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Pilot Report
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Glossary

AMR	Anti-microbial resistance
APACHE II	Acute Physiology and Chronic Health Evaluation II
BSI	Bloodstream Infection
CI	Confidence Intervals
CR-BSI	Central venous catheter-Related Bloodstream Infection
CRI	Central venous catheter-Related Infection
CRI-1	Central venous catheter-Related Infection- Local
CRI-2	Central venous catheter-Related Infection- General
CVC	Central venous catheter
ECDC	European Centre for Disease Control
GISA	Glycopeptide-Intermediate *Staphylococcus aureus*
HAI	Healthcare Associated Infection
HDL	Health Department Letter
HDU	High Dependency Unit
HELICS	Hospitals in Europe Link for Infection control through surveillance
HPS	Health Protection Scotland
IAP	Intubation Associated Pneumonia
ICU	Intensive Care Unit
ICUAI	Intensive Care Unit Associated Infection
IQR	Interquartile Range
LRT	Lower Respiratory Tract
LOS	Length of Stay
MSSA	Meticillin Sensitive *Staphylococcus aureus*
MRSA	Meticillin Resistant *Staphylococcus aureus*
NHS	National Health Service
NPV	Negative Predictive Value
PN	Pneumonia
PPV	Positive Predicative Value
SD	Standard Deviation
SICSAG	Scottish Intensive Care Society Audit Group
SSHAIP	Scottish Surveillance Associated Infection Programme
SPSP	Scottish Patient Safety Programme
VAP	Ventilator-Associated Pneumonia

Summary Report

- This is the first report from the Intensive Care Unit Associated Infection (ICUAI) national surveillance programme.
- Surveillance data relating to central venous catheter-related infection (CRI), catheter related bloodstream infection (CR-BSI), pneumonia (PN) and bloodstream infections (BSI) were collected in accordance with the Hospitals in Europe Link for Infection Control through Surveillance (HELICS) methodology[1].
- Data from 2900 patients admitted to 19 Scottish Intensive Care Units (ICUs) were collected and a total of 235 infections were reported from 189 (6.5%) patients.
- Of the 235 infections reported, 117 (49.8%) were PN, 103 (43.8%) were BSI (including CR-BSI) and 15 (6.4%) were Local CRI (CRI-1) and General CRI (CRI-2).
- Of the 117 PN, 91.5% were ventilator-associated pneumonia (VAP) and the incidence density for VAP was 6.5 per 1000 ventilator days. The European Centre for Disease Control (ECDC) publication of HELICS ICUAI surveillance data reported an incidence density of 12.2 VAP per 1000 ventilator days[2].
- A total of 3.6% of patients developed a BSI and the incidence density for BSI was 3.8 per 1000 patient days. This is comparable with the rate published by ECDC which was 3.4%[2].
- The incidence of CR-BSI was 0.7 CR-BSI per 1000 central venous catheter (CVC) days, this is relatively low when compared to the ECDC average of 4.3 CR-BSI per 1000 CVC days[2].
- The ECDC report also showed that 52%[2] of BSIs were defined as CR-BSI whereas only 11.7% of Scottish BSI were CR-BSI.
- In general, the findings of this report are consistent with the ECDC publication of HELICS ICUAI surveillance data.
- Future work will include further analysis of data to identify potential risk factors for ICUAI and determine a means of stratifying data, adjusting for risk and providing more meaningful infection rates that may be used for benchmarking. Data will also be submitted to the ECDC for inclusion in future reports of European data.
- Validation of the ICUAI surveillance data found that the data are robust and infection ascertainment was good.

1. INTRODUCTION

1.1 Surveillance of Intensive Care Unit Associated Infections in Scotland

The Scottish Intensive Care Society Audit Group (SICSAG) and Health Protection Scotland (HPS) have been working together over recent years to develop a national surveillance programme for Intensive Care Unit Associated Infection (ICUAI). This collaboration came in response to two Health Department Letters (HDL), "A Framework for National Surveillance of Hospital Acquired Infection in Scotland" HDL (2001) 57[3] and HDL (2006) 38[4], "A revised framework for national surveillance of Healthcare Associated Infection (HAI) in Scotland". These HDLs require that NHS Boards implement surveillance using standardised methodologies over defined timescales and that in addition to the mandatory requirements for surveillance, voluntary surveillance programmes such as ICUAI surveillance should be carried out by all NHS Boards.

Following an initial pilot study in 2005 to assess the feasibility of using the Hospitals in Europe Link for Infection Control through Surveillance (HELICS) data definitions[1] and WardWatcher software as a data collection tool, WardWatcher was upgraded in 2008 and the upgraded version better facilitates the collection of data for ICUAI surveillance. Since the roll out of the upgraded version of WardWatcher, a large number of Intensive Care Units (ICUs) in Scotland have commenced continuous data collection for this surveillance programme. Both WardWatcher and HELICSwin software are being used to collect ICUAI surveillance data. As such this is the first report from the surveillance programme.

1.2 Aims and Objectives of ICUAI surveillance in Scotland

- Monitor the incidence and trends of ICUAI.
- To increase awareness of ICUAI among clinical staff.
- Examine the impact of interventions intended to reduce ICUAI.
- Gain information on the quality of care.
- Prioritise the allocation of resources.
- To establish a national database of robust ICUAI surveillance data for Scotland.
- Contribute to the European ICUAI surveillance dataset and provide a benchmark for Scottish data in the context of other European countries.

2. DATA COLLECTION

2.1 Data Collection

Demographic, invasive device exposure and ICUAI data were collected in accordance with the methods and data definitions set out in the HELICS protocol for surveillance of ICUAI[1]. All ICUAI surveillance data were collected either via WardWatcher or HELICSwin data collection software.

Data were collected by a wide range of staff and the methods for data collection varied between units. In units using HELICSwin for data collection, a dedicated data collector was employed.

Training in terms of data collection using WardWatcher and the HELICS definitions was delivered by HPS and SICSAG to representatives from participating units. A protocol developed by HPS and SICSAG was distributed to all participating ICUs.

2.2 Patient population

Data were collected from adult patients with a stay of more than two days in the ICU[1].

2.3 Infections included in the surveillance programme

Data relating to central venous catheter related infection (CRI) which includes local CRI (CRI-1), general CRI (CRI-2) and catheter-related bloodstream infection (CR-BSI), pneumonia (PN) and bloodstream infections (BSI) were collected. All infections reported were identified in accordance with the HELICS surveillance methodology[1].

2.4 Exclusion criteria and data cleansing

(i) Records with essential data missing such as discharge dates were removed.
(ii) Duplicate records were identified and removed.
(iii) Duplicate infections were excluded. Criteria for determining possible duplicates were based on those specified by HELICS. Infection episodes were defined by a minimum of a four day interval between PN episodes and a seven day interval for BSI and CRI[5].

2.5 Data Analysis Methods

Data analyses were carried out using STATA version 9.The Wilson method was used to calculate 95% confidence intervals (CI)[6].

2.6 Validation of ICUAI data

A sample of patient records from the period May 2009 to January 2010, from each participating unit was randomly selected.

A random list of 10% of records from non-infected patients and 20% of infected patients was reviewed from each ICU by external, independent reviewers. Where a unit recorded less than 25 infections, five cases were reviewed where possible.

It is noted that not all units have participated for equal time and therefore the sample size varies considerably between units. Data sampling covered different periods depending on how long units had been participating. The size of unit and duration of participation therefore affected sample size.

The patient records (limited to case notes) were reviewed by the validation team. Review was blind and all staff reviewing the data were trained in the data definitions and the review process.

3. RESULTS

3.1 Participating ICUs

A total of 19 adult ICUs in Scotland contributed ICUAI surveillance data to the Scottish ICUAI database between 01/05/2009 and 30/01/2010. Not all 19 participating units contributed data for the whole time period covered in this report.

Of the units contributing data 14 (74%) were solely ICUs and five (26%] were combined ICU/ High Dependency Units (HDU). The size of the contributing units ranged from three to 18 beds. For the purpose of this report all units including the combined ICU/HDU will be referred to as ICUs.

3.2 Patient Population

Data from 2900 patients admitted to the participating ICUs between 01/05/2009 and 29/01/2010, and discharged on or before 31/01/2010, with a stay of more than two days in the ICU were included. A total of four patient records were excluded from the database as records for these patients were incomplete.

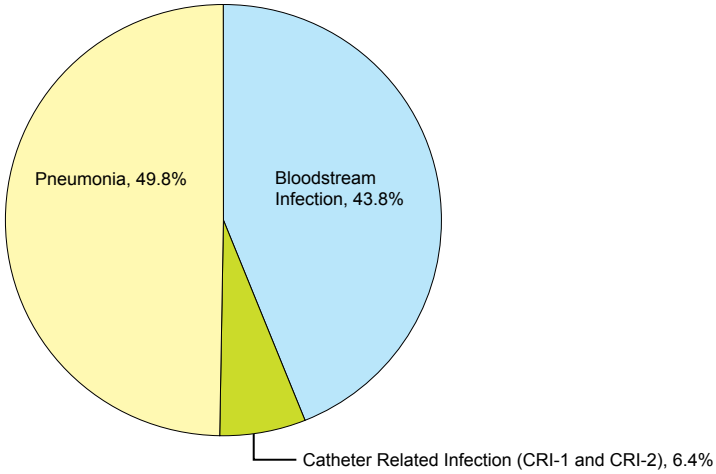
Of the 2900 admissions, 1667 (57.5%) were male and 1233 (42.5%) were female. The median length of stay was five days (interquartile range [IQR] 3,9), the mean Acute Physiology and Chronic Health Evaluation II (APACHE II)[7] score performed within the first 24 hours of the patient stay was 20 (standard deviation [SD], 7.6) and the mean age was 59 (SD, 16.9).

3.3 ICUAI Epidemiology

In total 235 ICUAIs (PN, CRI and BSI) were reported (and met the criteria for inclusion) from the patient population and over the time period specified via the surveillance system. Of the 2900 admissions, 189 (6.5%, 95% CI: 5.7-7.5) patients developed at least one ICUAI as defined by the HELICS protocol[1]. Two duplicate infections and one infection recorded prior to day three were removed from the database.

Of these 235 infections, 117 (49.8%) were PN, 103 (43.8%) were BSI (including CR-BSI) and 15 (6.4%) were CRI-1 and CRI-2. Figure 1 shows the percentage of each infection type reported.

Figure 1. Percentage of each type of ICUAI (PN, BSI and CRI)



Comparison of age, APACHE II[7] score and length of stay between patients with ICUAI and patients without ICUAI is shown in Table 1. The mean age of patients with an ICUAI and patients without an ICUAI is not significantly different. The mean APACHE II Score for patients with (19.9) and without ICUAI (21.5) is significantly different (p=0.01, Student T-test), this is also likely to be clinically significant. The median length of stay (LOS) for patients with an ICUAI and patients without an ICUAI is significantly different (p<0.00001, Mann Whitney U test).

Table 1. Comparison of age, APACHE II score and length of stay (LOS) between patients with and without ICUAI.

Variable	**No ICUAI (n= 2711)**		**ICUAI (n=189)**		
	Mean	**95% CI** (Lower CI, Upper CI)	**Mean**	**95% CI** (Lower CI, Upper CI)	**P value** (Student T-test)
Age in years	58.0	57.4, 58.7	55.7	53.2, 58.2	p=0.06
APACHE II[6]	19.9	19.6, 20.2	21.5	20.4, 22.5	p=0.01
	Median	**IQR**	**Median**	**IQR**	**P value** (Mann Whitney U)
Length of stay in days (LOS)	5	3, 8	19	12, 30	p<0.00001

3.4 Pneumonia

A total of 117 pneumonias were reported from 110 (3.8%) patients. Of these infections 107 (91.5%) infections were considered to be ventilator-associated pneumonia (VAP) as the patient had an invasive respiratory device present in the 48 hours preceding the onset of infection. The remaining 10 (8.5%) pneumonia were not considered to be VAP. Incidence density rates for pneumonia are shown in Table 2.

Table 2. Incidence Density for Pneumonia.

Invasive respiratory device present*	No. Pneumonia	Incidence Density for Pneumonia	95% CI (Lower CI, Upper CI)
No	10	0.4 PN/1000 patient days	0.23,0.77
Yes	107	6.5 VAP/1000 ventilator days	5.39,7.86
All	117	4.9 PN per 1000 patient days**	4.11,5.90

* Invasive respiratory device present in the 48 hours preceding the onset of infection

** Rate calculated ONLY to allow comparison with European incidence density figures. This rate does not adjust for ventilator days at risk but is used by HELICS to present country level incidence rates where the data are stratified by the percentage of patients ventilated.

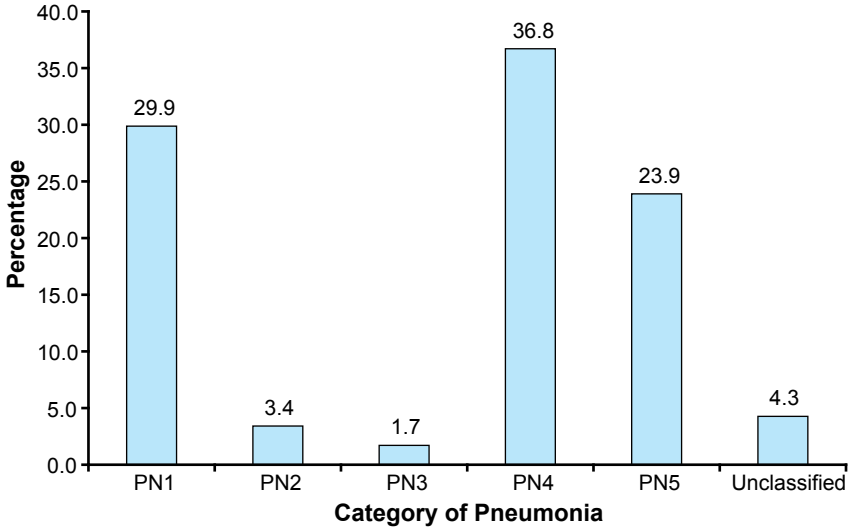
3.4.1. Diagnostic categories of pneumonia

Pneumonia is categorised (for surveillance purposes) according to the microbiology methods (and clinical signs) used to identify the infection[1], details are given in Table 3. The distribution of pneumonia reported by diagnostic category is shown in Figure 2.

Table 3. Diagnostic categories and microbiology method for pneumonia (PN1 to PN5).

Diagnosis category	Microbiology Method
PN1	Positive quantitative culture from minimally contaminated lower respiratory tract (LRT) specimen e.g. broncho-alveolar lavage
PN2	Positive quantitative culture from possibly contaminated LRT specimen e.g. endotracheal aspirate
PN3	Alternative microbiology methods
PN4	Positive sputum culture or non-quantitative LRT specimen culture
PN5	No positive microbiology (Clinical diagnosis only)
Unclassified	This category covers discrepant data where the pneumonia was reported as PN5 however a microbiology result was recorded for that patient.

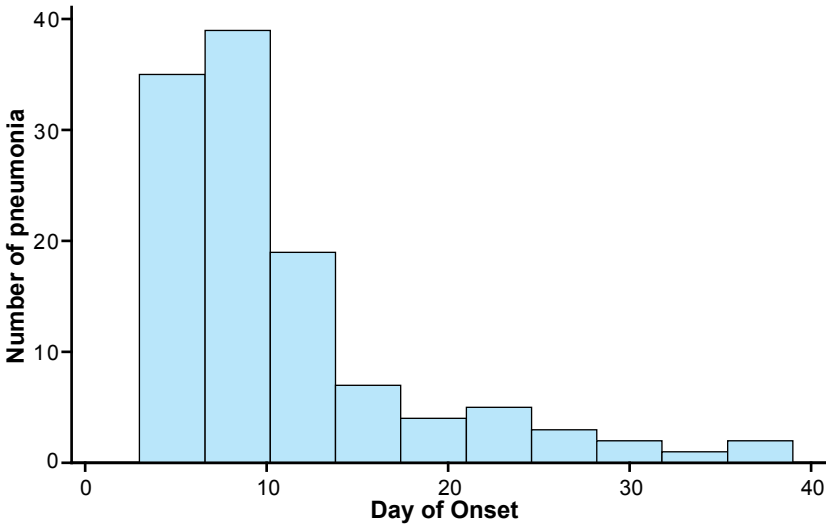
Figure 2. The distribution of diagnostic categories of all pneumonia reported.



3.4.2. Day of onset of pneumonia

The median time to pneumonia infection was nine days (IQR, 5,12), the distribution of the day of onset of infection (from day three of ICU stay onwards) for pneumonia is shown in Figure 3.

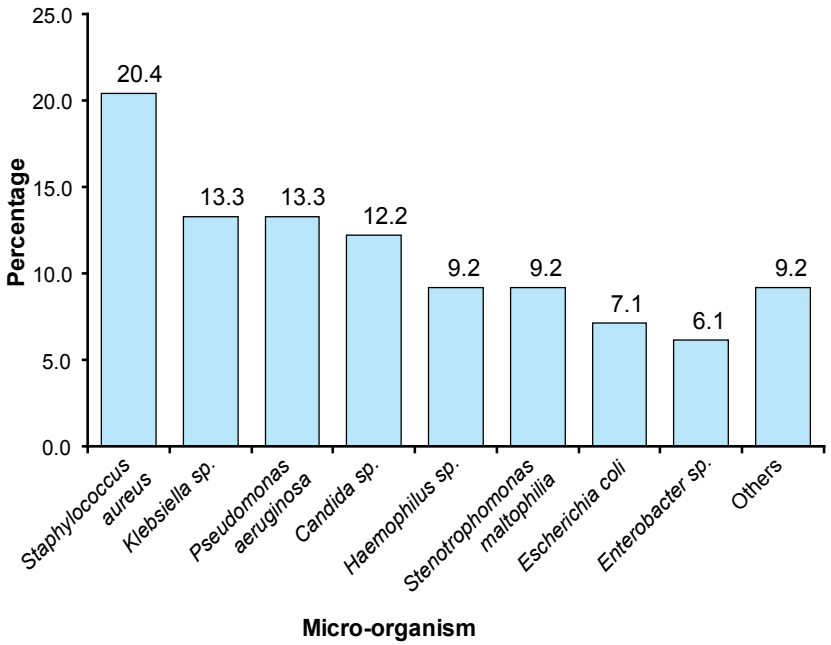
Figure 3. Number of pneumonia infections by the day of onset.



3.4.3. Distribution of micro-organisms isolated from pneumonia

Data for a total of 98 micro-organisms were reported for pneumonia infections. Figure 4 shows the distribution of micro-organisms isolated from pneumonia.

Figure 4. The distribution of micro-organisms isolated from pneumonia.



Summary Points

- 3.8% of patients developed pneumonia.
- A total of 117 pneumonia were reported, 91.5% were VAP.
- Incidence density for VAP was 6.5 per 1000 ventilator days.
- The median day of onset for VAP was nine days.
- *Staphylococcus aureus* (20.4%) *Klebsiella sp.* (13.3%), *Pseudomonas aeruginosa* (13.3%) and *Candida sp*, (12.2%) were the most frequently isolated organisms from pneumonia.

3.5. Bloodstream infections

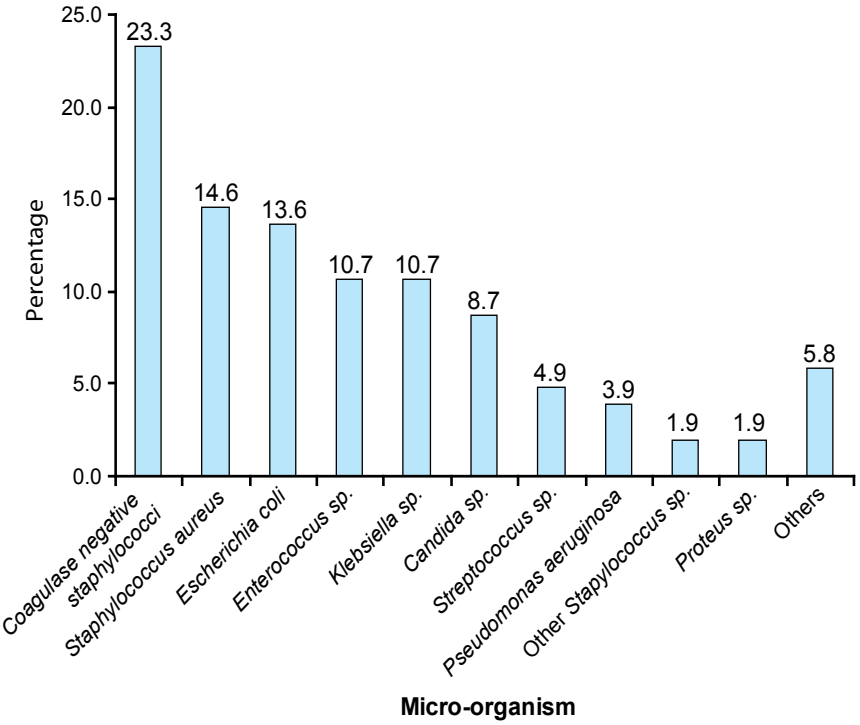
A total of 103 BSI were reported from 103 (3.6%) patients. The median day of onset was day 10 (IQR: 6, 16). Of these 103, 12 (11.7%) were CR-BSI, the incidence density of CR-BSI was 0.7 per 1000 central venous catheter (CVC) days (95% CI: 0.41-1.24).

The incidence density of BSI (not including CR-BSI) was 3.8 per 1000 patient days, (95% CI: 3.12-4.70).

3.5.1. Distribution of micro-organisms isolated from BSI.

The distribution of micro-organisms from all BSI (CR-BSI and non CR-BSI) is shown in Figure 5. Coagulase negative staphylococci were the most frequently isolated organism (23.3%) from BSI followed *S. aureus* (14.6%) and *Escherichia coli* (13.6%).

Figure 5. The distribution of micro-organisms isolated from BSIs



Summary Points

- 3.6% of patients developed a BSI.
- The incidence density for BSI was 3.8 per 1000 patient days.
- The incidence density for CR- BSI was 0.7 per 1000 CVC days.
- Coagulase negative staphylococci (23.3%) and *S. aureus* (14.6%) were the most frequently isolated micro-organisms isolated from BSI.

3.6. CVC related infection (non-BSI)

In total 10 CRI-1 and five CRI-2 were reported, the incidence density of CRI-1 and CRI-2 was 0.9 per 1000 CVC days, (95% CI: 0.54-1.46). The median day to infection was 14 (IQR: 11, 18).

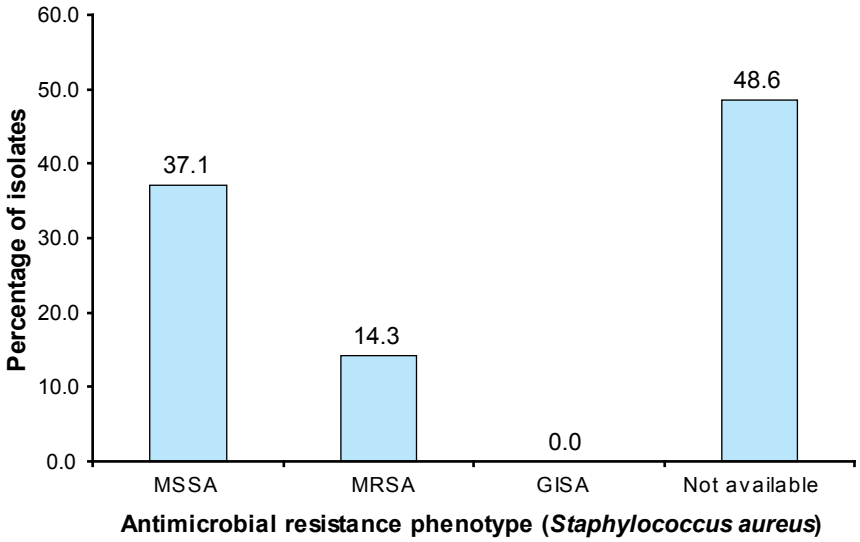
Summary Points

- The incidence density of CRI (CR-1 and CR-2) was 0.9 per 1000 CVC days.
- The number of CRI-1 and CRI-2 are very small, these figures have been validated by the data validation study.

3.7. Antimicrobial resistance of organisms

Figure 6 shows the antimicrobial resistance (AMR) phenotype of *S. aureus* isolates from ICUAIs. Resistance data from 18 of 35 *S. aureus* isolates were reported.
N.B. AMR phenotype data was collected from 17 of the 19 contributing units.

Figure 6. Percentage of S. aureus isolates by antimicrobial resistance phenotype.



Summary Points

- AMR data was reported for 18 (51.4%) of *S. aureus* from 17 of the 19 ICUs
- Of the 18 isolates, 37.1% were Meticillin Sensitive *Staphylococcus aureus* (MSSA) and 14.3% were Meticillin Resistant *Staphylococcus aureus (*MRSA). No Glycopeptide-Intermediate *Staphylococcus aureus* (GISA) were isolated.

3.8 Findings from the ICUAI validation study

N.B. All data presented are aggregated data from Ward Watcher and HELICSwin data collection systems.

A total of 260 patient records were reviewed as part of the data validation study. The study found that overall patient data collected was 94.4% complete, a breakdown of completeness by data field can be found in Appendix I (Table 1).

The sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) for pneumonia and bloodstream infections (BSI and CR-BSI have been aggregated due to small numbers of CRI-BSI reported) are shown below in Table 4. The two by two tables from which these figures are generated can bee seen in Appendix I.

Due to the small number of CRI-1 and CRI-2 reported, the above calculations cannot be reliably carried out.

Table 4. The sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) for pneumonia and bloodstream infections.

Infection Type	Sensitivity	Specificity	PPV	NPV
Pneumonia	74.4%	94.5%	72.7%	94.9%
Bloodstream Infections***	80.0%	92.9%	63.4%	96.8%

*** BSI and CR-BSI have been aggregated due to small numbers of CRI-BSI reported

4. Discussion

The findings presented in this report represent the ICUAI surveillance data collected by 19 ICUs in Scotland over a nine month period. The ICUAI surveillance programme is voluntary and the participation of so many ICUs is a major step to achieving the objective of a national database for Scottish ICUAI data and Scotland's future contribution to the European dataset for ICUAI. All Scottish ICUs are now contributing data for future reporting.

In general, the findings of this report are consistent with the European Centre for Disease Control (ECDC) publication of HELICS ICU surveillance data. The European reports include data from a total of 10 countries collecting patient based surveillance data in accordance with the HELICS surveillance protocol[1].

The incidence density of VAP in Scotland was 6.5 VAP per 1000 ventilator days. This is compared with the intubation associated pneumonia (IAP) rate published by ECDC[8], IAP is equivalent to VAP and the infection definitions for each are identical. VAP is a more frequently used acronym in the UK and is therefore used in this report. The Scottish rate is lower than the overall rate for Europe which is 12.2 IAP (VAP) per 1000 ventilator days. There was however considerable variation in rates between countries, ranging from 3.7 to 20.2 VAP per 1000 ventilator days. The rate for Scottish ICUs most closely compares with that of Luxembourg which had the second lowest rate (6.6 IAP per 1000 ventilator days)[2].

In terms of the diagnostic methods used to report pneumonia, the HELICS report in 2005[5] suggested that the methods used vary considerably between countries. From the data presented in this report it is evident that PN4 is the most frequently reported category and PN1 and PN5 account for a large proportion of all reported pneumonia. Clearly a clinical diagnosis supported by a microbiological finding (PN1-4) is desirable but it is recognised that this may not always be possible. It is important that units continue to report PN5 despite the absence of a positive microbiology test result, but it is worth noting that microbiology data can be updated retrospectively within the WardWatcher system and this is encouraged.

In 2008 and 2009, ECDC reported that 3.4%[2] and 3.0%[8] of patients acquired a BSI, this compares well to 3.6% of Scottish patients. The incidence of CR-BSI was 0.7 CR-BSI per 1000 CVC days, this seems relatively low when compared to the ECDC average of 4.3 CR-BSI per 1000 CVC days[2].

The ECDC report also showed that 52%[2] of BSI were defined as CR-BSI whereas only 11.7% of BSI reported in Scotland were CR-BSI. This inconsistency may be explained if routine microbiology testing in Scotland does not support the criteria for CR-BSI to be fulfilled and thus differentiating BSI from CR-BSI is difficult. Our impression however, is that routine sampling is carried out which would support this. We cannot rule out an effect of the SICSAG Central Line Insertion Bundle and the Scottish Patient Safety Programme which have been established across Scottish ICU's since 2008 reducing CR-BSI incidence to low levels.

No ECDC figures for CRI-1 and CRI-2 are published and therefore we cannot make any comparisons at present. The rate for Scotland was 0.9 per 1000 CVC days.

The distribution of the most frequently isolated micro-organism from pneumonia in Scottish ICUs is similar to that reported by ECDC. *P. aeruginosa* (19%) is most frequently isolated in Europe followed by *S. aureus* (17%)[8]. In Scotland *S. aureus* (20%) is the most frequent isolate, followed by *Klebsiella sp*. (13%) and *P. aeruginosa* (13%). The percentages vary slightly, however the distribution is comparable.

For BSI, the most frequently isolated organisms from Scottish ICUs were coagulase negative staphylococci, *S. aureus* and *E. coli*. The distribution in Europe was similar but perhaps worthy of note is that *P. aeruginosa* was less frequently isolated in Scotland than in Europe.

It is encouraging that the Scottish data are consistent with the ECDC data. The variation in rates between countries is expected and it is likely that variation largely reflects the minor methodological differences in surveillance despite using standardised protocols[9].

Limitations of the data

As participation in the surveillance programme has been ongoing over a number of months, some units have contributed data for the whole time period and others for just a few months. As such, the units are not equally represented and therefore those who have participated for longer are over represented. The effect of this may be to over or underestimate the infection rates. As the majority of units are now contributing data this will not be an issue for future reporting and in addition future reports will also include stratified or risk adjusted infection rates. Further analysis of data will determine the best methods for risk adjusting the data.

Data validation

The data validation process has demonstrated that the data are robust and that infection ascertainment is good. Infection ascertainment for pneumonia had a sensitivity and specificity of 74.4% and 94.5% respectively, and for bloodstream infection the infection ascertainment had a sensitivity and specificity of 80.0% and 92.9% respectively. Due to the difficulties in information finding in case notes, it is likely that the sensitivity and specificity are in fact underestimated.

The data will also be investigated at unit level and if there are any particular issues at any unit, these will be brought to the attention of the unit. Where minor inadequacies in terms of completeness have been identified, these will be investigated locally where necessary.

Due to the positive findings from validation and the resource implications of robust and thorough data validation, it has been decided that no further validation is required for the next five years unless there are any inexplicable changes in the data before that time.

Reducing Infection

It is generally accepted that healthcare associated infection rates in the intensive care unit are higher than elsewhere in the hospital. This reflects both the intrinsic and extrinsic risk factors that affect patients in critical care. These patients have severe illness, may be immunocompromised and are subject to many invasive procedures which are likely to increase their risk of developing an ICUAI[10,11].

It is recognised that healthcare associated infection causes an increase in morbidity and mortality, extends hospital stays and increases the cost of treatment. It is therefore important to promote infection prevention and reduce ICUAI for both patient and economic benefit.

The ICUAI surveillance programme helps to increase awareness of infection among clinical staff, provides a means by which to measure quality of care and the effect of interventions. ICUs are encouraged to use their surveillance data locally to monitor infection rates in order to improve patient care and reduce infection. The Scottish Patient Safety Programme (SPSP) requires that ICUs monitor VAP and CR-BSI on a monthly basis. As such, SICSAG provide monthly infection rates to units in order that they can monitor trends over time, evaluate changes to clinical practice and reduce infection rates.

Future reporting

Future reporting will include a more detailed analysis of the data to identify possible risk factors for infection and provide stratified or risk-adjusted infection rates that can be used for benchmarking.

Stratifying by severity of illness may be most appropriate as this is likely to influence the infection rates[8]. HELICS stratify by the percentage of patients ventilated on the unit as a measure of severity of illness but the suitability of this as a means of stratifying Scottish data would have to be investigated. The small numbers of infections may also present an issue in terms of stratifying Scottish data.

Alternative methods for analysing and presenting the BSI data to provide a better estimate for a CR-BSI incidence density should be investigated.

Dissemination of data

HPS will disseminate the findings from this report to staff in NHS Boards including clinical staff working in the ICU and infection control teams.

SICSAG will directly present the findings to the intensive care community and it is anticipated that they will use the data to inform infection reduction activity and prioritisation of resources.

HPS will liaise with ECDC to ensure that Scottish ICU data will be submitted to ECDC for inclusion in the next ECDC report.

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Appendix I

Table 1 shows the completeness of ICUAI surveillance data. Where possible HELICswin and WardWatcher data have been aggregated. Where data items are exclusive to one or other of the data collection systems, they are presented as such.

Table 1. The Completeness of ICUAI "Patient Data"

Data Item	No. Complete Records		No. Incomplete Records		Total	
	No.	%	No.	%	No.	%
Admission Date	2900	100.0%	0	0.0%	2900	100.0%
Age	2890	99.7%	10	0.3%	2900	100.0%
Sex	2900	100.0%	0	0.0%	2900	100.0%
Source	2253	100.0%	0	0.0%	2253	100.0%
Source housed	2245	99.6%	8	0.4%	2253	100.0%
Prior source	2253	100.0%	0	0.0%	2253	100.0%
Prior source housed	2251	99.9%	2	0.1%	2253	100.0%
Admission date to hospital	2900	100.0%	0	0.0%	2900	100.0%
Unit Outcome	2725	94.0%	175	6.0%	2900	100.0%
Discharge Date	2900	100.0%	0	0.0%	2900	100.0%
Surgery at admission or in the 7 days prior	2125	94.3%	128	5.7%	2253	100.0%
Surgery in the 30 days prior to ICU admission	2125	94.3%	128	5.7%	2253	100.0%
Surgery in first 7 days of ICU stay	2125	94.3%	128	5.7%	2253	100.0%
Surgical site 1 (if surgery)	588	90.9%	59	9.1%	647	100.0%
Surgical site 2 (if surgery)	185	28.6%	462	71.4%	647	100.0%
Trauma admission	2344	80.8%	556	19.2%	2900	100.0%
Coronary disease admission	2349	81.0%	551	19.0%	2900	100.0%
Antimicrobials administered in the 48 hours prior to admission	2125	94.3%	128	5.7%	2253	100.0%
Antimicrobials administered in days one/two of stay	2125	94.3%	128	5.7%	2253	100.0%
Antimicrobials in the 48 hours prior to admission or days one/two of stay	598	92.4%	49	7.6%	647	100.0%
Patient Origin	644	99.5%	3	0.5%	647	100.0%
APACHE II Score	2642	91.1%	258	8.9%	2900	100.0%
Admission Type	642	99.2%	5	0.8%	647	100.0%
Total	**46834**	**94.4%**	**2778**	**5.6%**	**49612**	**100.0%**

Key

☐ Aggregated data from WardWatcher and HELICSwin

☐ WardWatcher field only

☐ HELICSwin field only

Tables 2 and 3 show the findings presented in two by two tables of the validation of pneumonia and bloodstream infections respectively.

Table 2. Two by two table showing the results of the validation of pneumonia

		Validated Data		Sensitivity	74.42%
Pneumonia		Infection	No infection	Specificity	94.47%
Actual Data	Infection	32	12	PPV	72.73%
	No infection	11	205	NPV	94.91%

Table 3. Two by two table showing results of the validation of bloodstream infections (BSI and CR-BSI)

		Validated Data		Sensitivity	80.00%
BSI (All CR-BSI and BSI)		Infection	No infection	Specificity	92.89%
Actual Data	Infection	28	16	PPV	63.64%
	No infection	7	209	NPV	96.76%

Appendix II

Reader's Notes

Confidence Intervals

A range of values within which we are fairly confident the true population value lies. A 95% CI means that we can be 95% confident that the population value lies within the lower and higher confidence limits.

Incidence Density

Incidence Density for BSI and PN

Total number of BSI/PN as a proportion of the sum of the ICU in-patient days contributed by each patient in the study population. The proportion is expressed as the number of BSI/PN per 1000 patient days.

Incidence Density for CRI and CR-BSI

Total number of CRI/CR-BSI as a proportion of the sum of the CVC days (days that a patient had a CVC *in situ*) contributed by each patient in the study population. The proportion is expressed as the number CRI/CR-BSI per 1000 CVC days

Incidence density for VAP

Total number of VAP as a proportion of the sum of the ventilator days (days that a patient required mechanical ventilation) contributed by each patient in the study population. The proportion is expressed as the number VAP per 1000 ventilator days.

Inter Quartile range

The inter quartile range for a distribution is the distance between the first and third quartiles. The quartiles split the distribution into four equal parts with the median being the second quartile. Consequently the inter quartile range is the range containing the middle 50% of the data.

Mean

The mean value is obtained by adding all the values in a population or sample and dividing the total by the number of samples that are added.

Median

The median of a finite set of values is that value which divides the set into two equal parts such that the number of values equal to or greater than the median is equal to the number of values equal to or less then the median. If the number of observations is odd, the median will be the middle value when all values have been arranged in order of magnitude, when the number of observations is even, the median is the mean of the two middle observations.

Sensitivity and Specificity

Sensitivity and specificity are used to assess the ability of a diagnostic test (in this case ICUAI surveillance methods) to correctly classify individuals by presence or absence of infection (e.g. pneumonia).

To estimate the sensitivity and specificity, the individual needs to be classified definitively as having or not having the infection. This definitive classification is called the "Gold Standard", in this study the "Gold Standard" result was the result of the validation review.

Sensitivity
Proportion of true positives correctly identified as such.

Specificity
Proportion of true negatives correctly identified as such.

Positive Predictive Value
Proportion of test positives that are true positives.

Negative Predicative Value
Proportion of test negatives that are true negatives.

Standard Deviation

A measure of how close the sample mean is to the population mean.
A low standard deviation indicates that the data points tend to be very close to the mean, whereas high standard deviation indicates that the data are spread out over a large range of values.