Point Prevalence Survey of Healthcare-Associated Infections & Antimicrobial Use in European Acute Care Hospitals: 2023

INTENSIVE CARE UNIT REPORT: IRELAND 2023

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Executive Summary

This report presents the findings of a sub-analysis of the third European point prevalence survey (PPS) of healthcare-associated infections (HAI) and antimicrobial use (AMU) in Ireland. The survey took place across Europe coordinated by the European Centre for Disease Prevention and Control (ECDC) and was led nationally by the HSE Health Protection Surveillance Centre (HPSC) in May 2023. This report focuses on HAIs and AMU in intensive care units (ICUs) in Ireland. The results provide a snapshot of the number of patients experiencing HAI and prescription levels of antimicrobials in ICUs in all acute care hospitals in Ireland.

Data was collected from all acute care hospitals in Ireland (both public and private) between the 1st and 31st of May 2023 and included in-patients of all age groups. Data collected included patient data on demographics, exposure to potential risk factors, the presence of an active HAI and AMU. Microbiological and antimicrobial resistance (AMR) data, where available, was also recorded for active HAIs. We used statistical software R (version 4.3.1) to transform the data extracted from the national PPS database on 1st December 2023. A descriptive analysis was conducted and, where possible and appropriate, comparisons were made between data from ICU and non-ICU patients. The overall prevalence of HAI, types of HAI, HAI causative pathogens, with key antimicrobial resistance profiles in ICU, and location of HAI onset and origin were calculated and described. AMU prescribing patterns were also summarised. Prevalence ratios (PR) were calculated to determine whether there was an association between age, gender, birth weight, history of surgery, McCabe score, and exposure to invasive devices, and an increased prevalence of HAI and AMU. Results with p-values less than 0.05 were considered statistically significant.

Sixty-five hospitals were surveyed which included 12,587 patients, of which 394 (3%) were ICU patients. The prevalence of HAI in ICU patients was higher (18%) than that in non-ICU patients (7%). 71% of HAIs in ICU were not present at admission to hospital. Pneumonia (47%), systemic (22%) and gastrointestinal (9%) infections were the most prevalent HAIs in ICU. *Escherichia coli* was the most frequently isolated pathogen (20%), followed by *Staphylococcus aureus* (17%) and *Klebsiella pneumoniae complex* (13%). Although the numbers of pathogens reported were low, the proportions of resistance to 3rd generation cephalosporins in Enterobacterales spp, and to meticillin in *S. aureus* isolates were higher in ICU patients than in non-ICU patients (15% vs 4%, and 40% vs 20%, respectively).

Sixty per cent of patients in ICU were receiving at least one antimicrobial (AM), with a prescribing rate of 1.9 AMs per patient. Treatment of infection accounted for 82% of AMU, of which 39% were being treated for pneumonia, 15% for intra-abdominal sepsis, and 14% for clinical sepsis. The most prescribed AM groups were penicillin combinations (21%), glycopeptides (11%) and carbapenems (10%). The most common route of antimicrobial administration in ICU was parenteral (87%) followed by oral (11%).

The analysis of HAI risk among ICU patients identified key clinical and procedural factors driving infection risk. Use of invasive devices, particularly central venous catheters (PR = 2.03, 95% CI: 1.27–4.38, $p < 0.001$), urinary catheters (PR = 2.11, 95% CI: 1.68–2.64, $p < 0.001$), and intubation (PR = 1.53, 95% CI: 1.31–1.79, $p < 0.001$), significantly increased HAI prevalence. Severity of underlying illness, measured by McCabe score, was also a strong predictor, with rapidly fatal disease significantly increasing infection prevalence (PR = 1.48, 95% CI: 1.26–1.74, $p < 0.001$). Longer hospital stays showed a complex relationship with HAI prevalence; prevalence rose markedly after the first week but

appeared to plateau or decline beyond 21 days. Age, gender, birthweight, and recent surgery were not significantly associated with HAI in this cohort.

Antimicrobial use (AMU) patterns reflected similar drivers, with markedly lower use in infants under 1 month (PR = 0.42, 95% CI: 0.29–0.60, $p < 0.001$) and paediatric patients under 2 years, while older adults did not differ significantly from the adult reference group. Clinical severity strongly influenced AMU, with rapidly fatal disease increasing likelihood of antimicrobial receipt by nearly 50% (PR = 1.48, 95% CI: 1.26–1.74, $p < 0.001$). Invasive devices were also associated with increased AMU, notably central venous catheters (PR = 2.03) and urinary catheters (PR = 2.11). Length of stay showed an inverse trend with AMU beyond the first week; antimicrobial prescribing was highest in the initial days of admission and declined significantly in patients hospitalised for more than 21 days (PR = 0.69, 95% CI: 0.54–0.89, $p = 0.003$), suggesting early treatment focus rather than prolonged antimicrobial use.

The results demonstrate a strong association between invasive devices and increased prevalence of HAI and AMU among ICU patients, especially those with severe underlying conditions. Central venous catheters, intubation, and urinary catheters were major contributors to these outcomes. To mitigate these risks, strict adherence to evidence-based protocols for device insertion and maintenance, regular evaluation of device necessity, and consistent hand hygiene practices are essential. Additionally, implementing care bundles, enhancing staff training, and reinforcing infection prevention measures are critical. Given the close link between device exposure and antimicrobial use, targeted antimicrobial stewardship interventions are vital to reduce unnecessary prescribing and help combat antimicrobial resistance in critical care settings.

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Abbreviations:

AMU – antimicrobial use

AMR – antimicrobial resistance

BSI – bloodstream infection

CNS – central nervous system infection

CVS – cardiovascular infection

EENT – eye, ear, nose and throat infection

GI – gastrointestinal infection

HAI – healthcare associated infection

HPSC – Health Protection Surveillance Centre

ICU – intensive care unit

LRI – lower respiratory tract infection

PN – pneumonia

PPS – Point Prevalence Survey

REPR – reproductive tract infection

RTI – respiratory tract infection

SSI – surgical site infection

SST – skin and soft tissue infection

SYS – systemic infection

UK – United Kingdom

UTI – urinary tract infection

A. Introduction & Methods

A.1 Introduction

The European Centre for Disease Prevention and Control (ECDC) estimates that 3.1-4.6 million people acquire a healthcare-associated infection (HAI) each year in acute care hospitals in EU/EAA countries. HAIs can lead to increased patient morbidity and mortality and account for more than 90,000 deaths each year in EU countries, Iceland, Norway and the United Kingdom (UK). HAIs are the single most deadly and costly adverse events, representing up to 6% of public hospital budgets. (1) In Ireland, the previously most reported types of HAI were pneumonia (PN), surgical site infections (SSIs), urinary tract infections (UTIs) and bloodstream infections (BSIs) which have been associated with various associated factors such as: recent surgery, having a drip or a urinary catheter, being in an ICU, being older or very young in age, and receiving antibiotics. (2) The Health Service Executive (HSE) in Ireland has a national clinical programme for the prevention of HAIs and antimicrobial resistance, which aims to improve patient safety and reduce the spread of infection. (3)

As well as managing HAIs, it is critical that hospitals and national health systems have a feasible method for HAI surveillance to inform infection prevention and control activities and keep them up to date. Point Prevalence Surveys (PPS) provide a useful and cost-effective tool to quantify HAIs, providing robust baseline data for policymakers. Ireland conducted its first PPS on antimicrobial use (AMU) and HAIs in 2006 in collaboration with the UK. In 2010, EU member states agreed to conduct a European-wide PPS of HAI and AMU in acute care hospitals once every five years. ECDC developed a standardised protocol for this, and 29 EU member states utilised it to conduct the first PPS over a 2-year period in 2011/2012. The second European PPS took place between 2016 and 2017. In Ireland, these were conducted in May 2012 and May 2017, respectively.

The results from Ireland's second PPS in 2017 found that patients admitted to ICU were at higher risk for both antimicrobial exposure and HAIs than other patient types. These patients generally presented with more severe underlying illness, comorbidities, and had increased exposure to invasive devices. (2) In 2017, the prevalence of AMU in ICUs was almost twice as high as the overall hospital patient population (70%), whereas the prevalence of HAI was four times higher than that of the overall hospital patient population (24%). (2)

Because of the impact of the COVID-19 pandemic, the third European PPS was conducted a year later than scheduled. In Ireland, the PPS was carried out in May 2023. In total, all 65 acute hospitals participated, with 12,472 eligible patients surveyed.

This report presents the results of a sub-analysis of the national PPS data in Ireland focusing on hospitals with an ICU and patients who were in-patients in an ICU at the time of the survey. The aim of this study was to describe the prevalence and identify key risk factors for HAI and AMU among the ICU patient population in Ireland and set up priorities for prevention and mitigation strategies at national, hospital, and ward level. The protocol for the overall PPS is available in Annex 1. A summary of the methods relevant to this ICU analysis is provided below.

A.2 Methods

Study Design

Cross-sectional point prevalence.

Study-population

All hospital in-patients (adults and children) in an ICU between the 1st and 31st of May 2023 in Ireland.

Data sources and sampling strategy

Data was extracted from the national point prevalence survey (PPS) database for HAI and AMU in Ireland on 1st December 2023. The PPS targeted all acute care hospitals (n=65) in Ireland (including 39 ith an ICU). The PPS was conducted using the standardised protocol devised by ECDC utilising their specific inclusion and exclusion criteria of hospitals, wards, and patients (Annex 1, pg. 8). HAIs were categorised according to standardised European case definitions of infection (Annex 1, pg. 78).

Data collection

Data collected included hospital-level data on infection prevention and control (IPC) resources, as well as individual patient data, including demographics, risk factors, and the presence of an active HAI and AMU. The data collection was conducted by a multidisciplinary team comprising of infection prevention and control teams, clinical microbiologists, antimicrobial pharmacists, and hospital ward staff (nurses, midwives, and medical staff). All data collectors attended a mandatory PPS protocol training day delivered by HPSC in April 2023.

The survey consisted of 6 form types:

1. Hospital forms (H1, H2, H3)
2. Ward form (Form W)
3. Ward patient list (Form WPL)
4. Patient form (Form P)
5. AMU Form
6. HAI Form

See Annex 1, pg. 12-47 for copies of form types and definitions of variables.

Data was collected in a single day for each ward/unit. Data collection in all wards of a single hospital was completed within a two-week window. The algorithm used to guide data collection is presented in Figure 1 below. Data collected on paper during the survey was entered onto HelicsWin.Net by the data collection team in each participating hospital. Complete datasets for each hospital were extracted from this platform and submitted to HPSC via email by 23rd June 2023. For further information on data collection see Appendix 1, section 5.5.

Definitions

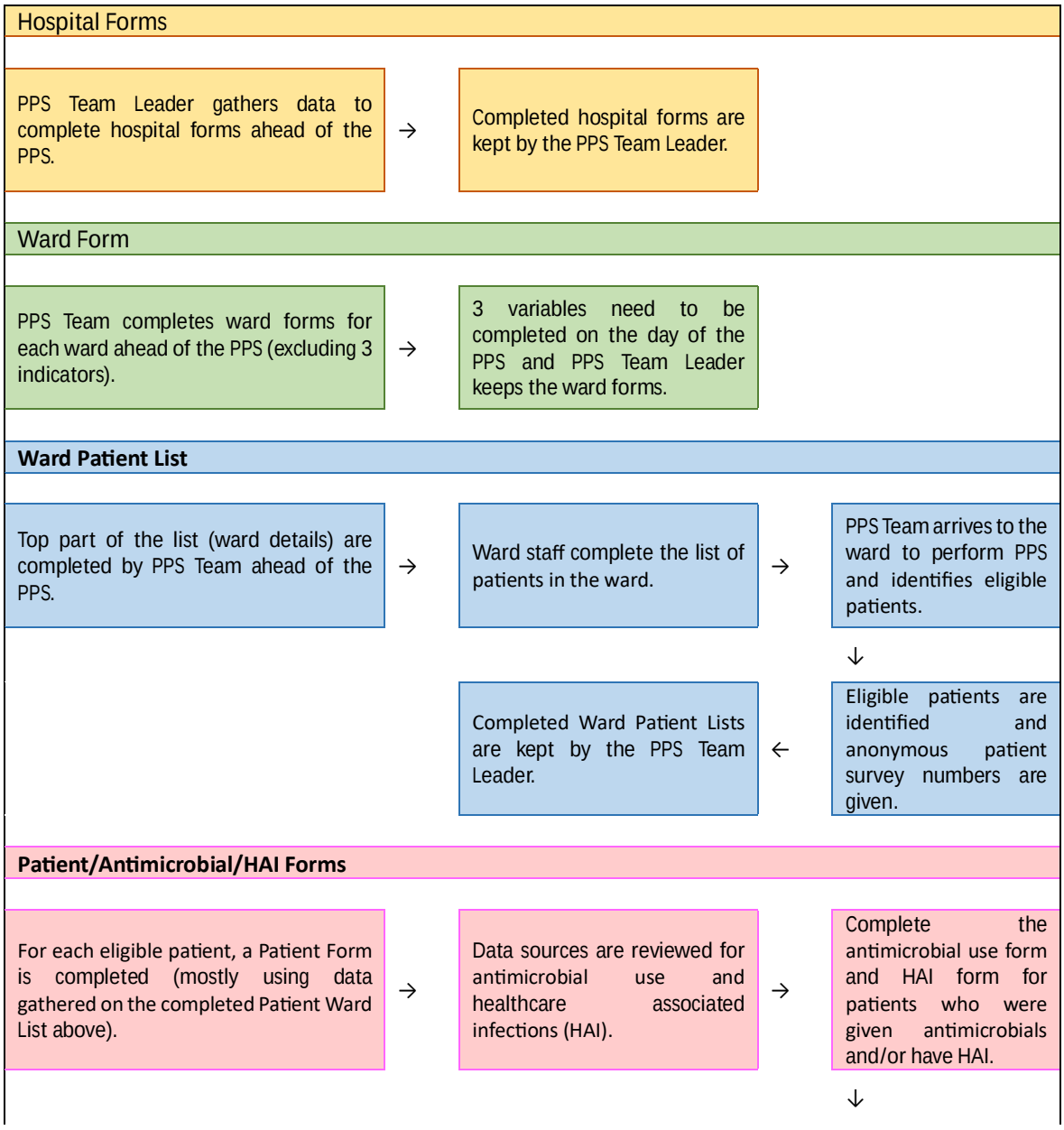
For standardisation across EU participating countries, hospitals were classified into primary, secondary, tertiary, specialist and paediatric hospitals. Under the Irish classification of hospitals this is equivalent to Model 2, Model 3, Model 4 and Specialist hospitals (e.g. maternity, orthopaedic & oncology), respectively. Paediatric hospitals are also considered specialist hospitals in Ireland but have been sub-divided into their own category for the purpose of this PPS. HAIs were categorised according to standardised European case definitions of infection (Annex 1, page 78).

Data analysis:

We transformed the data extracted from the national PPS database. Data from the different study forms were stored as six individual files in MS Excel format. These were then converted to RDS format and imported into R as the following data sets:

1. Hospital level data
2. Ward level data
3. Patient level data
4. Infection data
5. Resistance data
6. Antimicrobial use data

For each level of data, we applied filtering techniques, and created six datasets for ICU. We conducted a descriptive analysis for each of the six data levels and where possible and appropriate, made comparisons between data from ICU and non-ICU patient groups. We calculated and described the overall prevalence of HAI, types of HAI, HAI causative pathogens and key antimicrobial resistance profiles, and location of HAI onset and origin, in ICU. We also summarised AMU prescribing patterns.



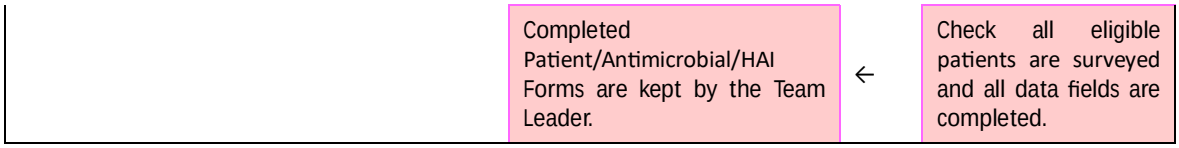


Figure 1: Data collection algorithm used to guide collection for different data types using the standardised study forms at the hospital, ward, patient, HAI and antimicrobial prescribing levels.

We conducted univariate prevalence ratio analyses using the epitools::riskratio function, to assess the association between each predictor variable (age, gender, birth weight, history of surgery, McCabe score, presence of invasive devices and length of hospital stay) and HAI status and AMU respectively. For each categorical predictor, prevalence ratios (PR), 95% confidence intervals (CI), and Fisher's exact test p-values were calculated, using pre-defined reference groups. Results with p-values less than 0.05 were not considered statistically significant.

All data analyses were conducted using statistical software R (version 4.3.1). Data analysis was conducted by a data study team comprising 3 individuals. R scripts were shared, and cross validated amongst team members.

Quality assurance

The study protocol for this analysis was developed by the Princinpal Investigator (Laura Paris, EPIET fellow) and reviewed by all members of the study team in consultation with EPIET Supervisors and Frontline Coordinator.

Sampling methods and data collection for this study were conducted using the standardised ECDC protocol and HAIs were defined using standardised European definitions of infection. All variables, indicators and relevant codes are well defined, and specific definitions may be found in Appendix 1. All data collectors attended a mandatory PPS protocol training day delivered by HPSC in April 2023.

A validation study, standardised by the ECDC Advisory Forum was performed where trained validation teams visited a sub-set of selected hospitals and did a repeat collection of basic demographic, HAI and AMU data, applying the exact definitions of the ECDC PPS protocol ('gold standard' data collection). The objectives of the validation study were to assess the validity, reliability and inter-country comparability of the data collected during the national PPS, and to assess data accuracy of selected process and structure indicators at the hospital level. Hospital staff do not participate in the validation process/data collection.

Protection of human subjects

Vulnerable populations: Data was collected from all eligible patients at the time of the PPS survey. No specific measures were required to protect vulnerable populations as there was no direct interaction between the PPS study team and the patients. All data was taken from hospital records and anonymised.

Risks: Patients who were in hospital at the time of the PPS experienced no additional risk through having data taken from their medical records. Having data collected by the PPS team did not in any way impact hospital experience or treatment outcomes. Furthermore, there was no contact between patients and the PPS team since data was extracted directly from hospital records.

Benefits: There were no direct benefits to patients, hospital staff, wards, or hospitals for participating in the PPS. However, results from the PPS, as well as from this sub-analysis, provide a detailed picture of HAI and AMU prevalence in hospitals and ICUs across Ireland which, through the tailored and data-

informed recommendations above, will enhance infection prevention and control initiatives and policy. Furthermore, these results have been made publicly available and both participating and non-participating hospitals will have access to this report. Participating hospitals also received individual tailored reports which will assist hospital management in identification of areas requiring further attention and strengthening of infection prevention and control strategies as well as antibiotic prescribing on an individual hospital level.

Confidentiality

All data was immediately anonymised at point of entry. A unique and anonymised 7-digit number composed of three parts (a hospital, ward and patient code) was used to link the patient, as recorded on the completed Ward Patient List, to the HAI/AMU data. The patient counter has no meaning outside of the hospital and it ensures that the patient data collected during the PPS remains anonymous. Data were always handled and stored in a secure location only accessible by authorised members of the data collection team. Data collected on paper during the survey was entered by the data collection team into via HelicsWin.Net software and submitted to HPSC by each participating hospital. Study data submitted via HelicsWin.Net is stored in a centralised and secure database only accessible by the study team at HPSC.

Biological specimens

No biological specimens were taken by the PPS study team. Where necessary results from analyses of biological specimens were taken from already existing hospital databases using the study forms.

Ethical committee clearance

No ethical committee clearance was required for the HAI and AMU PPS as this is a routine surveillance activity conducted in Ireland and the wider EU/EEA region. HPSC gave authorisation for this sub-analysis and no ethical approval was required.

B. Results

1. Participating hospitals and ICUs

Overall, 65 hospitals (public and private) participated in the survey (100% of acute hospitals in the country). Of those, 39 (60%) had an ICU or included ICU beds. Of the 15,259 hospital beds surveyed, 463 (3%) were ICU beds. (88%; n=408) of ICU beds surveyed were in public hospitals.

Of ICU bed data, 39% came from Tertiary hospitals (termed Model 4 by the HSE) followed by 22% from Specialist hospitals and 20% from Secondary (Model 3) hospitals.

Table 1.1 Point Prevalence Survey (PPS) participating hospitals by hospital group/ownership, hospital type and number of ICU beds and acute care beds during 2023 national PPS survey in Ireland

Hospital Type	N hospitals	% of all hospitals	N hospitals with ICU	% of all hospitals with ICU beds	Total beds	N ICU beds	% of all ICU beds
Paediatric	3	5%	2	3%	382	32	7%
Primary	10	15%	0	0%	773	0	0%
Private	15	23%	6	9%	1,832	55	12%
Secondary	17	26%	17	26%	4,682	92	20%
Specialist	11	17%	5	8%	1,390	103	22%
Tertiary	9	14%	9	14%	6,200	181	39%
Total	65	100%	39	60%	15,259	463	100%

2. Patient summary

2.1 Patient demographics and factors associated with HAI

Of 12,587 surveyed patients from 65 Irish hospitals in 2023, 394 (3%) were admitted to ICUs in 39 hospitals, consisting of 234 (59%) males and 160 (41%) females. The mean patient age (excluding children <23 months) in ICU was 59 years (SD: 18.7), differing from the median age which was 63 years (IQR +/- 24.5 years) (Fig. 2.1).

A significantly higher proportion of male patients were observed in ICU (60%) than in non-ICU patient groups (49%) ($p = 0.004$). A variation in gender proportions between age groups was observed, however, it was not statistically significant ($p = 0.059$) (Figure 2.1). The ICU patient group had a higher proportion of patients under one year and a smaller number of patients over the age of 75 when compared to non-ICU patients (Figure 2.2).

Of the ICU patients, 27% (n=107) were under 1 year and admitted to specialist hospitals, specifically to maternity hospitals, (Figure 2.3) with 64% of them reported to have a low birth weight (Figure 2.4).

ICU patients had higher exposure levels than non-ICU patients to invasive procedures including recent surgery, central venous catheters (CVC), urinary catheters or intubation. McCabe score did not differ much between patient groups, although higher levels of rapidly fatal disease were observed in the ICU patient group (6.3% vs 3.7%). COVID-19 vaccination levels of ICU patients were also lower (29%) than non-ICU patients (52%).

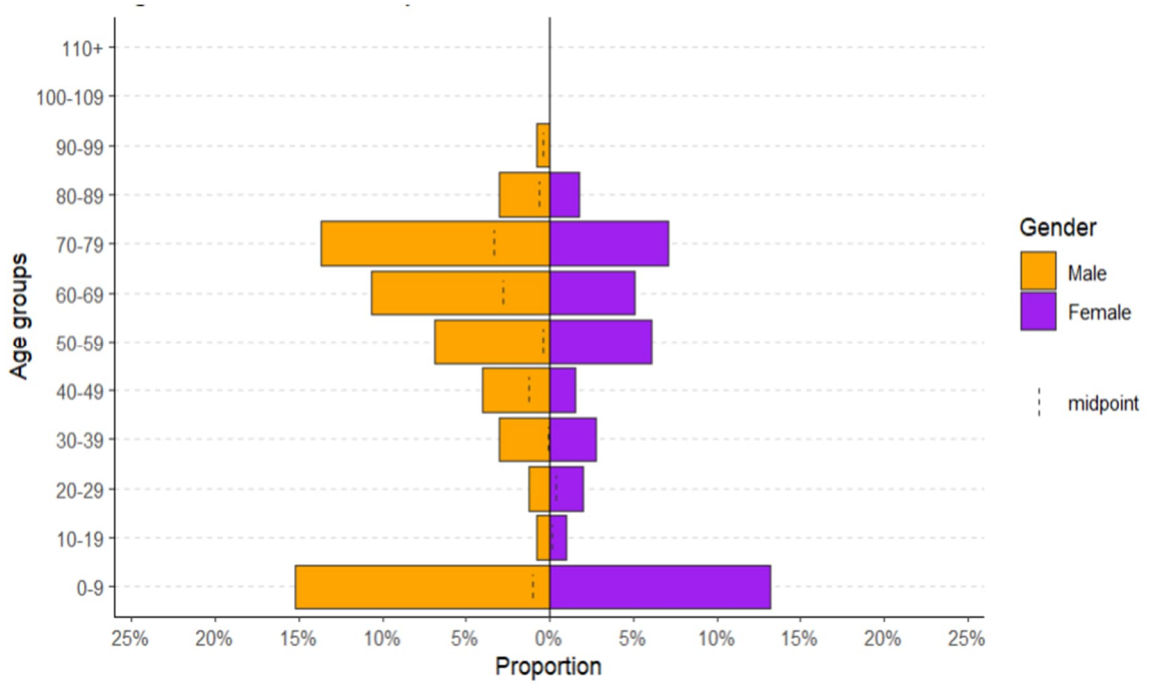


Figure 2.1 Distribution of ICU patients by age group and gender during the 2023 national PPS survey in Ireland

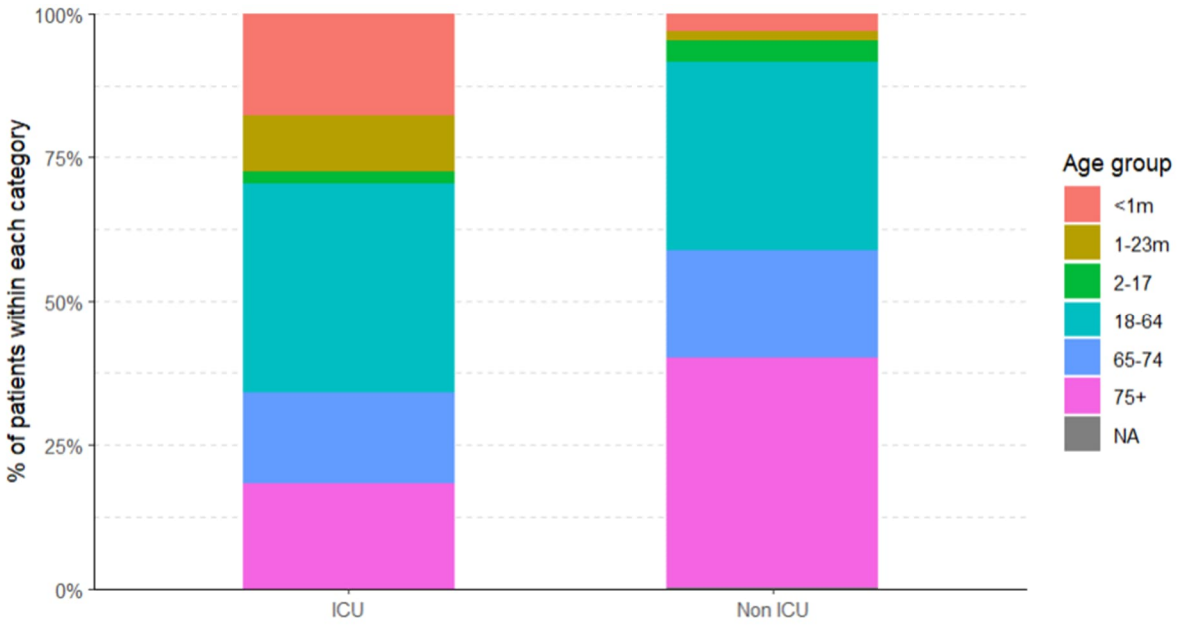


Figure 2.2 Age distribution of hospital patients in ICU and non-ICU patient groups during the 2023 national PPS survey in Ireland

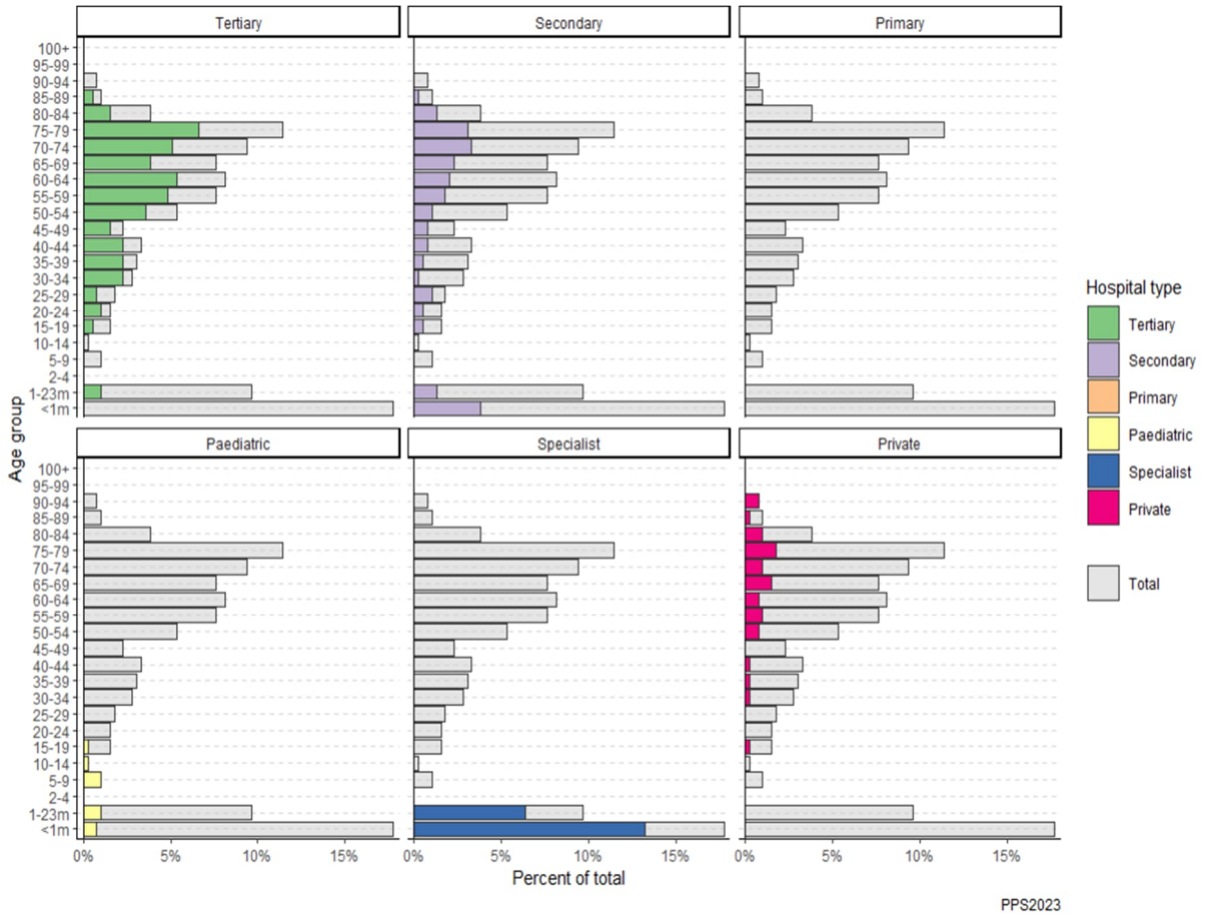


Figure 2.3 Age distribution of ICU patients by hospital type during the 2023 national PPS survey in Ireland

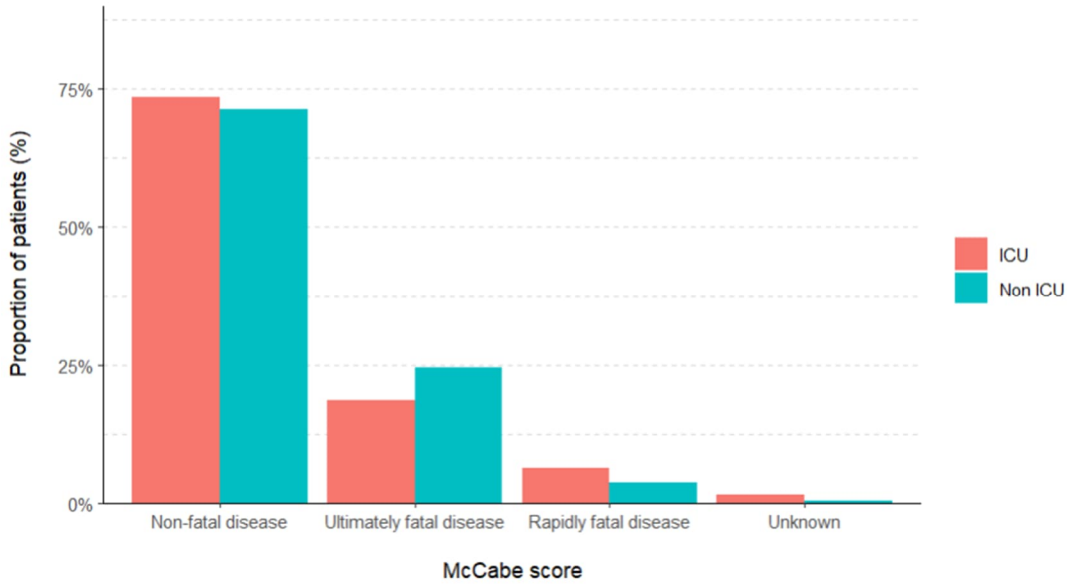


Figure 2.4 McCabe score of hospital patients in ICU and non-ICU patient groups during the 2023 national PPS survey in Ireland

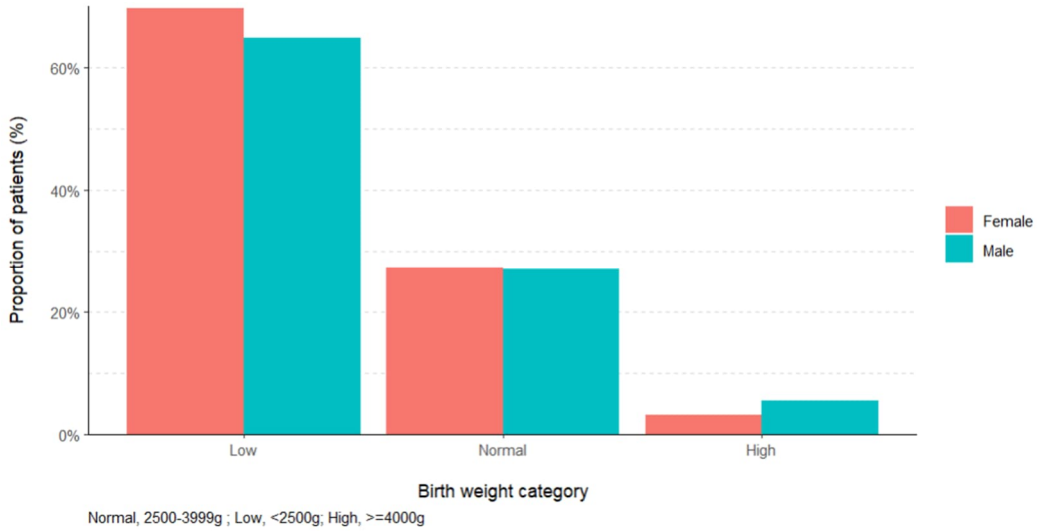


Figure 2.5 Birth weight category for all neonates (children <23 months) in ICU by gender during the 2023 national PPS survey in Ireland

2.2 HAI patient summary

Of 394 ICU patients, 18% (n=72) met a case definition for having an active HAI. In total, 75 HAIs were identified in ICU, which equates to 1.04 HAI per HAI-infected ICU patient; 70 of the patients had a single HAI, one patient had two HAIs, and another was recorded to have three HAIs. All 72 patients with an active HAI in ICU were receiving antimicrobials (AM). Of HAIs in ICU, 54% (n=40) were observed in males. HAIs varied by age group and were more common in the youngest (0-9 year) and oldest (>=50 years) age groups (Figure 2.6).

In non-ICU patients, a total of 891 (7.1%) HAIs were detected amongst 860 patients equating to a rate of 1.04 HAIs per HAI-infected patient: 831 of the patients had a single HAI, 27 patient had 2 HAIs and 2 were recorded to have 3 HAIs. Four-in-ten (40%; n=4,855) non-ICU patients were receiving AMs.

Table 2.1. Number of patients with an active HAI in ICU and non-ICU groups, AMU and number of active HAIs per HAI infected patient during the 2023 national PPS survey in Ireland

	ICU	Non-ICU	Total
N with HAI (%)	72 (18.3)	860 (7.1)	932 (7.4)
Has 1 HAI (%)	70 (97.2)	831 (96.6)	901 (96.7)
Has 2 HAI (%)	1 (1.4)	27(3.1)	28 (3.0)
Has 3 HAI (%)	1 (1.4)	2 (0.2)	3 (0.3)
N receiving AMs (%)	232 (58.9)	4855 (39.8)	5087 (40.4)

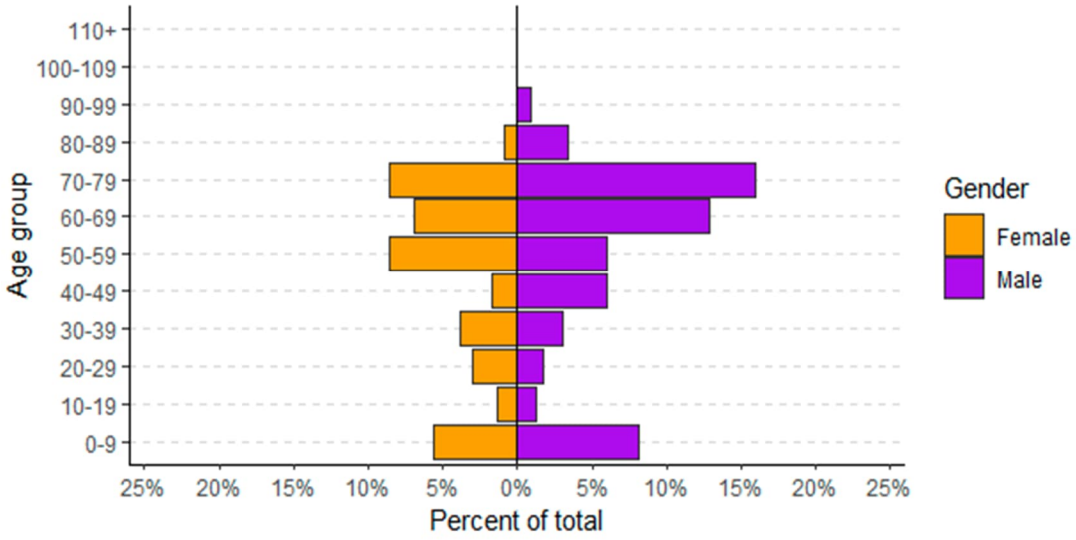


Figure 2.6 Distribution of ICU patients with an active HAI by age group and gender during the 2023 national PPS survey in Ireland

2.3 Risk factors among patients with HAI

Seventy-one percent (n=51) of HAIs in ICU presented after current hospital admission. Common factors associated with having an active HAI recorded in ICU patients included having a recent surgery (36%), central venous catheter (CVC) (74%), urinary catheter (71%) and intubation (49%). These were more prevalent in ICU patients than in non-ICU patients (Table 2.3 & Figure 2.6). McCabe score shows no major difference between ICU and Non-ICU patients with rapidly fatal disease.

Table 2.3 *Prevalence of HAI-associated factors for all ICU (n=72) and non-ICU patients (n=860) with HAI during the 2023 national PPS survey in Ireland*

	ICU	Non-ICU	Total
N patients with HAI	72	860	932
Had recent surgery	36.1%	23.8%	24.8%
With CVC	73.6%	15.5%	20.0%
With urinary catheter	70.8%	26.5%	29.9%
Intubated	48.6%	0.8%	4.8%

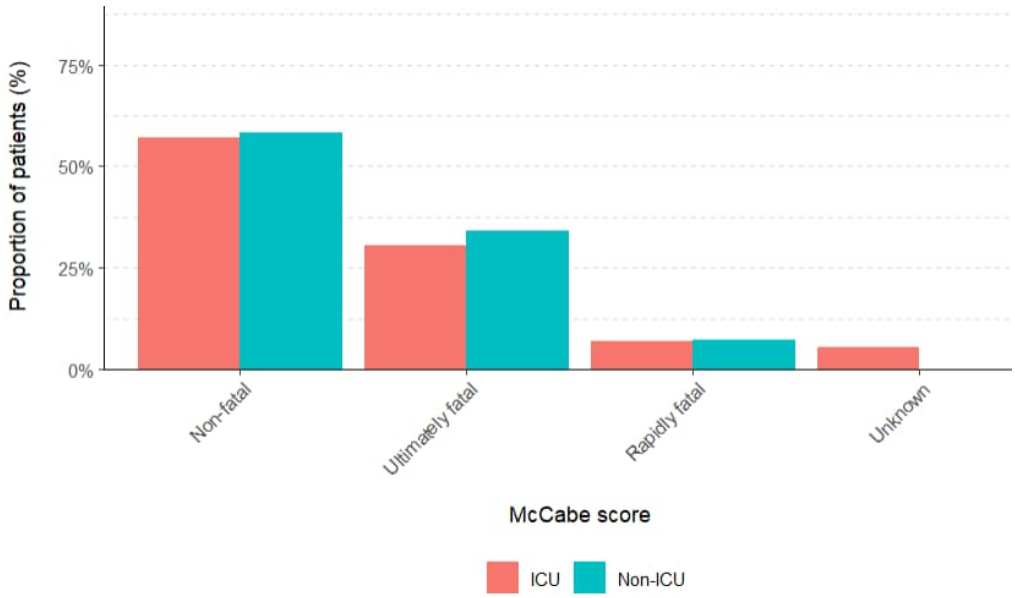


Figure 2.7 Prevalence of McCabe score for all ICU (n=72) and non-ICU patients (n=860) during 2023 national PPS survey in Ireland

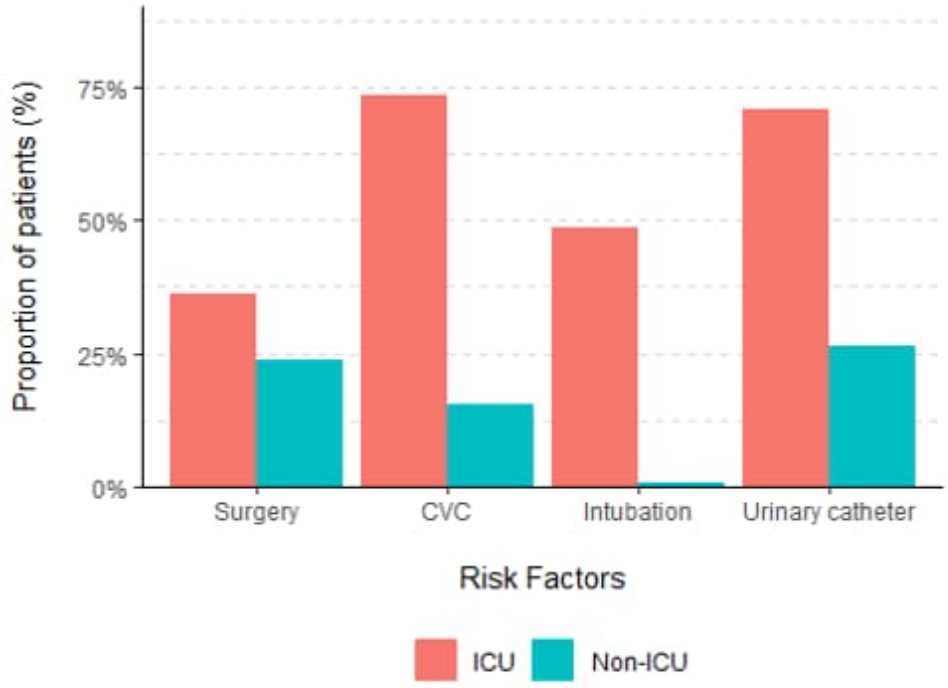


Figure 2.8 Prevalence of HAI associated factors for all ICU (n=72) and non-ICU patients (n=860) during 2023 national PPS survey in Ireland

3. HAIs

3.1 Onset and origin of HAIs in ICU

Of HAIs detected in ICU, 72% (n=53) were not present at hospital admission. For the 22 HAIs that were present at admission to ICU, 27% (n=19) originated in the current hospital (i.e. infection related to a prior admission to the current hospital), 50% (n=36) originated in another acute hospital and the origin of the remainder was unknown.

Table 2.4 Origin of HAIs among ICU and non-ICU patients during 2023 national PPS survey in Ireland

	ICU	Non-ICU	Total
Total patients with HAI	72	860	932
Total HAIs	75	891	966
% HAI at admission	29.3%	31.8%	31.6%
% HAI after admission	71.7%	68.1%	68.3%
Association	ICU	Non-ICU	Total
N assoc. with current hospital	59	690	749
% assoc. with current hospital	78.7%	77.4%	78.5%
N assoc. with other acute hospital	11	81	92
% assoc. with other acute hospital	14.7%	9.1%	9.5%
N assoc. with long-term care	0	112	112
% assoc. with long-term care	0%	12.6%	11.6%
% other origin or unknown	6.7%	0.9%	1.3%
Association with current ward	ICU	Non-ICU	Total
N assoc. with current ward	42	518	560
% assoc. with current ward	56.0%	58.1%	58.0%
Device association	ICU	Non-ICU	Total
N with BSI	4	79	83
% device-assoc. BSI	25%	32%	31.3%
N with PN	34	231	265
% device-assoc. PN	32%	5%	8.7%
N with UTI	4	137	141
% device-assoc. UTI	25%	39%	38.3%

3.2 Distribution of HAI by infection type

Pneumonia was the most reported infection type of HAI in ICU, accounting for 45% (n=34) of infections and affecting 9% of all ICU patients. This was followed by systemic infections which accounted for 21% (n=16) of HAIs in ICU, affecting 4% of all ICU patients (Table 3.1). By comparison, pneumonia was also the most reported infection type of HAI among non-ICU patients but accounted for a smaller proportion of all HAIs (26%) and affected a smaller proportion of patients (2%) in this group. Other infection types were more commonly observed in non-ICU patient groups. Figure 3.1 shows the distribution of HAIs in both ICU and non-ICU patients.

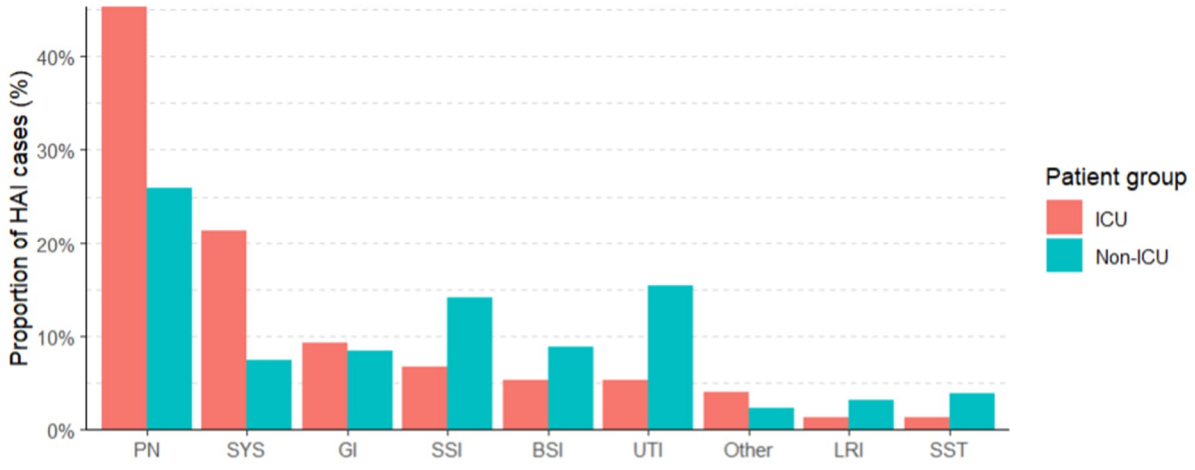
Neonatal ICU accounted for the highest number of HAIs in ICU (n=17), followed by mixed ICU (n=12) and by general medicine (n=8). The highest prevalence of HAI was observed in cardiovascular surgery (100%), however patient numbers were too small to infer any statistical significance (Table 3.2).

Of all patients with pneumonia, UTI or BSI, invasive devices were present in 31% (n=34) of these patients in ICU. This was most observed in pneumonia cases where an invasive device (i.e. intubation) was present in 11 out of 34 infections (32%). Invasive devices were also recorded as present in 1 out of 4 BSI infections (25%), and 1 in 4 UTI infections (25%) (Table 3.3).

Table 3.1: HAI infection types ranked by order of frequency in ICU and non-ICU patient groups and national level.

	ICU				Non-ICU				**All patients**			
Rank	HAI type	N	% Total	Prev %	HAI type	N	% Total	Prev %	HAI type	N	% Total	Prev %
1	PN	34	45.3	8.8	PN	231	25.9	1.9	PN	265	27.4	2.1
2	SYS	16	21.3	4.1	UTI	137	15.4	1.1	UTI	141	14.6	1.1
3	GI	7	9.3	1.8	SSI	126	14.1	1.0	SSI	131	23.6	1.1
4	SSI	5	6.7	1.3	BSI	79	8.9	0.7	BSI	83	8.6	0.7
5	BSI	4	5.3	1.0	GI	75	8.4	0.6	GI	82	8.5	0.7
6	UTI	4	5.3	1.0	COV	73	8.2	0.6	SYS	82	8.5	0.7
7	CNS	2	2.7	0.5	SYS	66	7.4	0.5	COV	73	7.6	0.6
8	EENT	1	1.3	0.3	SST	35	3.9	0.3	SST	36	3.7	0.3
9	LRI	1	1.3	0.3	LRI	28	3.1	0.2	LRI	29	3.0	0.2
10	SST	1	1.3	0.3	BJ	21	2.4	0.2	BJ	21	2.2	0.2
11					EENT	11	1.2	0.1	EENT	12	1.2	0.1
12					REPR	4	0.4	0.0	CNS	5	0.5	0.0
13					CNS	3	0.3	0.0	REPR	4	0.4	0.0
14					CRI	1	0.1	0.0	CRI	1	0.1	0.0
15					CVS	1	0.1	0.0	CVS	1	0.1	0.0

BJ, bone and joint infection; BSI, bloodstream infection; CNS, central nervous system infection; COV, covid-19 infection; CRI, catheter related infection; CVS, cardio-vascular system infection; EENT, eye, ear, nose and throat infection; GI, gastrointestinal infection; LRI, lower respiratory tract infection; PN, pneumonia; REPR, reproductive tract infection; SSI, surgical site infection; SST, skin and soft tissue infection; UTI, urinary tract infection.



BSI, bloodstream infection GI, gastrointestinal infection; LRI, lower respiratory tract infection; PN, pneumonia; SSI, surgical site infection; SST, skin and soft tissue infection; UTI, urinary tract infection.

Figure 3.1 Prevalence of the most common HAIs infection types in ICU and non-ICU patients during the 2023 national PPS survey in Ireland

Table 3.2 Top 10 patient categories for HAIs in ICU during the 2023 national PPS survey in Ireland

Patient category	**N patients**	N HAI	Prevalence %	95% CI
Neonatal ICU	101	17	16.8	9.5 - 24.2
Mixed (polyvalent) ICU	40	12	30.0	15.6 - 14.4
General medicine	55	8	14.5	5.1 - 23.9
Medical ICU	26	6	23.1	6.6 - 39.6
Cardio surgery	24	4	26.7	1.0 - 31.9
Paediatric ICU	12	3	25.0	-0.6 - 50.6
Surgical ICU	19	3	15.8	-1.1 - 32.6
Cardiovascular surgery	2	2	100.0	100.0 - 100.0
Digestive tract surgery	8	2	25.0	-7.1 - 57.1
Neurosurgery	20	2	10.0	-3.5 - 23.5

CI= Confidence Interval

Table 3.3 HAI by presence/absence of invasive device during the 2023 national PPS survey in Ireland

HAI Invasive Device	ICU Present	Non-ICU Present	**All Patients** Present
BSI (%)	1 (25.0)	25 (31.6)	26 (31.3)
PN (%)	11 (32.4)	12 (5.2)	23 (8.7)
UTI (%)	1 (25.0)	53 (38.7)	54 (38.3)
Total (%)	13 (31.0)	90 (20.1)	103 (21.1)

BSI: bloodstream infection, PN: pneumonia, UTI: urinary tract infection

Table 3.4: Summary of the top six HAI infection types and pathogens reported (where microbiologically-confirmed) among ICU patients with HAI in Ireland, 2023

HAI	N (%)	Prev in ICU %	Microbiologically Confirmed (%)	Pathogens detected (n)
PN	34 (47.2)	8.8	38.2	*Klebsiella pneumoniae complex (6)* *Staphylococcus aureus (5)* *Candida albicans (2)* *Enterobacter cloacae (2)* *Escherichia coli (2)* *Pseudomonas aeruginosa (2)* *Other Candida spp. (1)* *Aspergillus fumigatus (1)* *Enterococcus faecium (1)* *Moraxella catarrhalis (1)*
SYS	16 (22.2)	4.1	0.0	*NA*
GI	7 (9.3)	1.8	100.0	*Clostridiodes difficile (3)* *Escherichia coli (2)* *Pseudomonas aeruginosa (1)* *Staphylococcus epidermis (1)* *Candida spp. not specified (1)*
UTI	4 (7.3)	2.0	100.0	*Escherichia coli (4)*
SSI	5 (6.6)	1.2	60.0	*Escherichia coli (2)** *Staphylococcus aureus (1)* *Anaerobic bacteria, unspecified (1)**
BSI	4 (5.6)	1.0	Yes (100.0)	*E. faecium (1)* *E. faecalis (1)* *Staphylococcus haemolyticus (1) *** *Serratia marcescens (1) ***

* One patient reported with both *E. coli* and Anaerobes; **Same patient

4. Microbiology and key antimicrobial resistance markers

4.1 Microbiology and antimicrobial resistance data

Information on the availability of microbiology results was reported for 58 HAIs from 55 ICU patients. Microbiological investigation was undertaken for 44 HAIs from 41 patients. At least one pathogen, or microorganism, was reported for 30 HAIs (68%) from 27 patients. A total of 43 isolates representing 23 different microorganisms was reported. *Escherichia coli* was the most frequently isolated pathogen (n=6; 14%), followed by *Staphylococcus aureus* (n=5; 12%) and *Klebsiella pneumoniae complex* (n=6; 12%) (Table 4.2). These results were consistent with those observed in non-ICU patients.

Resistance to third generation cephalosporins was reported in two Enterobacterales isolates (one isolate each of *Escherichia coli* and *Serratia marcescens*). Two oxacillin-resistant *S. aureus* (or MRSA) isolates were reported. While the overall numbers of Enterobacterales and *S. aureus* isolates from ICU patients were low, the proportions with resistance to third-generation cephalosporins and oxacillin, respectively, were higher in ICU patients than in non-ICU patients. No vancomycin-resistance in enterococci or carbapenem-resistance in Enterobacterales or *Pseudomonas aeruginosa* were reported in ICU patients (Table 4.3).

Table 4.1 Availability of microbiology results for individual HAIs reported from ICU and non-ICU patient groups during the 2023 national PPS survey in Ireland

Microbiology result	ICU n (%) (N=58)	Non-ICU n (%) (N=558)	Total N (%) (N=616)
Pathogen detected	30 (51.7)	359 (64.3)	389 (63.1)
No microbiology data provided	12 (20.7)	64 (11.5)	76 (12.3)
Specimen not sent	2 (3.4)	72 (12.9)	74 (12.0)
Results not available or missing	9 (15.5)	32 (5.7)	41 (6.7)
Pathogen not isolated	5 (8.6)	31 (5.6)	36 (5.8)

Table 4.2 Distribution of most common microorganisms detected in ICU and non-ICU patients with HAI during 2023 national PPS survey in Ireland.

	ICU		Non-ICU	
Rank	Microorganism	N (%) (N=43)	Microorganism	N (%) (N=441)
1	*Escherichia coli*	6 (14.0)	*Escherichia coli*	67 (15.2)
2	*Klebsiella pneumoniae* complex	5 (11.6)	*Staphylococcus aureus*	66 (15.0)
3	*Staphylococcus aureus*	5 (11.6)	*SARS-Cov-2*	45 (10.2)
4	*Clostridiodes difficile*	3 (7.0)	*Clostridiodes difficile*	40 (9.1)
5	*Pseudomonas aeruginosa*	3 (7.0)	*Enterococcus faecium*	27 (6.1)
6	*Candida albicans*	2 (4.7)	*Klebsiella pneumoniae complex*	22 (5.0)
7	*Enterococcus faecium*	2 (4.7)	*Pseudomonas aeruginosa*	18 (4.1)
8	*Serratia marcescens*	2 (4.7)	*Enterococcus faecalis*	17 (3.9)
9	*Others*	15 (34.9)	*Staphylococcus epidermis*	14 (3.2)
10			*Proteus mirabilis*	12 (2.7)
11			*Candida albicans*	9 (2.0)
12			*Others*	104 (23.6)

Table 4.3 Antimicrobial resistance markers test summary for HAIs in ICU patients during the 2023 national PPS survey in Ireland.

Antimicrobial resistance markers	ICU n (%) (N=79)	Non-ICU n (%) (N=293)	Total n (%) (N=319)
Enterobacterales spp.	13 (16.5)	113 (38.6)	126 (39.5)
3GC-R	15 (19.0)	4 (6.0)	6 (1.9)
% CAR-R	0 (0.0)	1 (0.3)	1 (0.3)
Staphylococcus aureus	5 (6.3)	64 (21.8)	69 (21.6)
OXA-R	40 (50.6)	20 (6.8)	22 (6.9)
GLY-R	0 (0.0)	0 (0.0)	0 (0.0)
Enterococcus spp.	3 (3.8)	49 (16.7)	52 (16.3)
GLY-R	0 (0.0)	18 (6.1)	17 (5.3)
Pseudomonas aeruginosa	3 (3.8)	18 (6.1)	21 (6.6)
CAR-R	0 (0.0)	6 (2.0)	5 (1.6)

3GC, 3rd-generation cephalosporin, CAR, carbapenem; OXA, oxacillin; GLY, glycopeptide

5. Antimicrobial use (AMU)

5.1 AMU summary

Of 394 patients in ICU, 232 (58.8%) were prescribed 436 AMs equating to 1.9 AM per patient prescribed AMs. Of the 12,193 patients in the non-ICU patient cohort, 4,855 (39.8%) were prescribed 6,715 AMs, which equates to 1.4 antimicrobials per prescribed patient. ICU patients were 1.5 times more likely to be prescribed AMs than non-ICU patients, they were also more likely to receive more than one AM. In ICU, treatment of infection accounted for 82% of AMU, 8% was administered for the purpose of surgical prophylaxis, 6% was medical prophylaxis, and 4% was classed as "other". ICU patients aged between 60-80 years and <10 years had higher AMU than other age groups. AMU was overall higher in males (Figure 5.1).

Despite the differences in sizes between patient groups, a higher proportion of ICU patients were prescribed more than one AM than non-ICU patients (56.5% and 24.2%, respectively). In ICU, the proportion of patients on AMs who received three or more AMs was 22.0% (n=51), which is 5.1-times higher than that observed in the non-ICU group (4.3%, n=211) (Table 5.1).

Table 5.1 AMU coverage in ICU and non-ICU patient groups and subcategorised by number of AMs prescribed per patient during the 2023 national PPS survey in Ireland

	ICU	Non-ICU	Total
N patients	394	12,193	12,587
N with HAI	72	860	932
N receiving AMs	232	4855	5087
AMU prevalence (%)	58.9	39.8	40.4
Receiving 1 AM	101	3679	3870
Receiving 2 AM	80	965	1045
Receiving 3 AM	36	177	213
Receiving 4 AM	8	31	39
Receiving 5 AM	7	3	10
N AMs prescribed	436	6279	6715

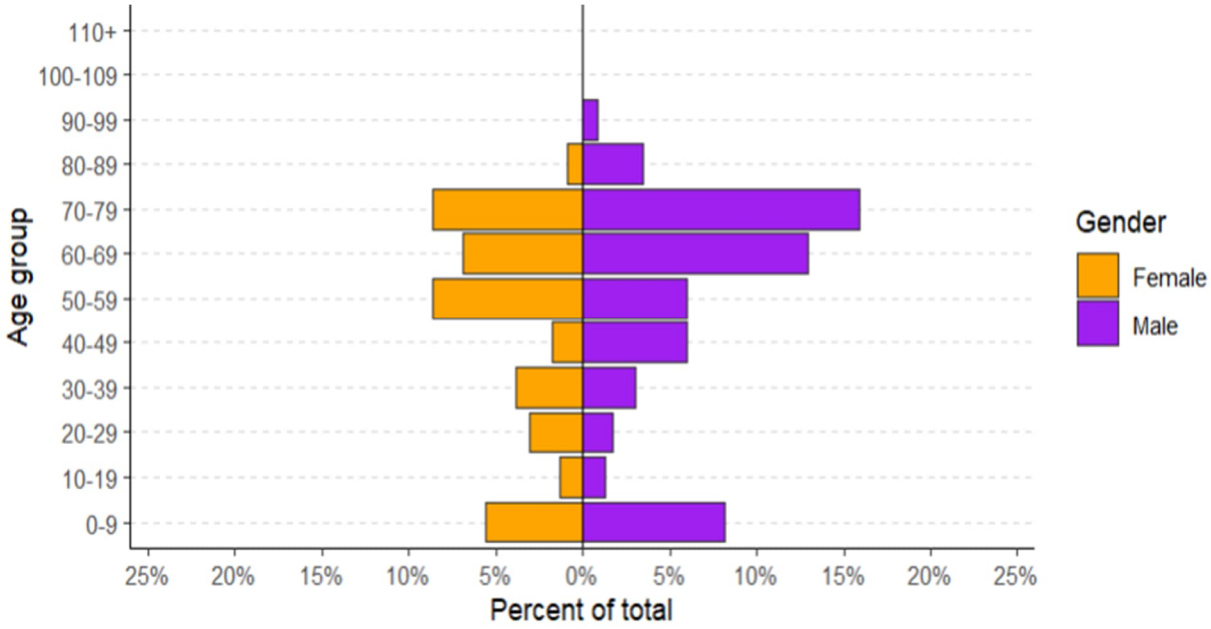


Figure 5.1 Age distribution of AMU in ICU patients by age group and gender during the 2023 national PPS survey in Ireland

5.2 AMU prevalence by patient specialty

Of 394 ICU patients, 101 (26%) were admitted under the care of a neonatal consultant, 55 (14%) under general medicine and 40 (10%) under a consultant in intensive or critical care medicine. Despite neonatal ICUs having the highest number of ICU patients, general medicine (82%) and mixed (polyvalent) ICUs (80%) had the highest prevalence of AMU (Table 5.2).

Table 5.2 AMU prevalence, by top 10 patient speciality in ICU during the 2023 national PPS survey in Ireland

Consultant speciality	**All patients** N	AMU n	AMU %
1. General medicine	55	45	81.8
2. Mixed (polyvalent) ICU, general intensive or critical care	40	32	80.0
3. Neonatal ICU	101	25	24.8
4. Medical ICU	26	20	76.9
5. Cardio surgery	24	18	75.0
6. General surgery	17	11	64.7
7. Surgical ICU	19	11	57.9
8. Pneumology	15	10	66.7
9. Paediatric ICU	12	8	66.7
10. Neurosurgery	20	7	35.0

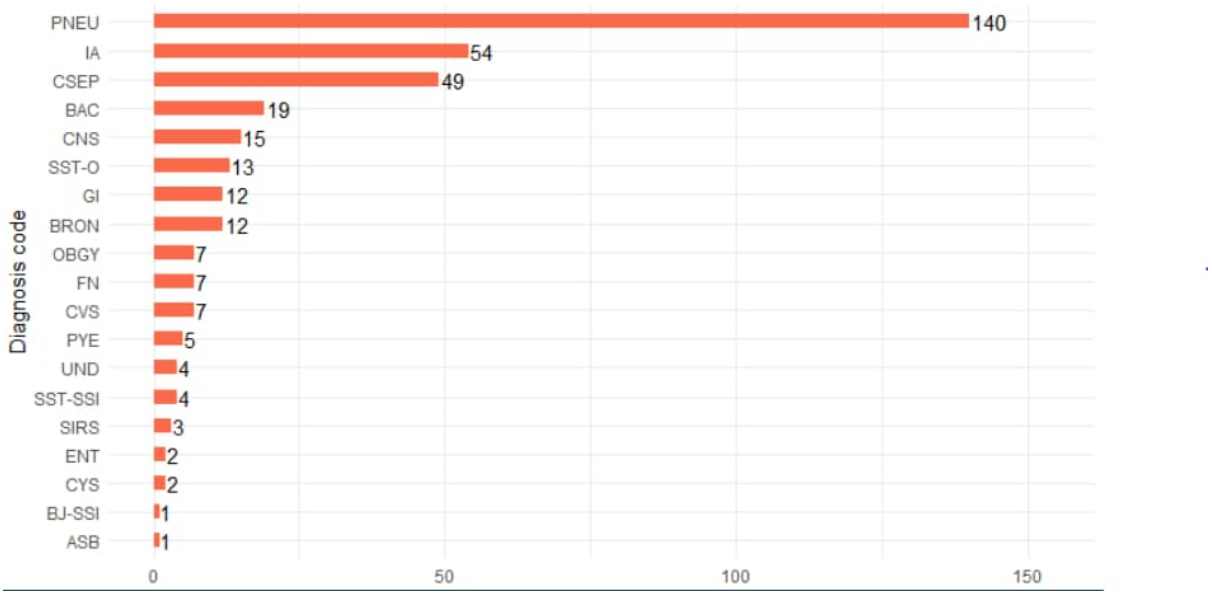
5.3 Description of prescribed antibacterials

In ICU, the most prescribed AMs were penicillin combinations[1] (21%), followed by glycopeptides (11%) and carbapenems (10%) (Table 5.3). The distribution of the top five agents was largely unchanged since the PPS 2017. Treatment of infection accounted for 82% (n=357) of all AMU in ICU, of which 56% were for community infection, 43% for hospital infection and 1% for long-term care infection. Treatment of pneumonia accounted for the highest proportion of AMU in ICU (37%; n=140) followed by intra-abdominal sepsis (14%), and clinical sepsis (5%) (Figure 5.2). The top three diagnosis sites remain unchanged since PPS 2017. The primary route of antimicrobial administration in ICU was parenteral (88%) followed by oral (11%). No AMs were administered rectally or via inhalation in ICU (Table 5.4).

Table 5.3 Description of top 10 prescribed AMs in ICU and non-ICU patient groups during 2023 national PPS survey in Ireland

Rank	ICU				Non-ICU				National			
	Antimicrobial	n	%	Prev	Antimicrobial	n	%	Prev	Antimicrobial	n	%	Prev
1	Piperacillin/ tazobactam	65	14.9%	16.5%	Amoxicillin/ clavulanic acid	1,234	19.7%	10.2%	Amoxicillin/ clavulanic acid	1,261	18.8%	10.1%
2	Vancomycin - parenteral	49	11.2%	12.4%	Piperacillin/ tazobactam	1,161	18.5%	9.6%	Piperacillin/ tazobactam	1,226	18.3%	9.8%
3	Meropenem	43	9.8%	10.9%	Cefuroxime	390	6.2%	3.2%	Cefuroxime	403	6.0%	3.2%
4	Amoxicillin/ clavulanic acid	27	6.2%	6.9%	Flucloxacillin	325	5.2%	2.7%	Flucloxacillin	332	4.9%	2.7%
5	Metronidazole - parenteral	27	6.2%	6.9%	Ceftriaxone	242	3.9%	2.0%	Vancomycin - parenteral	262	3.9%	2.1%
6	Gentamicin	21	4.8%	5.3%	Metronidazole - parenteral	215	3.4%	1.8%	Ceftriaxone	260	3.9%	2.1%
7	Ceftriaxone	18	4.1%	4.6%	Vancomycin - parenteral	213	3.4%	1.8%	Metronidazole - parenteral	242	3.6%	1.9%
8	Benzylpenicillin	15	3.4%	3.8%	Meropenem	195	3.1%	1.6%	Meropenem	238	3.5%	1.9%
9	Linezolid	14	3.2%	3.6%	Clarithromycin	187	3.0%	1.5%	Clarithromycin	197	2.9%	1.6%
10	Sulfamethoxazole/ trimethoprim	14	3.2%	3.6%	Sulfamethoxazole/ trimethoprim	178	2.8%	1.5%	Sulfamethoxazole/ trimethoprim	192	2.9%	1.5%
	Other antimicrobials	144	33.0%	36.5%	Other antimicrobials	1,938	30.9%	15.9%	Other antimicrobials	2,102	31.3%	16.7%

[1] Amoxicillin/clavulanic acid and Piperacillin/tazobactam



ASB, Asymptomatic bacteriuria; BAC, Laboratory-confirmed bacteraemia; BJ-SSI, Septic arthritis, osteomyelitis of surgical site; BSI, bloodstream infection; BRON, bronchitis; CNS, infectious of the central nervous system; CSEP, clinical sepsis; CVS, cardio-vascular system infection; CYS, symptomatic lower urinary tract infection; ENT, eye, ear, nose and throat infection; FN, febrile neutropenia; GI, gastrointestinal infection; LRI, lower respiratory tract infection; OBGY, obstetric or gynaecological infections; PNEU, pneumonia; PYE, symptomatic upper urinary tract infection; SIRS, systemic inflammatory response with no clear anatomical site; SST-O, cellulitis, wound, deep soft tissue; SSI, surgical site infection; SST, skin and soft tissue infection; UTI, urinary tract infection.

Figure 5.2: ICU patients being treated for infection by diagnosis code

Table 5.4 Number and percentage of AM by route of administration in ICU and non-ICU patients during the 2023 national PPS survey in Ireland

AM administration Route	ICU n (%) (N=437)	Non-ICU n (%) (N=6,724)	Total n (%) (N=6,711)
Parenteral	390 (89.2)	4,308 (68.6)	4,698 (70.0)
Oral	47 (10.7)	1,929 (30.7)	1,976 (29.4)
Inhalation	0 (0)	25 (0.003)	25 (0.003)
Rectal	0 (0)	12 (0.001)	12 (0.001)

6.0 Associated factors

6.1 Analysis of factors associated with HAI in ICU

The analysis of HAI associated factors among ICU patients identified invasive medical interventions, underlying health status, and length of hospital stay as the strongest predictors of infection. The presence of a central venous catheter (CVC) was associated with more than double the prevalence of HAI (PR = 2.25, 95% CI: 1.39–3.66, p = 0.001), while intubation (PR = 1.82, 95% CI: 1.20–2.76, p = 0.006) and urinary catheter use (PR = 1.68, 95% CI: 1.04–2.70, p = 0.032) also significantly increased the prevalence of infection.

Length of hospital stay demonstrated a strong and statistically significant association with HAI prevalence. Compared to patients with a hospital stay of 1–3 days, the prevalence increased substantially with longer durations: patients hospitalised for 8–14 days had more than double the prevalence (PR = 2.52, 95% CI: 1.33–4.80, p = 0.006), those staying 15–21 days had more than triple the prevalence (PR = 3.51, 95% CI: 1.79–6.86, p = 0.001), and those with stays longer than 21 days also faced significantly elevated prevalence (PR = 2.36, 95% CI: 1.27–4.38, p = 0.008). Patients with rapidly fatal underlying disease (as per McCabe score) had over twice the prevalence of HAI compared to those with non-fatal disease (PR = 2.13, 95% CI: 1.36–3.34, p = 0.003).

Age was not significantly associated with HAI prevalence, although slightly higher prevalence was observed among infants and older adults. Gender also did not show a statistically significant association (PR = 0.86, 95% CI: 0.56–1.30, p = 0.508). Likewise, birthweight and recent surgery did not demonstrate significant associations with infection in this cohort.

Table 6.1. Univariable analysis for HAI by age group, gender, birth weight, history of surgery, McCabe score, exposure to CVC, IV catheter and intubation, in ICU patients during 2023 national PPS survey in Ireland

Variable	Predictor	N ICU patients	N HAI	Prev %	PR (vs Ref)	95% CI	P-value
Age group	18-64*	144	24	16.7	1	*NA*	*NA*
	<1m	70	12	17.1	1.029	0.547 - 1.934	1.00
	0-23m	38	7	18.4	1.105	0.516 - 2.369	0.81
	2-17	8	1	12.5	0.75	0.116 - 4.863	1.00
	65-74	62	13	21.0	1.258	0.686 - 2.306	0.553
	75+	72	15	20.8	1.25	0.7 - 2.232	0.458
Gender	Female*	160	32	20.0	1	*NA*	*NA*
	Male	234	40	17.09	0.855	0.562 - 1.3	0.508
Birth weight	Normal*	19	1	5.3	1	*NA*	*NA*
	High	3	10	33.3	6.333	0.525 - 76.39	0.26
	Low	47	1	2.1	4.043	0.555 - 29.437	0.156
Surgery	No*	278	46	16.5	1	*NA*	*NA*
	Yes	116	26	22.4	1.355	0.882 - 2.081	0.198
McCabe score	Non-fatal disease*	290	41	14.1	1	*NA*	*NA*
	Ultimately fatal disease	73	22	30.1	1.415	0.615 - 3.256	0.386
	Rapidly fatal disease	25	5	20.0	2.132	1.359 - 3.343	0.003
CVC	N*	176	19	10.8	1	*NA*	*NA*
	Y	218	53	24.3	2.252	1.387 - 3.658	0.001
Urinary catheter	N*	157	21	13.4	1	*NA*	*NA*
	Y	237	51	21.5	1.678	1.043 - 2.702	0.032
Intubation	N*	257	37	14.4	1	*NA*	*NA*
	Y	137	35	25.5	1.817	1.198 - 2.755	0.006
Length of stay in hospital	1-3 days*	135	14	10.3	1	*NA*	*NA*
	4-7 days	75	8	10.7	1.029	0.452 - 2.339	1
	8-14 days	65	17	26.2	2.522	1.327 - 4.795	0.006
	15-21 days	33	12	36.4	3.506	1.793 - 6.856	0.001
	>21 days	86	21	24.2	2.355	1.267 - 4.376	0.008

**Reference groups*

6.2 Analysis of factors associated with AMU

The analysis of AMU among ICU patients revealed significant variation across age groups, clinical severity, invasive device use, and length of hospital stay. Infants under 1 month had a substantially lower prevalence of receiving antimicrobials compared to the reference group (18–64 years), with a 58% reduced prevalence (PR = 0.42, 95% CI: 0.29–0.60, $p < 0.001$), and similarly low AMU rates were seen in other paediatric groups under 2 years. Older adults showed no significant difference in AMU compared to the reference group.

Clinical severity was strongly associated with AMU; patients with rapidly fatal disease were significantly more likely to receive antimicrobials (PR = 1.48, 95% CI: 1.26–1.74, $p < 0.0001$), while those with ultimately fatal disease showed a non-significant increase. Use of invasive devices markedly increased AMU prevalence, with central venous catheters doubling the prevalence (PR = 2.03, 95% CI: 1.66–2.49, $p < 0.0001$), urinary catheters increasing it similarly (PR = 2.11, 95% CI: 1.68–2.64, $p < 0.0001$), and intubation also linked to higher AMU (PR = 1.53, 95% CI: 1.31–1.79, $p < 0.0001$). Surgery was associated with a modest but significant increase (PR = 1.24, 95% CI: 1.05–1.46, $p = 0.018$), while gender and birthweight showed no significant effects.

Length of hospital stay was inversely related to AMU beyond the first few days; patients hospitalised for 4–7 days had a slightly higher prevalence (75%) compared to those with shorter stays (1–3 days, 67%), but longer stays were associated with progressively lower AMU prevalence, with those hospitalised over 21 days showing the lowest use (47%, PR = 0.69, 95% CI: 0.54–0.89, $p = 0.003$). This pattern suggests that antimicrobial prescribing may be concentrated earlier in admission, potentially reflecting treatment initiation or prophylaxis rather than prolonged therapy.

Table 6.2 Univariable analysis for AMU by age group, gender, birth weight, history of surgery, Mc Cabe score, exposure to CVC, IV catheter and intubation, and N antimicrobials in ICU patients during 2023 national PPS survey in Ireland

Variable	Predictor	N ICU Patients	N receiving AM	Prev AMU %	PR (vs Ref)	CI	P-value
Age group	18-64*	144	104	72.2	1	*NA*	*NA*
	<1m	70	21	30.0	0.415	0.286 - 0.603	<0.001
	0-23m	38	9	23.7	0.328	0.184 - 0.586	<0.001
	2-17	8	6	75.0	1.038	0.687 - 1.569	1.00
	65-74	62	47	75.8	1.05	0.883 - 1.248	0.732
	75+	72	45	62.5	0.865	0.705 - 1.063	0.162
Gender	Female*	160	94	58.8	1	*NA*	*NA*
	Male	234	138	59.0	1.004	0.848 - 1.188	1.00
Birth weight	Normal*	19	5	26.3	1	*NA*	*NA*
	High	3	1	33.3	1.267	0.216 - 7.424	1.00
	Low	47	15	31.9	1.213	0.513 - 2.867	0.772
Surgery	No*	278	153	55.0	1	*NA*	*NA*
	Yes	116	79	68.1	1.237	1.051 - 1.458	0.018
McCabe score	Non-fatal disease*	290	153	52.8	1	*NA*	*NA*
	Ultimately fatal disease	73	57	78.1	1.289	0.964 - 1.723	0.209
	Rapidly fatal disease	25	17	68.0	1.48	1.257 - 1.742	<0.001
CVC	N*	176	66	37.5	1	*NA*	*NA*
	Y	218	166	76.1	2.031	1.655 - 2.492	<0.001
Urinary catheter	N*	157	56	35.7	1	*NA*	*NA*
	Y	237	176	74.3	2.106	1.681 - 2.639	<0.001
Intubation	N*	257	128	49.8	1	*NA*	*NA*
	Y	137	104	75.9	1.53	1.31 - 1.787	<0.001
Length of stay in hospital	1-3 days*	135	91	67.4	1	*NA*	*NA*
	4-7 days	75	39	75.0	0.771	0.603 - 0.988	0.038
	8-14 days	65	40	61.5	0.913	0.729 - 1.143	0.431
	15-21 days	33	22	66.7	0.989	0.756 - 1.293	1.00
	>21 days	86	40	46.6	0.69	0.535 - 0.891	0.003

**Reference groups*

7.0 COVID-19

Only 14 cases of COVID-19 from five acute hospitals were found in ICU at the time of the survey (May 2023), none of which were reported as HAIs but was ascertained from the hospital questionnaire: 9 in tertiary hospitals, 4 in secondary hospitals, and one in a private hospital. One of the 14 COVID-19 cases was admitted to ICU for COVID-19-related complications. This patient was aged >65 years and was fully vaccinated.

8.0 Limitations

The study, while providing valuable insights into HAIs and AMUs in ICUs in Ireland, has several limitations. As a point prevalence survey (PPS), the data represent a snapshot of HAIs and AMU at a single time point. This limits the ability to establish causal relationships or track trends over time and

may not capture seasonal variations in HAI incidence or AMU practices. The study also only included in-patients at the time of the survey and ICU patients who were discharged or died prior to the survey period are not accounted for, potentially underestimating the overall burden of HAIs and AMU in ICU settings. The study did not adjust for risk factors (e.g., age, gender, invasive devices), there may be other confounding variables, such as underlying comorbidities or ICU practices, that were not fully accounted for, potentially influencing the results. Additionally, the relatively small sample size of ICU patients may have limited the statistical power to detect significant associations, especially for subgroup analyses, leading to potentially inconclusive findings for certain risk factors.

The study did not capture detailed information on ICU staffing levels and resources, or compliance with infection prevention protocols, all of which could significantly impact HAI rates and AMU. Variations in the quality of data collection, hospital reporting standards, or staff expertise could also influence the accuracy of HAI and AMU reporting. Whilst the study followed ECDC definitions for HAIs, there may be variability in how hospitals interpreted and applied these definitions, leading to inconsistencies in HAI identification across sites. Addressing these limitations in future studies would enhance the understanding of HAIs and AMU in ICUs, allowing for more robust conclusions and tailored interventions.

9.0 Conclusions and Recommendations

Both an increasing McCabe score and the presence of invasive devices were the strongest risk factors for the development of healthcare-associated infections (HAIs) in critical care settings. As McCabe score is not modifiable, resources should be focused on:

- Surveillance and prevention of device-related infections, and
- Developing, implementing, and supporting national guidelines and care bundles for device management.

Antimicrobial use (AMU) in critical care units is also notably high and predominantly broad-spectrum. To address both HAIs and excessive AMU, ongoing education and support of clinical staff is essential. Individual institutions should assess the need to:

- Increase the frequency of multidisciplinary ICU/Microbiology/Antimicrobial Pharmacy rounds,
- Expand access to these rounds during weekends, particularly as Ireland moves toward a 6/7-day model of care.

National-Level Recommendations

1. **Develop and implement a national ICU prospective infection surveillance programme**, prioritising pneumonia, bloodstream infections, and central line-associated infections.
2. While the national point prevalence survey (PPS) of HAI and AMU is conducted every five years, this frequency is insufficient to evaluate the impact of preventative strategies or track performance over time.
    - Future PPS protocols should incorporate ICU-specific illness severity scores (e.g., SOFA, APACHE II).
3. **Prioritise ePrescribing rollout** across all hospitals to enable accurate monitoring of antimicrobial use, resistance trends, and inappropriate prescribing.

4. Fund research into novel infection prevention interventions, such as antimicrobial-impregnated devices and innovative care protocols.
5. Encourage data-**driven solutions**, including the use of data analytics and machine learning to predict HAI risk and guide real-time interventions in ICUs.

Hospital-**Level Recommendations**

1. Ensure **antimicrobial stewardship resources** are available and utilised in all hospitals and ICUs.
2. Staffing levels for frontline healthcare workers must reflect patient case mix and dependency. Trained and well-supported nurses play a critical role in HAI prevention and care quality.
3. ICU IT systems should support:
    - Electronic prescribing with decision support,
    - Electronic health records,
    - Laboratory information systems.
      These systems improve prescribing practices, reduce medication errors, enhance documentation, and optimise resource use.
4. Share **local and national results of the 2023 PPS** with hospital and ICU staff to inform and drive quality improvement.
5. **Promote antimicrobial de-escalation**, ensuring therapies are reassessed within 48–72 hours of initiation and adjusted to narrower-spectrum agents where appropriate.

ICU Ward-**Level Recommendations**

1. Universally implement **multi**-modal strategies for preventing common ICU HAIs, especially pneumonia and device-related infections. These should include:
    - Device maintenance care bundles,
    - Insertion checklists,
    - Staff induction and ongoing education,
    - Availability of local guidelines, and
    - Continuous audit and surveillance.
2. For the **prevention of ventilator**-associated pneumonia, strategies should include:
    - Reducing mechanical ventilation exposure,
    - Excellent oral hygiene, and
    - Subglottic suctioning.

3. In neonatal ICUs, reduce HAIs through targeted disinfection and cleaning protocols, tailored to this unique environment and population. Implement IPC bundles and multimodal strategies proven effective in neonatal care.
4. Conduct daily audits to assess the ongoing need for invasive devices, with the goal of early removal when clinically appropriate.
5. Strengthen **antimicrobial stewardship programmes** at the ward level, integrated with clinical care.
6. Expand surveillance of HAIs and AMU within ICUs to guide targeted interventions.
7. **Invest in staff education and training** to sustain good IPC practices, ensure adherence to antimicrobial guidelines, and foster a culture of safety and accountability.

Summary recommendations

These policy recommendations aim to enhance infection control, reduce unnecessary antimicrobial use, and improve patient safety in ICUs across Ireland. A multifaceted approach that includes strict adherence to device management protocols, robust antimicrobial stewardship programs, continuous staff education, and a strong surveillance infrastructure is essential to reducing the incidence of HAIs, AMU and subsequently and AMR in ICUs.

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Annex:

1. Point Prevalence Survey of Healthcare-Associated Infections & Antimicrobial Use in European Acute Care Hospitals Irish Protocol 2023. Available at: PPS 2023 Irish Protocol (www.hpsc.ie)
2. Point Prevalence Survey of Healthcare-Associated Infections & Antimicrobial Use in European Acute Care Hospitals Irish Report 2023. Available at: PPS 2023 Irish Report (www.hpsc.ie)