	<0.1	<0.1	<0.1
Ceftobiprole medocaril (J01DI01)	7	<0.1	<0.1	0.0	0.0
Ceftaroline fosamil (J01DI02)	15	<0.1	<0.1	<0.1	0.0
Faropenem (J01DI03)	1	<0.1	<0.1	0.0	0.0
Ceftolozane and enzyme inhibitor (J01DI54)	24	<0.1	<0.1	0.0	<0.1
Other cephalosporins and penems, unclassified (J01DI99)	1	<0.1	0.0	<0.1	0.0
Trimethoprim and derivatives (J01EA)	1 093	0.8	0.8	0.2	1.7
Trimethoprim (J01EA01)	1 039	0.7	0.8	0.2	1.4
Brodimoprim (J01EA02)	1	<0.1	0.0	<0.1	0.0
Trimethoprim and derivatives, unclassified (J01EA99)	53	<0.1	<0.1	0.0	0.2
Short-acting sulfonamides (J01EB)	6	<0.1	<0.1	<0.1	<0.1
Sulfamethizole (J01EB02)	3	<0.1	<0.1	0.0	<0.1
Sulfadimidine (J01EB03)	1	<0.1	0.0	<0.1	0.0
Sulfafurazole (J01EB05)	2	<0.1	0.0	0.0	<0.1
Intermediate-acting sulfonamides (J01EC)	78	0.1	<0.1	<0.1	0.1
Sulfamethoxazole (J01EC01)	65	<0.1	<0.1	<0.1	0.1
Sulfadiazine (J01EC02)	6	<0.1	<0.1	0.0	<0.1
Sulfamoxole (J01EC03)	1	<0.1	<0.1	0.0	0.0
Combinations of intermediate-acting sulphonamides (J01EC20)	6	<0.1	<0.1	0.0	<0.1
Long-acting sulfonamides (J01ED)	7	<0.1	<0.1	<0.1	<0.1
Sulfadimethoxine (J01ED01)	4	<0.1	<0.1	<0.1	<0.1
Sulfametomidine (J01ED03)	2	<0.1	<0.1	0.0	0.0

Antimicrobial agent (ATC code)	Total	%	Treatment (%)	Surgical prophyl-axis (%)	Medical prophyl-axis (%)
Sulfamethoxypyridazine (J01ED05)	1	<0.1	0.0	0.0	0.0
Combinations of sulfonamides and trimethoprim, incl. derivatives (J01EE)	3 629	2.6	1.6	0.7	11.8
Sulfamethoxazole and trimethoprim (J01EE01)	3 342	2.4	1.5	0.6	11.0
Sulfadiazine and trimethoprim (J01EE02)	108	0.1	<0.1	<0.1	0.4
Sulfametrole and trimethoprim (J01EE03)	85	0.1	<0.1	0.1	0.2
Sulfamoxole and trimethoprim (J01EE04)	39	<0.1	<0.1	<0.1	0.1
Sulfadimidine and trimethoprim (J01EE05)	32	<0.1	<0.1	<0.1	0.1
Sulfadiazine and tetroxoprim (J01EE06)	2	<0.1	<0.1	0.0	<0.1
Sulfamerazine and trimethoprim (J01EE07)	18	<0.1	<0.1	0.0	<0.1
Combinations of sulfonamides and trimethoprim, incl. derivatives, unclassified (J01EE99)	3	<0.1	<0.1	0.0	<0.1
Macrolides (J01FA)	4 378	3.1	3.5	0.4	3.4
Erythromycin (J01FA01)	341	0.2	0.1	<0.1	0.4
Spiramycin (J01FA02)	69	<0.1	0.1	<0.1	<0.1
Roxithromycin (J01FA06)	63	<0.1	0.1	0.0	<0.1
Josamycin (J01FA07)	5	<0.1	<0.1	<0.1	<0.1
Clarithromycin (J01FA09)	2 670	1.9	2.5	0.2	0.6
Azithromycin (J01FA10)	1 226	0.9	0.8	0.1	2.3
Miocamycin (J01FA11)	1	<0.1	<0.1	0.0	0.0
Rokitamycin (J01FA12)	2	<0.1	<0.1	0.0	0.0
Telithromycin (J01FA15)	1	<0.1	<0.1	0.0	0.0
Lincosamides (J01FF)	3 041	2.2	2.3	2.3	1.2
Clindamycin (J01FF01)	3 019	2.2	2.3	2.3	1.2
Lincomycin (J01FF02)	22	<0.1	<0.1	0.0	<0.1
Streptogramins (J01FG)	32	<0.1	<0.1	0.0	0.0
Pristinamycin (J01FG01)	31	<0.1	<0.1	0.0	0.0
Quinupristin/dalfopristin (J01FG02)	1	<0.1	<0.1	0.0	0.0
Streptomycins (J01GA)	15	<0.1	<0.1	0.0	<0.1
Aminoglycosides (J01GB)	5 944	4.3	4.1	4.8	4.4
Tobramycin (J01GB01)	300	0.2	0.2	0.2	0.3
Gentamicin (J01GB03)	4 199	3.0	2.8	3.7	3.0
Kanamycin (J01GB04)	2	<0.1	<0.1	0.0	0.0
Neomycin (injection, infusion) (J01GB05)	1	<0.1	<0.1	0.0	0.0
Amikacin (J01GB06)	1 395	1.0	1.0	0.8	1.0
Netilmicin (J01GB07)	46	<0.1	<0.1	0.1	0.1
Sisomicin (J01GB08)	1	<0.1	<0.1	0.0	0.0
Fluoroquinolones (J01MA)	13 601	9.7	10.6	4.5	11.0
Ofloxacin (J01MA01)	276	0.2	0.2	0.1	0.2
Ciprofloxacin (J01MA02)	8 544	6.1	6.5	3.5	6.8
Pefloxacin (J01MA03)	72	0.1	<0.1	0.1	<0.1
Norfloxacin (J01MA06)	194	0.1	0.1	0.1	0.4
Lomefloxacin (J01MA07)	1	<0.1	<0.1	0.0	0.0
Fleroxacin (J01MA08)	1	<0.1	<0.1	0.0	0.0
Grepafloxacin (J01MA11)	1	<0.1	<0.1	0.0	0.0
Levofloxacin (J01MA12)	3 748	2.7	3.0	0.6	3.3
Trovafloxacin (J01MA13)	1	<0.1	<0.1	0.0	0.0
Moxifloxacin (J01MA14)	757	0.5	0.7	0.1	0.3
Prulifloxacin (J01MA17)	3	<0.1	<0.1	0.0	0.0
Garenoxacin (J01MA19)	3	<0.1	<0.1	<0.1	0.0
Other quinolones (J01MB)	29	<0.1	<0.1	<0.1	<0.1
Nalidixic acid (J01MB02)	2	<0.1	<0.1	0.0	0.0
Piromidic acid (J01MB03)	2	<0.1	<0.1	0.0	0.0
Pipemidic acid (J01MB04)	11	<0.1	<0.1	0.0	<0.1

Antimicrobial agent (ATC code)	Total	%	Treatment (%)	Surgical prophyl-axis (%)	Medical prophyl-axis (%)
Oxolinic acid (J01MB05)	1	<0.1	0.0	0.0	0.0
Cinoxacin (J01MB06)	9	<0.1	<0.1	<0.1	<0.1
Flumequine (J01MB07)	4	<0.1	<0.1	0.0	0.0
Combinations of antibacterials (J01RA)	276	0.2	0.2	0.1	0.3
Penicillins, combinations with other antibacterials (J01RA01)	129	0.1	0.1	0.0	0.2
Sulfonamides, combinations with other antibacterials (excl. trimethoprim (J01RA02)	22	<0.1	<0.1	0.0	0.1
Cefuroxime and metronidazole (J01RA03)	61	<0.1	<0.1	0.1	<0.1
Spiramycin and metronidazole (J01RA04)	3	<0.1	<0.1	0.0	0.0
Levofloxacin, combinations with other antibacterials (J01RA05)	20	<0.1	<0.1	0.0	<0.1
Cefepime and amikacin (J01RA06)	1	<0.1	<0.1	0.0	0.0
Azithromycin, fluconazole and secnidazole (J01RA07)	4	<0.1	<0.1	0.0	<0.1
Ciprofloxacin and metronidazole (J01RA10)	31	<0.1	<0.1	<0.1	<0.1
Ciprofloxacin and tinidazole (J01RA11)	3	<0.1	<0.1	0.0	0.0
Norfloxacin and tinidazole (J01RA13)	1	<0.1	0.0	<0.1	0.0
Combinations of antibacterials, unclassified (J01RA99)	1	<0.1	0.0	<0.1	0.0
Glycopeptide antibacterials (J01XA)	5 181	3.7	4.1	3.1	1.9
Vancomycin (parenteral) (J01XA01)	3 897	2.8	3.3	1.6	1.4
Teicoplanin (J01XA02)	1 259	0.9	0.8	1.5	0.5
Telavancin (J01XA03)	19	<0.1	<0.1	0.0	0.1
Dalbavancin (J01XA04)	6	<0.1	<0.1	0.0	<0.1
Polymyxins (J01XB)	862	0.6	0.8	0.1	0.4
Colistin (injection, infusion) (J01XB01)	861	0.6	0.8	0.1	0.4
Polymyxins, unclassified (J01XB99)	1	<0.1	<0.1	0.0	0.0
Steroid antibacterials (J01XC)	88	0.1	0.1	<0.1	0.0
Fusidic acid (J01XC01)	88	0.1	0.1	<0.1	0.0
Imidazole derivatives (J01XD)	7 243	5.2	4.9	7.4	3.8
Metronidazole (parenteral) (J01XD01)	7 212	5.2	4.9	7.3	3.8
Tinidazole (parenteral) (J01XD02)	2	<0.1	<0.1	<0.1	0.0
Ornidazole (parenteral) (J01XD03)	29	<0.1	<0.1	0.1	<0.1
Nitrofuran derivatives (J01XE)	925	0.7	0.7	0.1	1.4
Nitrofurantoin (J01XE01)	882	0.6	0.6	0.1	1.4
Nifurtoinol (J01XE02)	23	<0.1	<0.1	0.0	<0.1
Furazidin (J01XE03)	11	<0.1	<0.1	0.0	<0.1
Nitrofurantoin, combinations (J01XE51)	9	<0.1	<0.1	0.0	<0.1
Other antibacterials (J01XX)	2 119	1.5	1.8	0.4	1.1
Fosfomycin (J01XX01)	234	0.2	0.2	0.1	0.2
Xibornol (J01XX02)	3	<0.1	<0.1	0.0	<0.1
Spectinomycin (J01XX04)	1	<0.1	<0.1	0.0	0.0
Methenamine (J01XX05)	65	<0.1	<0.1	<0.1	0.3
Nitroxoline (J01XX07)	7	<0.1	<0.1	0.0	0.0
Linezolid (J01XX08)	1 335	1.0	1.2	0.2	0.4
Daptomycin (J01XX09)	427	0.3	0.4	0.1	0.1
Bacitracin (J01XX10)	1	<0.1	<0.1	0.0	0.0
Tedizolid (J01XX11)	37	<0.1	<0.1	<0.1	0.1
Other antibacterials, unclassified (J01XX99)	9	<0.1	<0.1	0.0	<0.1
Antimycotics, antibiotics (J02AA)	332	0.2	0.2	<0.1	0.7
Amphotericin B (parenteral) (J02AA01)	332	0.2	0.2	<0.1	0.7
Imidazole derivatives (J02AB)	15	<0.1	<0.1	<0.1	<0.1
Miconazole (J02AB01)	11	<0.1	<0.1	<0.1	0.0
Ketoconazole (J02AB02)	4	<0.1	0.0	<0.1	0.0
Triazole derivatives (J02AC)	3 436	2.5	1.9	0.3	8.8
Fluconazole (J02AC01)	2 723	2.0	1.7	0.2	6.0

Antimicrobial agent (ATC code)	Total	%	Treatment (%)	Surgical prophyl-axis (%)	Medical prophyl-axis (%)
Itraconazole (J02AC02)	91	0.1	<0.1	0.0	0.3
Voriconazole (J02AC03)	309	0.2	0.2	0.1	0.7
Posaconazole (J02AC04)	308	0.2	<0.1	<0.1	1.8
Isavuconazole (J02AC05)	5	<0.1	<0.1	0.0	<0.1
Other antimycotics for systemic use (J02AX)	677	0.5	0.5	<0.1	0.9
Flucytosine (J02AX01)	12	<0.1	<0.1	<0.1	0.0
Caspofungin (J02AX04)	274	0.2	0.2	<0.1	0.2
Micafungin (J02AX05)	192	0.1	0.1	0.0	0.5
Anidulafungin (J02AX06)	199	0.1	0.2	<0.1	0.1
Antimycobacterials, antibiotics (J04AB)	1 255	0.9	1.2	0.1	0.2
Cycloserine (J04AB01)	54	<0.1	0.1	0.0	<0.1
Rifampicin (J04AB02)	1 171	0.8	1.1	0.1	0.2
Rifabutin (J04AB04)	26	<0.1	<0.1	<0.1	0.0
Not specified (J04AB99)	4	<0.1	<0.1	0.0	0.0
Hydrazides (J04AC)	391	0.3	0.4	0.0	0.1
Isoniazid (J04AC01)	391	0.3	0.4	0.0	0.1
Other drugs for treatment of tuberculosis (J04AK)	634	0.5	0.6	0.0	0.1
Pyrazinamide (J04AK01)	293	0.2	0.3	0.0	<0.1
Ethambutol (J04AK02)	341	0.2	0.3	0.0	<0.1
Combinations of drugs for treatment of tuberculosis (J04AM)	12	<0.1	<0.1	<0.1	0.0
Not specified (J04AM02)	5	<0.1	<0.1	0.0	0.0
Not specified (J04AM05)	4	<0.1	<0.1	<0.1	0.0
Not specified (J04AM06)	3	<0.1	<0.1	0.0	0.0
Nitroimidazole derivatives (P01AB)	2 111	1.5	1.7	0.6	0.9
Metronidazole (oral, rectal) (P01AB01)	2 069	1.5	1.7	0.6	0.8
Tinidazole (oral, rectal) (P01AB02)	7	<0.1	<0.1	0.0	<0.1
Ornidazole (oral) (P01AB03)	10	<0.1	<0.1	0.0	0.0
Azanidazole (P01AB04)	3	<0.1	<0.1	0.0	<0.1
Secnidazole (P01AB07)	1	<0.1	<0.1	0.0	0.0
Metronidazole, combinations (P01AB51)	21	<0.1	<0.1	<0.1	<0.1

Table A1.7. National denominator data

Country	N of acute care hospitals	PPS national denominator data (TESSy)						Eurostat				Used for PPS 2016-2017 estimations					
		All beds in acute care hospitals			Acute care beds only												
		N of hospital beds	N of discharges / year	N of patient days/ year	N of hospital beds	N of discharges / year	N of patient-days/ year	N of hospital beds, all	N of hospital beds, curative	N of discharges / year	N of patient-days/ year	N of acute care hospitals	N of hospital beds	N of discharges / year	N of patient days/ year	Mean N of occupied beds per day	Source
Austria	162	48 816	2 707 753	13 267 989	-	-	-	6 4838	48 472	2 053 274	13 147 450	162	48 816	2 707 753	13 267 989	36 351	PPS-2
Belgium	197	52 035	1 858 726	13 742 704	46 714	1 836 793	11 566 135	64 448	56 952	1 866 298	12 581 806	197	52 035	1 858 726	13 742 704	37 651	PPS-2
Bulgaria	12	6 778	397 017	1 650 752	6 523	232 486	1 129 685	51 816	42 990	-	-	241	44 164	1 632 089	9 243 390	25 324	PPS-1
Croatia	32	12 171	667 849	4 032 061	12 171	-	-	22 917	14 531	668 000	4 247 616	32	12 171	667 849	4 032 061	11 047	PPS-2
Cyprus	83	2 918	166 295	524 684	-	-	-	2 918	2 918	64 452	376 891	83	2 918	166 295	524 684	1 437	PPS-2
Czechia	144	60 221	2 260 239	14 852 040	48 511	-	-	72 392	44 945	1 956 303	11 484 495	144	48 511	2 260 239	14 852 040	40 691	PPS-2
Denmark	-	-	-		-	-	-	12 398	11 957	721 444	-	52	15 895	721 444	4 329 265	11 861	PPS-1/Eurostat
Estonia	27	6 355	222 363	1 672 517	4 292	196 542	1 033 295	6 261	4 608	196 741	1 196 236	27	6 355	222 363	1 672 517	4 582	PPS-2
Finland	-	-	-	-	-	-	-	21 835	16 135	915 892	5 801 222	59	16 135	915 892	5 801 222	15 894	PPS-1/Eurostat
France	1 237	496 450	14 874 912	180 207 628	213398	11 330 996	58 330 486	404 248	210 003	10 355 602	58 664 660	1 237	213 398	11 330 996	58 330 488	159 810	PPS-2 ac
Germany	1 857	494 751	-	-	-	-	-	663 941	498 718	19 480 504	146 048 192	1 857	494 751	19 480 504	146 048 192	400 132	PPS-2/Eurostat
Greece	123	27 540	1 562 761	6 661 841	-	-	-	45 273	38 470	2 148 553	-	123	27 540	1 562 761	6 661 841	18 252	PPS-2
Hungary	94	65 947	2 226 485	16 839 002	42 731	2 006 645	9 974 580	68 713	42 211	1 699 732	9 365 010	94	65 947	2 226 485	16 839 002	46 134	PPS-2
Iceland	8	939	39 198	234 392	897	38 224	223 260	1 052	862	39 011	223 765	8	939	39 198	234 392	642	PPS-2
Ireland	60	-	-	-	12 000	705 000	3 990 000	12 359	11 483	644 996	3 806 282	60	12 000	705 000	3 990 000	10 932	PPS-2 ac
Italy	1 134	185 053	8 930 979	61 180 919	163 132	8 467 857	48 554 843	194 065	160 085	6 221 900	42 931 112	1 134	185 053	8 930 979	61 180 920	167 619	PPS-2
Latvia	24	7 102	300 575	1 871 485	6 364	-	-	11 208	6 681	291 759	1 728 760	24	6 364	300 575	1 871 485	5 127	PPS-2
Lithuania	64	18 380	705 224	5 333 780	14 045	609 293	-	19 193	16 668	649 534	4 596 577	64	18 380	705 224	5 333 780	14 613	PPS-2
Luxembourg	12	2 789	74 782	679 020	2 251	72 615	542 069	2 765	2 251	72 615	542 069	12	2 789	74 782	679 020	1 860	PPS-2
Malta	4	-	-	-	1 313	72 909	354 848	2 099	1 486	67 105	357 886	4	1 313	72 909	354 848	972	PPS-2 ac
Netherlands	79	41 103	1 700 000	8 821 000	35 258	-	-	61 767	54 424	1 649 905	8 268 165	79	35 258	1 700 000	8 821 000	24 167	PPS-2
Norway	53	13 078	776 203	3 834 454	-	-	-	19 303	17 238	828 192	-	53	13 078	776 203	3 834 454	10 505	PPS-2
Poland	936	163 827	8 254 611	43 979 400	163 827	7 867 197	38 484 000	252 136	186 722	6 667 717	44 625 416	936	163 827	8 254 611	43 979 400	120 492	PPS-2
Portugal	225	35 337	1 128 245	10 186 064	30 457	1 128 245	10 186 064	35 337	33 990	1 115 276	8 078 046	225	30 457	1 128 245	10 186 064	27 907	PPS-2
Romania	252	91 988	13 343 557	20 838 177	91 988	13 343 557	20 838 177	134 763	101 776	3 674 275	22 604 640	311	101 776	3 674 275	22 604 640	61 931	PPS-2/ Eurostat
Slovakia	107	30 057	1 005 003	7 401 985	26 493	956 694	6 450 685	31 412	26 493	956 694	6 450 685	107	30 057	1 005 003	7 401 985	20 279	PPS-2
Slovenia	21	8 013	380 077	2 037 083	7 536	-	-	9 266	8 650	343 299	2 225 910	21	7 536	380 077	2 037 083	5 581	PPS-2

Country	N of acute care hospitals	PPS national denominator data (TESSy)						Eurostat				Used for PPS 2016-2017 estimations					
		All beds in acute care hospitals			Acute care beds only												
		N of hospital beds	N of discharges / year	N of patient days/ year	N of hospital beds	N of discharges / year	N of patient-days/ year	N of hospital beds, all	N of hospital beds, curative	N of discharges / year	N of patient-days/ year	N of acute care hospitals	N of hospital beds	N of discharges / year	N of patient days/ year	Mean N of occupied beds per day	Source
Spain	576	129 901	5 247 215	30 991 441	-	-	-	138 008	111 905	5 247 215	30 991 440	576	129 901	5 247 215	30 991 440	84 908	PPS-2
Sweden	144	-	-	-	21 366	1 401 554	6 306 506	23 207	21 366	1 414 402	-	144	21 366	1 401 554	6 306 506	17 278	PPS-2
UK-England	158	109 617	-	-	109 617	9 450 142	35 322 510	-	-	-	-	158	109 617	9 450 142	35 322 512	96 774	PPS-2
UK-N Ireland	16	4 594	302 008	1 812 048	4 332	296 902	1 333 740	-	-	-	-	16	5 642	302 008	1 812 048	4 965	PPS-2
UK-Scotland	46	15 101	1 156 473	4 178 686	15 101	1 156 473	4 178 686	-	-	-	-	46	15 101	1 156 473	4 178 686	11 448	PPS-2
UK-Wales	21	7 848	827 634	2 451 003	6 400	-	-	-	-	-	-	21	6 400	827 634	2 451 003	6 715	PPS-2
EU/EEA												**8 307**	**1 945 490**	**91 885 503**	**548 916 661**	**1 503 881**	
Serbia	65	39 402	-	-	28 803	988 383	6 905 678	39 458	32 578	890 044	8 119 220	65	28 803	988 383	6 905 678	18 920	PPS-2

-=no data; Eurostat data from: Health care resources (non-expenditure data). Reference Metadata in Euro SDMX Metadata Structure (ESMS). Available from http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/EN/hlth_res_esms.htm; data are given for the last available year (majority from 2016). PPS-2: second ECDC point prevalence survey in acute care hospitals 2016-2017; PPS-2 ac: data for acute care hospitals; PPS-1: first ECDC point prevalence survey in acute care hospitals 2011-2012

Table A1.8. Number of hospitals reporting structure and process indicators at hospital and ward level, by country

Indicator	Austria	Belgium	Bulgaria*	Croatia	Cyprus	Czechia	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands*	Norway**	Poland	Portugal	Romania	Serbia	Slovakia	Slovenia	Spain	UK-England	UK-Northern Ireland	UK-Scotland	UK-Wales	Total	EU/EEA
Number of hospitals in database	49	43	12	34	8	45	23	51	50	49	42	38	2	60	56	14	62	12	4	19	43	80	93	40	66	50	20	96	32	16	45	21	1275	1209
IPC Plan, CEO approved	48	32	12	32	8	45	22	48	50	48	0	35	2	59	56	14	61	11	4	4	24	78	80	40	66	48	20	73	32	16	45	20	1133	1067
IPC Report, CEO approved	48	31	12	32	8	45	22	48	50	48	0	35	2	59	55	14	61	11	4	4	24	77	80	40	66	47	20	73	32	16	45	20	1129	1063
FTE IPC nurse	49	38	12	34	8	45	20	43	50	49	42	38	2	55	56	14	62	12	4	5	24	80	92	39	64	49	20	86	32	16	44	21	1205	1141
FTE IPC doctor	49	38	11	34	8	45	20	41	50	49	42	38	2	55	56	12	62	11	4	5	24	80	92	40	54	49	20	86	32	16	44	21	1190	1136
Microbiology services in weekend, all	45	27	6	16	7	44	16	18	0	46	0	32	1	60	52	14	0	11	4	6	22	69	56	27	9	40	19	96	31	16	45	21	856	847
Saturday, clinical tests	48	29	12	30	7	45	20	41	0	49	0	33	2	60	56	14	62	11	4	6	22	77	67	31	63	44	19	96	31	16	45	21	1061	998
Saturday, screening	47	28	10	25	7	45	20	21	0	49	0	33	2	60	56	14	0	11	4	6	22	76	69	31	29	43	19	96	31	16	45	21	936	907
Sunday, clinical tests	46	29	8	20	7	45	17	40	0	47	0	32	2	60	53	14	62	11	4	6	22	70	58	30	20	43	19	96	31	16	45	21	974	954
Sunday, screening	46	27	6	18	7	44	18	19	0	46	0	32	1	60	52	14	0	11	4	6	22	69	65	29	9	41	19	96	31	16	45	21	874	865
FTE IPC nurses	49	38	12	34	8	45	20	43	50	49	42	38	2	55	56	14	62	12	4	5	24	80	92	39	64	49	20	86	32	16	44	21	1205	1141
FTE IPC doctors	49	38	11	34	8	45	20	41	50	49	42	38	2	55	56	12	62	11	4	5	24	80	92	40	54	49	20	86	32	16	44	21	1190	1136
Number of blood cultures previous year	47	36	12	32	8	45	16	47	43	46	0	38	2	59	55	10	62	12	4	0	23	80	83	37	65	50	20	84	32	16	45	21	1130	1065
Number of stool tests for CDI previous year	49	32	12	31	8	45	14	47	46	44	0	38	2	54	55	7	62	12	4	0	22	80	83	37	65	50	20	83	31	16	31	21	1101	1036
Multimodal strategies, hospital (at least one `Y' or `N' answer)	47	30	12	30	8	45	19	48	0	49	0	38	2	57	55	14	57	11	4	19	24	79	79	36	65	44	20	59	32	16	45	14	1058	993
Multimodal strategies, ICU (at least one `Y' or `N' answer)	39	30	12	30	8	45	19	29	0	44	0	29	2	36	54	14	62	11	3	19	24	78	66	37	65	42	16	55	0	16	25	13	923	858
Alcohol-based handrub consumption, hospital level	49	40	12	34	8	45	23	50	50	49	41	38	2	55	56	14	62	12	4	6	23	80	91	39	65	50	19	91	32	16	38	20	1214	1149
Alcohol-based handrub consumption, ward level	49	31	11	30	6	0	17	0	0	46	0	0	2	0	53	13	52	11	3	0	0	80	89	37	64	44	18	0	30	0	0	0	686	622
Hand hygiene opportunities	49	39	12	34	8	45	17	37	0	49	0	36	2	55	56	14	62	12	4	1	23	80	93	39	66	50	20	72	31	16	44	0	1066	1000
FTE registered nurses, hospital	49	33	12	34	8	45	16	48	48	47	0	38	2	57	55	10	62	12	3	2	24	80	84	39	65	49	20	87	32	16	45	18	1140	1075
FTE registered nurses, ICU	40	30	12	34	6	45	14	26	17	35	0	29	2	36	41	6	54	7	2	2	22	73	50	39	61	44	16	69	16	11	25	14	878	817
FTE nursing assistants, hospital	49	31	12	33	8	45	15	45	48	46	0	38	2	56	54	9	60	12	3	2	24	80	83	39	64	49	20	87	32	16	45	4	1111	1047
FTE nursing assistants, ICU	38	29	12	33	6	45	13	21	17	33	0	29	2	36	41	5	54	6	2	2	23	73	50	39	58	44	16	69	16	11	25	14	862	804
Combined FTE registered nurses + nursing assistants, hospital	49	30	12	33	8	45	15	45	48	46	0	38	2	56	54	9	60	12	3	2	24	80	79	39	63	49	20	86	31	15	44	4	1101	1038
Combined FTE registered nurses + nursing assistants, ICU	38	27	12	33	6	45	13	20	17	33	0	29	2	36	41	5	54	6	2	2	22	73	50	39	58	44	16	69	16	11	23	14	856	798
Number of occupied beds at midnight, hospital level	0	5	10	28	7	0	14	48	0	42	0	35	1	0	44	2	0	9	0	19	24	53	58	2	62	47	20	54	32	16	45	8	685	623

Indicator	Austria	Belgium	Bulgaria*	Croatia	Cyprus	Czechia	Estonia	Finland	France	Germany	Greece	Hungary	Iceland	Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands*	Norway**	Poland	Portugal	Romania	Serbia	Slovakia	Slovenia	Spain	UK-England	UK-Northern Ireland	UK-Scotland	UK-Wales	Total	EU/EEA
Number of occupied beds at midnight, ward level	49	34	12	32	8	0	16	0	0	48	0	0	2	60	54	14	0	12	4	0	0	80	88	40	66	47	20	0	32	16	45	21	800	734
Bed occupancy at midnight, hospital and/or ward	49	34	12	33	8	0	18	37	0	48	0	35	2	58	54	14	0	11	4	6	19	80	91	40	66	49	20	46	32	16	45	19	946	880
Bed occupancy from hospital patient-days (previous year) and number of beds (hospital denominator data)	46	41	12	34	8	44	23	49	48	48	41	37	2	53	52	14	61	11	4	19	42	80	86	39	66	50	19	96	22	16	45	21	1229	1163
AHR dispensers at point of care, hospital level	0	7	11	30	7	0	16	50	0	40	0	38	1	0	46	4	62	10	1	0	20	56	61	1	60	48	20	73	0	16	45	0	723	663
AHR dispensers at point of care, ward level	49	34	12	32	8	0	17	0	0	48	0	0	2	58	55	14	53	12	4	0	0	79	90	40	64	47	20	0	32	16	45	0	831	767
AHR dispensers at point of care, hospital and/or ward	49	34	12	33	8	0	20	50	0	48	0	38	2	58	55	14	62	12	4	0	20	80	93	40	66	50	20	73	32	16	45	0	1034	968
Percentage HCWs carrying AHR bottles, hospital level	0	6	11	28	7	0	17	49	0	48	0	28	2	0	48	7	54	10	1	0	23	58	55	4	59	47	20	71	32	0	40	0	725	666
Percentage HCWs carrying AHR bottles, ward level	49	24	11	31	8	0	16	0	0	47	0	0	2	0	52	13	53	12	4	0	0	78	83	38	61	46	20	0	32	0	45	0	725	664
Percentage HCWs carrying AHR bottles, hospital and/or ward level	49	25	12	33	8	0	19	49	0	48	0	28	2	0	55	14	61	12	4	0	20	79	91	36	66	49	20	70	32	0	40	0	922	856
Single rooms, hospital level	0	4	11	30	7	0	18	50	45	44	42	38	1	58	47	3	62	10	1	6	24	55	66	3	61	48	20	70	32	16	45	16	933	872
Single rooms, ward level	49	39	12	32	8	0	17	0	0	49	0	0	2	58	55	14	53	12	4	0	0	80	89	40	66	49	20	0	32	16	45	0	841	775
Single rooms, hospital and/or ward, per 100 beds	49	39	12	33	8	0	21	50	45	49	42	38	2	58	55	14	62	12	4	6	24	80	89	39	66	50	20	70	32	16	45	16	1146	1080
Single rooms, hospital and/or ward, per 100 rooms	49	39	12	33	8	0	22	48	44	49	0	38	2	58	55	14	62	12	4	6	24	80	91	40	66	50	20	68	22	16	45	0	1077	1011
Single rooms with toilet and shower, hospital level	0	4	11	30	7	0	16	48	0	44	0	36	1	0	46	3	61	10	1	3	24	55	61	3	61	48	20	70	32	16	45	14	770	709
Single rooms with toilet and shower, ward level	49	39	12	32	8	1	17	0	0	49	0	0	2	58	55	14	53	12	4	0	0	80	89	40	66	49	20	0	32	16	45	0	842	776
Single rooms with toilet and shower, hospital and/or ward level	46	38	10	32	8	0	20	47	0	49	0	36	2	57	53	14	54	12	4	3	23	79	88	37	64	48	19	69	32	10	45	14	1013	949
Number of airborne infection isolation rooms	49	32	12	33	8	45	16	46	0	48	0	38	2	0	56	13	61	11	4	4	24	79	82	36	63	49	20	86	32	16	45	4	1014	951
FTE antimicrobial stewardship consultants	49	35	12	32	8	45	15	35	50	46	0	38	2	56	55	11	62	12	4	7	24	80	83	37	61	50	20	81	32	16	43	21	1122	1061

IPC: infection prevention and control; CEO: hospital Chief Executive Officer; FTE: Fulltime equivalent; AHR: alcohol-based handrub; HCW: healthcare worker

Annex 2. Country summary sheets

Summary results of the ECDC PPS 2016-2017 by country are available as separate worksheets in an Excel file available online.

Disclaimer

Comparisons between country results should not be made without taking into account the limitations outlined in the discussion section of this report. The country rank and corresponding percentiles of the indicators in section IV of the country summary sheets are primarily given to facilitate discussions about underlying factors that may explain inter-country differences such as differences in patient case mix, type of hospital, healthcare system, interpretation of definitions, under- and overreporting, selection bias and poor representativeness.

Legend

Section IV (Indicators)

Mean: shows a mean, a percentage or a ratio. The mean is the pooled (aggregated) mean, not the hospital mean (mean of values by hospital). For example, the mean number of fulltime equivalent IPC nurses per 250 beds is the sum of all FTE IPC nurse for the country × 250 / total number of beds in participating hospitals for the country.

Hosp. P50: shows the hospital median of the indicator. It is not applicable when the mean shows a percentage of hospitals. The hospital median shows the "middle" value, separating the lower 50% of hospitals from the higher 50% hospitals.

N cntr: number of countries that reported the indicator

Rank: shows the position of the country out of all countries that reported the indicator, with position 1 being the highest.

Percentile: rank converted to a percentile (position if there were 100 countries)

Colour legend:

Negative (`more is bad') indicators:

95	percentile 90-100
75	percentile 75-<90
60	percentile >50-<75
45	percentile >25-50
15	percentile >10-25
5	percentile 1-10

Positive (`more is good') indicators:

95	percentile 90-100
75	percentile 75-<90
60	percentile >50-<75
45	percentile >25-50
15	percentile >10-25
5	percentile 1-10

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