Surveillance of Intensive Care Unit Associated Infections

Pilot Report
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SSHAIP
Scottish Surveillance of Healthcare Associated Infection Programme

Executive Summary

- A pilot study of surveillance of intensive care unit associated infections (ICUAI) was carried out in five hospitals in Scotland between 01/05/2005 and 31/08/2005.
- This pilot study tested the feasibility of utilising Ward Watcher to collect surveillance data electronically, the application of the Hospitals in Europe Link for Infection Control through Surveillance (HELICS) definitions for ICU associated infection in Scotland and the ability to collate Defined Daily Dose (DDD) data for all antibiotics supplied to all ICUs in Scotland.
- During the pilot study data were collected from 386 patients, 199 (52%) of which met the inclusion criteria for the surveillance and were included in the analysis. A total of 32 patients who met the criteria for inclusion in surveillance, developed 44 episodes of infection according to the HELICS definitions for ICUAI. The scientific findings identified as part of this pilot study are comparable to those reported elsewhere in the literature, including the findings reported by HELICS.
- The results of the pilot indicate that surveillance of infections acquired in ICUs in Scotland using Ward Watcher for data collection and the HELICS definitions for infection is a feasible process with a minimal requirement for additional staff resources.
- The HELICS definitions for ICUAI are applicable in Scotland; definitions for pneumonia, bloodstream infections and central venous catheter (CVC) related blood stream infections could be applied in all hospitals. Definitions for Local and General CVC related infections could only be applied in those hospitals where laboratories carry out the necessary diagnostic tests.
- The study demonstrated that it was feasible to collate DDD for antibiotics supplied to ICUs in Scotland.

List of abbreviations

HAI	Healthcare Associated Infection
BSI	Blood Stream Infection
CVC	Central Venous Catheter
CVC RI	Central Venous Catheter Related Infection
DDD	Defined Daily Dose
EPIC	European Prevalence of Infection in Intensive Care
HELICS	Hospitals in Europe Link for Infection Control through Surveillance
HPS	Health Protection Scotland
ICU	Intensive Care Unit
ICUAI	Intensive Care Unit Associated Infection
NNIS	National Nosocomial Infection Surveillance
SICSAG	Scottish Intensive Care Audit Group
SSHAIP	Scottish Surveillance of Healthcare Associated Infection Programme
VAP	Ventilator Associated Pneumonia

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1. Background

1.1 Epidemiology of Intensive Care Unit Acquired Infections

Healthcare associated infections (HAI) affect around 9% of all patients in hospital (Emmerson et al, 1996). It is generally accepted that the infection rate in the intensive care unit (ICU) is likely to be higher than elsewhere in the hospital, as patients in the ICU are critically ill and are subject to many invasive procedures which increase their risk of acquiring an HAI.

A number of published studies have been carried out to determine rates of infection in ICUs. However, these figures vary considerably between studies and depend upon the type of ICU and the infection definitions used in the study (Vincent et al, 2003).

The European Prevalence of Infection in Intensive Care (EPIC) study was carried out in 1992. This one-day prevalence study of patients in intensive care units was carried out in 17 countries in Western Europe and included 194 units in the UK. The study found that 21% of patients investigated had an ICU acquired infection, according to the CDC definitions for HAI. The prevalence of ICU acquired infection varied from 9.7% in Switzerland to 31.6% in Italy and the prevalence of ICU acquired infection in the UK was16%. Those infections most frequently reported were pneumonias (46.9%), lower respiratory tract infections (17.9%), urinary tract infections (17.6%) and bloodstream infections (12%), (Vincent et al, 1995).

Another large study of nearly 500,000 patients in combined medical-surgical intensive care units in 152 United States hospitals reported the incidence of ICU acquired infection at 16.2 per 1000 patient days; the NNIS definitions of HAI were used and the study included all types of infection originating in the ICU (Richards et al, 2000).

1.2 Surveillance of ICU associated infection in Scotland

The Scottish Surveillance of Healthcare Associated Infection Programme (SSHAIP) team at Health Protection Scotland (HPS), the Scottish Intensive Care Audit Group (SICSAG) and the Scottish Adult Critical Care Pharmacists Network have collaborated to develop a system for surveillance of Intensive Care Unit Associated Infections (ICUAI).

It was agreed that ICUAI surveillance data should be collected through the existing SICSAG Ward Watcher audit system currently in place in throughout Scotland. In consultation with Consultants in Intensive Care Medicine, Microbiologists and infection control staff it was agreed that the case definitions, data definitions and data set for surveillance would be those specified by the Hospitals in Europe Link for Infection Control through Surveillance (HELICS) protocol for Surveillance of Nosocomial Infections in Intensive Care Units.

HELICS is an international network aiming at the collection, analysis and dissemination of valid data on the risks of nosocomial infections in European Hospitals. HELICS associated networks, of which Scotland is one; collect data on HAI to standardised or HELICS compatible protocols. An expert advisory board to which Scotland contributes is responsible for review and evaluation of the functioning of the HELICS programme.

Scotland currently participates in sharing Surgical Site Infection surveillance data with HELICS and it is anticipated that Scotland would share the ICUAI surveillance data in the future.

Data collection for surveillance in Scotland comprises HELICS Level 2 surveillance of Blood Stream Infections (BSI), Central Venous Catheter Related Infections (CVC RI) and Ventilator Associated Pneumonia (VAP). This is a targeted surveillance programme, the methodology of which permits risk-adjusted rates for comparison of infection rates between ICUs, hospitals and countries (benchmarking). Risk factors are collected for every patient staying in the ICU, whether infected or not e.g. it is patient-based surveillance. In order to obtain sufficient precision of indicators, a minimum surveillance period of six months is recommended (HELICS, 2004). Full details of the HELICS protocol for surveillance of ICUAI can be found at http://helics.univ-lyon1.fr/protocols/icu_protocol.pdf.

2. The objectives of surveillance of ICU associated infections

2.1 Unit and hospital level:

- To monitor infection rates in a unit over time by providing relevant information to monitor and target infection control policies.

2.2 Scottish / National level:

- To provide the intensive care units with the necessary reference data to make comparisons of risk-adjusted rates between hospitals.
- To inform on epidemiological trends over time and to identify important pathogens and the epidemiology of emerging infections and antimicrobial resistance
- To identify risk factors of ICUAI.

2.3 EU (HELICS) level

In the future, it is anticipated that the data collected from surveillance of ICU associated infections in Scotland will form part of the HELICS dataset. Further details of how the data will be used by HELICS and the objectives of HELICS are available at http://helics.univ-lyon1.fr/.

3. Aims of the pilot study

(i) To evaluate the overall feasibility of carrying out surveillance of ICUAI in Scotland and to assist with the development of the programme for surveillance of ICUAI before rolling out to other volunteer sites within Scotland.

(ii) To evaluate Ward Watcher as a tool for collecting ICUAI surveillance data in the ICU.

(iii) To evaluate the applicability of the HELICS methodology for surveillance of ICUAI in Scotland.

(iv) To evaluate the feasibility of accessing Defined Daily Dose data for antibiotics supplied by hospital pharmacies to all ICUs throughout Scotland.

4. Methodology

4.1 Pilot Units

Initially six ICUs volunteered to participate in the pilot study. Subsequently, one site decided not to participate as they had secured resources to carry out enhanced surveillance utilising an alternative data collection system. As a result of this, five ICUs in Scotland participated in the pilot study and carried out surveillance for a minimum of two months between 01/05/2005 and 31/08/2005. Therefore, the results presented are from the five participating pilot sites. Details of the ICUs that participated in the pilot study are shown in Table 4.1.

Table 4.1: Details of the participating ICUs

Site	No. funded beds	Type of ICU	Duration of pilot
A	7	Mixed	3 months
B	7	Mixed	3 months
C	5	Mixed	3 months
D	7	Mixed	3 months
E	6	Mixed	2 months

4.2 Surveillance Methodology

A working group consisting of representation from the SSHAIP Team, Intensive Care Medicine Consultants and Microbiologists throughout Scotland agreed that the case definitions and data set for surveillance of ICUAI would be those specified by the HELICS protocol for Surveillance of Nosocomial Infections in Intensive Care Units (http://helics.univ-lyon1.fr/protocols/icu_protocol.pdf).

Patient based surveillance comprising of HELICS Level 2 surveillance (minimum dataset) of Blood Stream Infections (BSI), Central Venous Catheter Related Infections (CVC RI) and Ventilator Associated Pneumonia (VAP) surveillance data were collected. The dataset includes demographic, risk factor and infection data; the dataset is detailed in Appendix I.

Data were collected from *all* patients admitted to the ICU, irrespective of their length of stay. However, only that data from patients with a stay in the ICU of *more than two days* were included in the analyses and only those infections occurring more than 48 hours following admission to the ICU were considered to be ICUAI.

All infections were reported and diagnosed using the infection definitions described in the HELICS protocol for ICU surveillance (Appendix II), with the exception of pneumonia infections that, for the purpose of surveillance in Scotland could be diagnosed with the exclusion of the chest x-ray criteria. The decision to exclude chest x-rays was based on opinion and experience suggesting that chest x-rays were not carried out with sufficient frequency in Scotland to fulfil this part of the infection definitions.

4.3 Data Collection Methods

ICUAI surveillance data were collected through the existing Ward Watcher audit system currently in place in all ICUs throughout Scotland. This electronic system is used to collect data for the SICSAG. Amongst the data collected in Ward Watcher are demographics, details of diagnoses, patient treatments, interventions and severity of illness scores. Ward Watcher has been developed to facilitate the collection of additional data items required for surveillance of ICUAI according to the HELICS protocol.

Data collection in Ward Watcher for surveillance purposes comprises several screens dedicated to the collection of data for ICUAI. On the date of onset of infection, the data collector selects (within Ward Watcher) which of the three infections included in the surveillance programme is present/suspected. On determining this, Ward Watcher displays all the criteria (signs and symptoms, and results of diagnostic testing) required to fulfil the HELICS definition of infection. The data collector then selects those criteria present and Ward Watcher assigns the infection to the appropriate category (e.g. PN 4 or PN4) through an algorithm within Ward Watcher. This eliminates the need for the data collector to determine the diagnosis of infection according to the definitions, as Ward Watcher does this automatically.

Daily-Defined Dose (DDD) data for all antibiotics listed in Appendix III, that were supplied to all Scottish ICUs for the period April 2004-2005 (baseline data) and from the pilot sites for the duration of the pilot were collected. The DDD data were collected at individual hospital pharmacy level and collated by a member of the Scottish Adult Critical Care Pharmacists Network.

DDD is a unit of measurement developed by the World Health Organisation to serve as a tool for drug utilisation research studies (http://www.whocc.no/atcddd/). This tool is useful for making comparisons of drug usage; it does not represent recommended treatment doses.

4.4 Evaluation of data quality

Following manipulation of the Ward Watcher data into the format specified in the HELICS protocol, the data were checked using Microsoft Access queries to identify any potentially anomalous data. The primary objective of these checks was to identify the extent to which anomalous data was being reported.

Each infection record was checked manually and duplicate infections/episodes were sent back to the pilot sites for confirmation. Duplicate episodes of infection were then deleted and all infection rates in this report are based on the amended data.

4.5 Evaluation of the pilot study surveillance methods and HELICS definitions

The surveillance methods were evaluated by means of several questionnaires that were sent to key contacts at all pilot sites in order to determine their opinion and experience with various aspects of the study. These included surveillance methodology, applicability of the HELICS protocol and definitions, and the Ward Watcher data collection system.

Microbiologists involved in the pilot study at each site were asked to complete a questionnaire relating to the microbiological tests carried out routinely at their laboratory. This assisted with the assessment of the applicability and practicality of the HELICS case definitions for surveillance in Scotland.

4.6 Evaluation of the Resources required for surveillance at hospital level

The pilot sites were requested to provide information relating to the time required to carry out surveillance, and the number and type of staff involved in the surveillance at their site.

5. Results

5.1 Results: Scientific Findings

5.1.1 Overview of scientific findings

During the pilot period a total of 386 patients were admitted to the five pilot sites and 199 (51.6%) patients stayed for two days or more.

The total admissions and number of patients who stayed more than two days are shown in Table 5.1.

Of those patients with a length of stay of more than two days, 113 (57%) were male and 86 (43%) were female. The patients had a mean age of 57 and the mean APACHE score was 19. For patients staying more than two days the median and mean length of stay was 6 and 14 days respectively.

Table 5.1: Total admissions and the number of patients with a stay of more than two days

Site	Total admissions to the ICU	Number (%) of admissions with a stay of more than two days
A	79	39 (49.4)
B	112	54 (48.2)
C	69	32 (46.4)
D	74	46 (62.2)
E	52	28 (53.8)
Total	386	199 (51.6)

5.1.2 Infections Identified

A total of 32 (16%) patients staying for more than two days developed 44 episodes of infection according to the HELICS infection definitions listed in Appendix II. Twenty four (75%) patients developed one episode of infection, five (16%) patients had two episodes of infection, two (6%) patients developed three episodes of infection and one (3%) patient had four episodes of infection during their stay in intensive care.

Figure 5.1 shows the types infections diagnosed during the pilot.

The percentage of each category of pneumonia (PN1 to PN5) that were reported is shown in Figure 5.2. For further details of the criteria required to report differing categories of pneumonia, please refer to Appendix II.

Figure 5.1: Percentage of each infection type reported

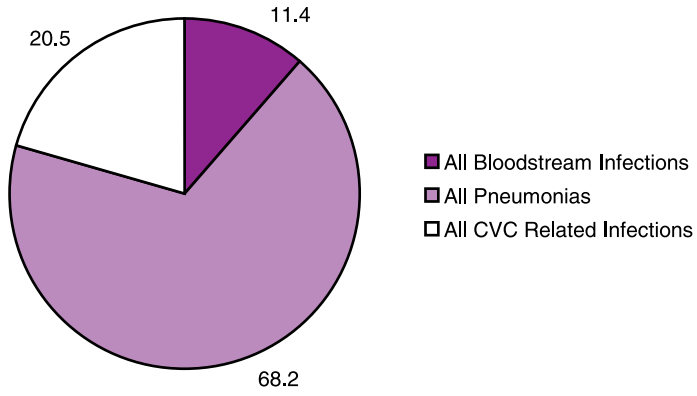
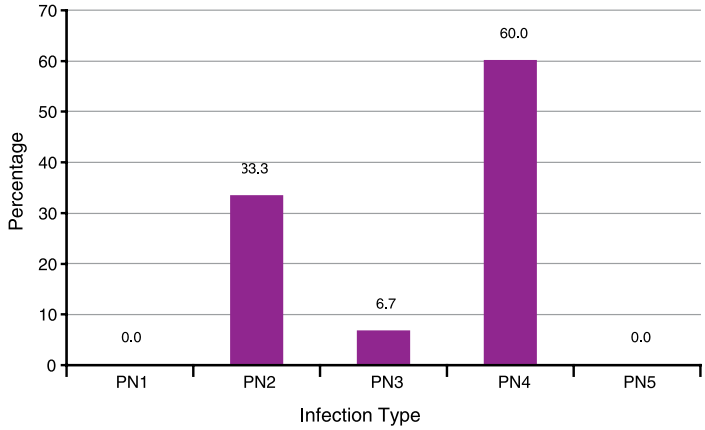


Figure 5.2: Percentage of each category of pneumonia



5.1.3 Infection Rates

The overall infection rate for all hospitals was 30.5 (95% C.I. 22.2, 40.9) infections per 1000 patient days. The infection rate (for all the infections included in surveillance) is shown by unit in Figure 5.3.

Infection rates for pneumonias, BSIs and CVC Related Infections from all pilot units are shown in Table 5.2.

Age, APACHE score and length of stay in the ICU were compared between patients who did and did not develop an ICUAI. The results of these analyses are shown in Table 5.3 and indicate that only length of stay in the ICU is statistically different between the two groups (p=<0.001).

Figure 5.4 shows the range of organisms isolated from ICUAI during the pilot study.

Figure 5.3: Total Infections (Pneumonia, CVC-RI and BSI) by Intensive Care Unit

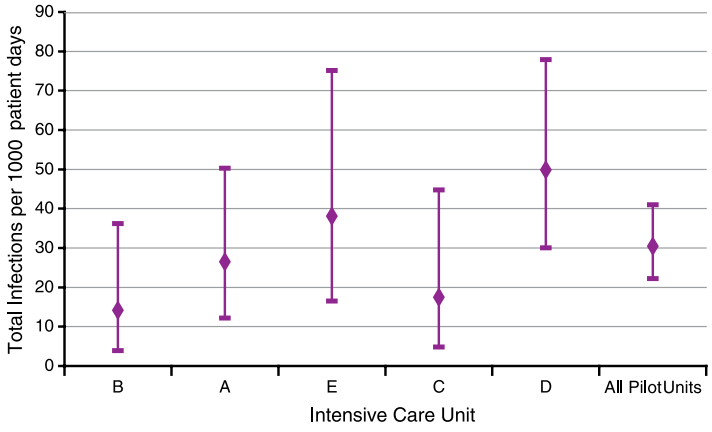


Figure 5.4: Organisms isolated from infections acquired in the ICU

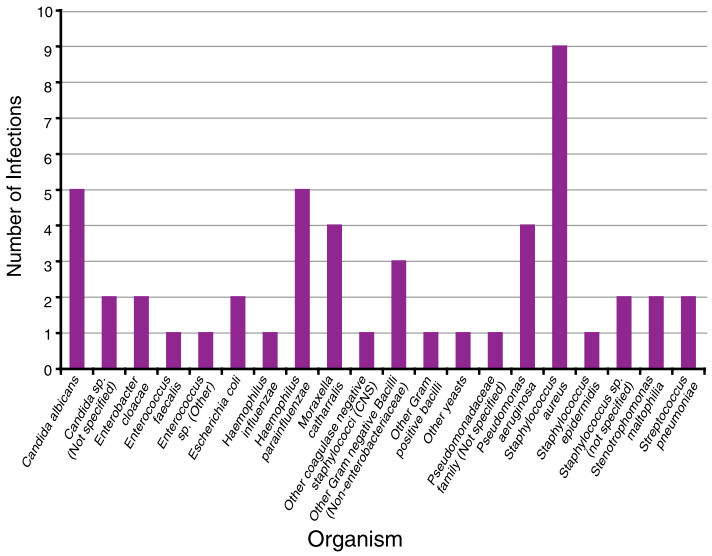


Table 5.2: Infection rates for pneumonia, BSI and CVC Related Infections

Infection Type		Infection Rate	(95% CI)	Percentage of patients with one or more episodes
Pneumonia				
All	(no. infections per 1000 patient days)	20.8	(17.1 - 36.2)	13.1
VAP[1]	(no. infections per 1000 ventilator days)	14.4	(8.4 - 23.0)	-
Non-VAP	(no. infections per 1000 patient days)	6.2	(2.9 - 11.8)	-
BSI	(no infections per 1000 patient days)	3.5	(1.1 - 8.1)	2.5
CVC (All)	(no. infection per 1000 CVC days)	7.5	(3.5 - 14.3)	4.5
CVCRI 1[2]	(no. infection per 1000 CVC days)	3.6	(0.4 - 13.0)	-
CVCRI 2[2]	(no. infection per 1000 CVC days)	3.6	(0.4 - 13.0)	-
CVCRI 3	(no. infection per 1000 CVC days)	4.2	(1.4 - 9.8)	-

[1] 70% of pneumonia were ventilator associated. VAP is defined as ventilator-associated (VAP) if an invasive respiratory device was present (even intermittently) in the 48 hours preceding the onset of infection.

[2] Only two sites had the capability to report CVCRI 1 and 2. Rates are therefore calculated for these two sites only and the denominator is calculated from these two sites only.

Table 5.3: Age, APACHE score and length of stay in the ICU for patients who did and did not develop an infection.

Variable	No ICU Associated Infection Present		ICU Associated Infection Present		Result of Student T-test
	Mean	Standard Deviation	Mean	Standard Deviation	
Age	57.5	19.8	57.5	16.4	p=0.99
APACHE score	19	8.9	18	9.6	p=0.81
Length of Stay	10.7	11.2	9.8	21.4	p=<0.001

5.1.4 Defined Daily Dose data for Antibiotics Supplied to Scottish ICUS

Table 5.5 shows the supplied DDD per 100 patient days for all antibiotic drug classes supplied to all pilot ICUs between the period April 2004 to March 2005 (baseline) and for the pilot period for each of the participating ICUs.

Table 5.5: Supplied DDD per 100 patient days for all antibiotic drug classes supplied to all pilot ICUs between the period April 2004 to March 2005 (baseline) and for the pilot period.

Antibiotic Group	Pilot Site A		Pilot Site B		Pilot Site C		Pilot Site D		Pilot Site E	
	Baseline	*Pilot*	Baseline	*Pilot*	Baseline	*Pilot*	Baseline	*Pilot*	Baseline	*Pilot*
Penicillins	37.9	*32.3*	29.2	*24.2*	49.9	*66.9*	67.4	*73.6*	59.5	*37.0*
Cephalosporins	22.6	*20.7*	62.1	*71.5*	30.7	*20.3*	20.1	*23.0*	43.4	*50.7*
Carbapenems	9.6	*7.4*	3.3	*3.8*	10.3	*4.7*	15.5	*7.6*	10.2	*6.7*
Tetracyclines	0.0	*17.7*	1.2	*0.0*	0.0	*2.1*	0.0	*0.0*	0.0	*0.0*
Aminoglycosides	20.3	*28.1*	109.9	*104.0*	12.5	*19.1*	4.0	*1.4*	32.0	*21.7*
Macrolides	22.9	*20.5*	34.2	*20.6*	15.3	*4.1*	24.1	*17.4*	21.5	*12.0*
Clindamycin	3.6	*6.5*	2.3	*8.5*	4.8	*0.9*	4.4	*4.7*	4.5	*2.8*
Anti-Staph	11.9	*25.2*	34.6	*26.5*	10.1	*25.2*	14.8	*16.9*	15.8	*11.6*
Sulphonamides	1.9	*0.0*	3.1	*1.6*	0.7	*0.0*	4.1	*0.9*	0.0	*0.0*
Anti-TB	7.6	*10.4*	3.6	*55.0*	2.6	*1.6*	3.7	*7.0*	4.2	*5.3*
Metronidazole	30.0	*12.2*	32.8	*16.9*	24.6	*26.7*	27.1	*19.9*	32.6	*41.4*
Quinolones	7.8	*8.5*	17.9	*14.6*	4.6	*1.9*	18.7	*18.5*	5.0	*1.3*
Nitrofurantoin	0.0	*0.0*	0.0	*0.0*	0.0	*0.0*	0.0	*0.0*	0.0	*0.0*
Other	0.0	*2.6*	0.0	*0.0*	0.0	*0.0*	0.0	*0.0*	0.0	*0.0*
Total	**176.0**	***189.5***	**334.2**	***347.2***	**166.0**	***173.6***	**204.0**	***191.1***	**228.7**	***190.5***

5.2 Results: Evaluation of the feasibility study for surveillance of ICUAI in Scotland

5.2.1 Evaluation of Ward Watcher as a data collection tool for ICUAI surveillance data.

All pilot sites found Ward Watcher to be straight forward and easy to use, and four of the units found ward Watcher to be efficient for data collection.

Comments regarding the Ward Watcher system were as follows:

One site noted that entry of retrospective data such as microbiology results was a time consuming process.

One site reported difficulties in collecting antibiotic use data prior to admission to the ICU.

Several sites reported concerns regarding the inefficiency of collecting data from patients who are in the unit for less than two days (48% of all patients included in the pilot study), as these patients are not included in the analysis.

One site reported confusion as to which day they should record a new infection. For example whether is should be reported as the day the specimen was sent, the day the microbiology results were obtained etc.

5.2.2 Evaluation of data quality

5.2.2(a) Infection data

Evaluation of the data revealed duplicate reporting of some infections, a total of 12 duplicate episodes were reported. Of these duplicate episodes, seven additional episodes of infection were reported more than once as more than one causative organism was identified. The remaining five infections were recorded more than once as additional microbiology tests were carried out and the results became available. The majority of infection duplicates were pneumonias.

Due to technical problems with the export of data, evaluation of the ability of Ward Watcher algorithm to “apply” the chosen criteria to “diagnose” the infection was not possible, this will be evaluated at a later date.

5.2.2(b) Non-infection data

Quality checks of the non-infection data found that 3% of the total data items for all records were “not recorded” and three anomalous dates were recorded.

5.2.3 Evaluation of the surveillance methodology

5.2.3(a) The HELICS case definitions

All pilot sites were satisfied that the HELICS definitions captured most CVC-related infections, blood stream infections and pneumonia in their units.

All sites agreed that the microbiology and the signs and symptom criteria in the HELICS definitions were easy to apply. However, several concerns were noted:

One site reported that there may be difficulties with the requirement for chest x-ray criteria for diagnosis of pneumonias in Scottish Hospitals.

Another site reported difficulties applying the laboratory criteria for Local CVC related infection (CVCRI 1) and General CVC related infection (CVCRI 2) as the necessary laboratory diagnostic criteria could not be fulfilled.

It was also noted that the signs and symptoms criteria for CVC related infections were not explicit and were difficult to apply.

5.2.3(b) Feedback from microbiologists

Criteria for diagnosing Pneumonia

All microbiologists reported that non-quantitative endotracheal aspirates were carried out most frequently to identify pneumonia infections; this correlates to HELICS PN 4. Occasionally, it will be possible for sites to report a PN2 or PN3. PN1 requiring a quantitative Broncho-Alveolar Lavage (BAL) would not be frequently reported as most laboratories in Scotland do not carry out this diagnostic procedure.

Criteria for diagnosing CVC-RI

Only two of the pilot sites have the ability to report/diagnose all three CVC-RIs according to the HELICS protocol. The sites unable to report these infections do not routinely carry out quantitative CVC tip culture and therefore would be unable to report a Local CVCRI or General CVCRI), however all sites can report a CVCR-BSI as no CVC tip culture is required for this.

Criteria for diagnosing BSIs

All sites carry out the microbiology analysis required to diagnose BSI according to the HELICS definitions.

5.2.4 Evaluation of Resources

Resources required at hospital level for the surveillance programme

Table 5.2 below lists the number of and type of staff who are involved in *collating and entering data* for the surveillance programme, the time spent per day is also shown. The type of staff involved in data collection varied from site to site.

Table 5.4: The number of and type of staff who are involved in *collating and entering data* for the surveillance programme, the time spent per day is also shown.

Pilot	Number of staff Site involved in the study	Type of staff involved involved	Time Spent on Surveillance per day	Average time per bed
A	3	Medical Consultants Senior Trainee Audit Clerk	<1 hour	<10 min
B	5	Medical Consultants Trainee Medical Staff	10 min	1.4 min
C	3	Infection Control Nurses, Research Nurse	45 min	9 min
D	2	Medical consultant Trainee Medical Staff and microbiologist	10 min	1.4 min
E	5	Trainee Medical Staff Avg	30 min 31 min	5 min 7 min

5.2.5 Daily-defined dose data for antibiotics supplied to the ICU

Figure 5.4 (a) and (b) demonstrate the type of antibiotic use data that can be achieved using the data collection methods described. DDD for all but three units for all antibiotic drug classes supplied to the ICU were collated for the period April 2004 to March 2005. DDD for all antibiotic drug classes supplied to the pilot units were collated for the period of the pilot at each of the units.

Figure 5.4 (a): DDD per 100 patient days for Penicillins and Cephalosporins supplied to all ICUs in Scotland, April 2004-March 2005.

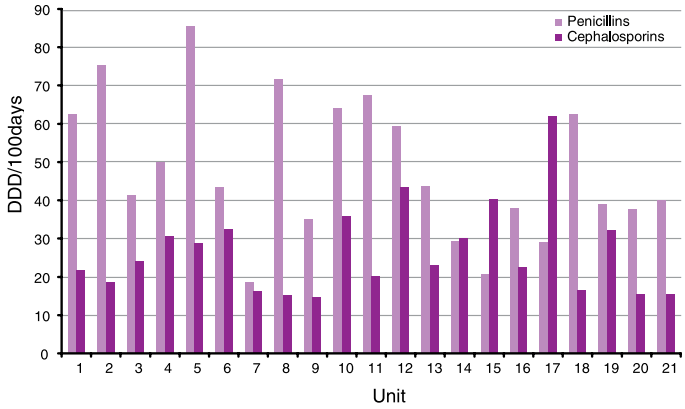
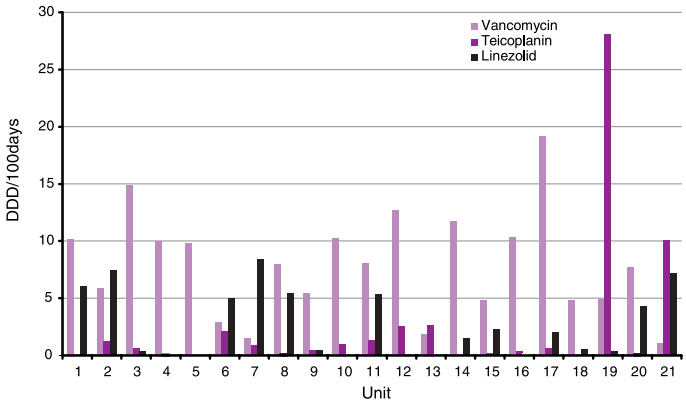


Figure 5.4 (b): DDD per 100 patient days for Vancomycin, Teicoplanin and Linezolid supplied to all ICUs in Scotland, April 2004-March 2005.



6. Discussion

6.1 Discussion: Scientific Findings

A total of 16% of patients staying for more than two days in the ICU during the pilot study developed an ICUAI. As expected, the majority of infections diagnosed were pneumonias (68%).

The overall infection rate was 30.5 (95% C.I. 22.2, 40.9) per 1000 patient days. This pilot study found 3.5 BSI per 1000 patient days and 20.8 pneumonias per 1000 patient days. In a report of ICUAI surveillance in eight countries in Europe published by HELICS in 2005, the incidence rate of BSI was 3.9 BSI per 1000 patient days and the rate of pneumonia was 8.4 pneumonia episodes per 1000 patient days (HELICS, 2005). There are currently no data published for CVC RI. Although the rate of BSI is roughly comparable, the data from HELICS suggest that pneumonia episodes acquired in the ICU may be high in Scotland and as such surveillance in this high-risk group should be continued.

Overall infection rates varied between the ICUs that participated in the pilot study. However, the confidence intervals indicate that this variation is not statistically significant. In addition these are crude rates, proper comparisons between hospitals would require risk- adjusted rates of specific infections.

The majority of the pneumonia infections were classed as a PN4, where the microbiological tests carried out for diagnosis are non-quantitative sputum analyses. This correlates with the types of tests routinely carried out in laboratories in Scotland and the anticipated output from surveillance of pneumonias in Scotland.

A total of 13% of patients acquired at least one episode of pneumonia. This is a little higher than expected when compared to those data presented in the HELICS-ICU Statistical Report published in 2005. HELICS reported that the percentage of patients who acquired at least one episode of pneumonia during their stay was 6.8%. This may partly reflect the adaptation of the HELICS definition to exclude chest x-rays from the diagnosis criteria in Scotland. Future data exports from Ward Watcher will include details of infection criteria and will allow rates for those infections including or excluding chest x-ray criteria to be calculated, thus more accurate comparisons could be made.

HELICS reported a BSI in 3.1% of patients; the findings from the pilot study indicate a similar rate for Scotland. This is of course a crude rate and takes no account of device use and other risk factors for infection.

Comparisons of age and APACHE score between those patients with an ICUAI and those patients with no ICUAI showed there to be no significant difference between the two groups. LOS was longer in the patients with an ICUAI; this is expected as patients with infection usually have longer stays as their medical condition becomes complicated by infection.

Future surveillance throughout Scotland would allow the accumulation of data over time and thus facilitate more detailed and precise analysis. Risk factors that influence infection in the ICU could be identified and may facilitate the development of risk indices for ICUAI, thus allowing comparisons between units to be make more accurately.

6.2 Discussion: The feasibility study

6.2.1 The feasibility of carrying our surveillance in the Intensive Care Unit in Scotland

This pilot study has demonstrated that surveillance of infections acquired in ICU in Scotland using the methods described above is a feasible process. The staff required to resource this activity are minimal and the collation and entry of data can easily be slotted into existing systems for review of patients and entry of data to Ward Watcher. Therefore, it is anticipated that most ICUs in Scotland could resource this surveillance programme with current staffing levels locally.

One major advantage of the system is that Ward Watcher determines whether an infection meets the infection definition based on the infection criteria entered into the database. This eliminates the need for the data collectors to apply such definitions. It is however essential that all personnel involved in surveillance have a good understanding of the methodology for surveillance.

Successful surveillance activity throughout Scotland would be dependent on several factors. Ward Watcher would require some refinements to improve efficiency, accuracy and ease of data collection.

Further development of the systems in place for surveillance would also be required, this would include further developing the training programme, development of practical resources to assist with surveillance and systems to manage, analyse and report data.

6.2.2 Ward Watcher as a tool for collecting HAI surveillance data.

Feedback for Ward Watcher as a tool to collect data for surveillance purposes was positive, all participants found that the system was easy to use.

Several sites noted concerns relating to entering retrospective data. Recording data retrospectively is a difficulty associated with any surveillance programme that relies on laboratory results and emphasises the need to collect data on a prospective basis where possible.

The major criticism of the system was that data from patients who were in the ICU for less than two days were required. This was considered to be inefficient, as the data collected from these patients would not be analysed. The initial decision to include these patients was taken as an attempt to simplify data collection. It is likely that further development of Ward Watcher could facilitate the requirement to collect data only for those patients who have a stay of more than two days.

Sites have also requested that Ward Watcher should offer an export facility for their data locally (as it does for other data items collated by the system). It is the intention that data would be made easily accessible to participants. Ownership of and access to data locally is a key component of any HAI surveillance programme.

6.2.3 Data quality

6.2.3(a) Missing data

Only 3% of all data items were “not recorded” with Glasgow Coma Score estimated and Glasgow Coma Score measured being those data items most often not recorded.

Three anomalous dates were identified and with regard to data accuracy, a future validation exercise would be required to ensure data quality and accuracy. Validation of data collected for any surveillance programme should be carried out in order that participants in the programme feel confident that the data are accurate.

Where possible Ward Watcher should be refined to support full compliance with infection data definitions to ensure that data are robust. HPS will also develop a more detailed resource pack to support staff carrying out surveillance and a training programme to emphasis the importance of the definitions to facilitate comparisons and ensure robust data set for the future.

6.2.3(b) Infection details data

There appeared to be some lack of clarity as to when infections should be recorded and what constituted an episode. Thus, duplicate reporting of infections was noted, this in part reflected a lack of clarity as to when infections should be reported, and difficulties in determining whether new episodes had occurred and duplicate reporting of an infection when new microbiology data became available. HELICS have also

reported such problems and thus this is not a difficulty with the Ward Watcher system, however refinement of Ward Watcher may assist in a resolution to this.

Recently, HELICS have applied a set of arbitrary rules to recalculate infection episodes. The definition provided by HELICS for a new episode of infection lacks detail and the difficulty encountered with this definition will be communicated to HELICS. In the absence of a clear definition for an episode of infection, possible solutions would be better training and resources, and application of agreed criteria to "clean" data.

6.2.4 The applicability of the HELICS methodology for surveillance of ICUAI Scotland.

The application of the HELICS criteria for BSI and pneumonia is feasible with the current diagnostic practices carried out in Scotland. The criteria for pneumonia have been adapted to permit diagnosis of pneumonia without the need for chest x-rays. The decision to adapt this definition was made in response to concerns that some units would not be able to fulfil the existing criteria. This adaptation would not affect the integrity of the data for export to HELICS as units using chest x-ray criteria would record this and only infection records fulfilling the HELICS criteria be contributed to the European database. Any comparisons of rates would be only made with other institutions carrying out the same practices.

It has been noted from the information supplied by microbiologists at several sites that their current laboratory practice does not facilitate the requirement for diagnosis of Local CVC Related Infection (CVCRI-1) or General CVC Related Infection (CVCRI-2) as specified in the HELICS protocol. Therefore, some units in Scotland may be unable to carry out surveillance of CVCRI and this may need to be an option rather than a requirement of participation in the programme.

6.2.5 Resources

6.2.5(a) Hospital Level

Feedback from pilot sites indicate that the workload was minimal, with the most efficient pilot sites putting in place a system whereby infections were discussed as part of a multidisciplinary discussion e.g. ward round. The additional time required to collate the information required was acceptable and could be achieved at current staffing levels at most units.

6.2.5(b) Resources required by SIGSAG

Currently, a member of SICSAG staff must physically visit each unit to export the data. With SICSAG current staff resource levels, this would not be sustainable with more than five units.

Export of the data for the pilot was time-consuming, however a programme within to export the data should reduce the time required. Should the programme be rolled out throughout Scotland, additional resources would be required.

6.2.5(c) Resources/Staff required by HPS for the surveillance programme

Should the surveillance programme be made available to all Scottish ICUs, there would be resource implications for the SSHAIP team at HPS. Data management support would be required in terms of managing receipt of data, importing and recoding data for analysis, quality checking data and maintenance of systems for data management and reporting. The level resource would depend on the level of surveillance e.g. continuous or non-continuous surveillance undertaken by the units, the number participating etc.

Scientific support to lead and manage the programme is available. The role would include project management, training, analysis and reporting of data.

6.2.6 Antibiotic data

Collection of the DDD data from some hospitals revealed some challenges relating to the format of these data. However, the problems were overcome and it is anticipated that the data required could be collected in the future. Executive guidance has given reporting of antibiotic usage a much higher priority at a national level, thus, there should be an improvement in the availability and quality of data (Scottish Executive, 2002).

The caveat associated with these data is that they take no account of drugs that may be issued to a unit but are not used. However, the advantages of collecting data at this level rather than patient level are huge, particularly in terms of the resources required.

The antibiotic use data generated from the ICUs demonstrates the variation in antibiotic usage between hospitals. This is likely to reflect local policies and the resistance/sensitivity patterns of organisms causing infections in individual hospitals or units. These data could be used alongside antimicrobial resistance data from organisms causing infection in the ICU to better understand the epidemiology of antimicrobial resistance in the ICU.

In order to utilise these antibiotic data fully, HPS would require that data relating to antimicrobial resistance be collected for organisms causing infection in the ICU. HPS propose that the most straightforward way to collect these data may be directly from microbiology staff at hospitals participating in surveillance.

The data suggest that collation of DDD from a three month period is representative of the whole year, however if possible, it may be more desirable to collate data by month by unit in order to achieve maximum use of data and to account for variation in use of antibiotics at different times of year.

7. Conclusions and Recommendations

Surveillance of ICUAI in Scotland using Ward Watcher for data collection and the HELICS definitions for infection is a feasible process with a minimal requirement for additional staff resources.

It is recommended that Ward Watcher be further refined to facilitate accurate and simple data collection. These refinements would be required prior to roll out of this programme and financial support would be necessary to fund the software updates required.

Voluntary sites would collect data only from patients with a length of stay of more than 2 days, for an agreed minimum period of six months. In order to obtain sufficient data, a minimum surveillance period of six months is recommended (HELICS, 2004). Surveillance would include pneumonia, blood stream infections and CVC related blood stream infections. Local and General CVC related infections would be offered as an option for those sites with the diagnostic capability.

Ward Watcher would be the recommended means of data collection for those not carrying out enhanced surveillance. Sites wishing to undertake enhanced surveillance would be invited to share their data with HPS for contribution to the HELICS data set for ICU. Staff at HPS would provide support in terms of the protocol and interpretation of definitions, whilst data collection systems would be determined locally and local support to operate these systems would be required.

Collection of data relating to microbiology and antimicrobial resistance should be expanded. Expanded data collection is likely to involve both refinements to Ward Watcher and requests for data from microbiologists directly.

Experiences with the methodology should be communicated to HELICS to inform refinement of their protocol.

8. Acknowledgements

The working group are grateful to all staff at the pilot sites for their co-operation with this study and to the pharmacists throughout Scotland who contributed to the antibiotic usage data.

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APPENDIX I

Data items required for ICU Surveillance

Data	Item Definition	Location within Ward Watcher	Data Item within Ward Watcher
Patient ID	**Unique patient code**	Admission and Identity Data	**Key**
Date ICU Admission	**Date of admission to the ICU**	Admission and Identity Data	**Date admitted to the unit**
Discharge Date from ICU	**Date of discharge from ICU**	Unit Discharge Details	Discharged on
Discharge Status	**Status at discharge from ICU:** Alive on discharge Died in ICU	Unit Discharge Details	Extracted from: Reason Discharged and Died on Date
Gender	**Gender of Patient**	Admission and Identity Data	Sex
Age	**Age in Years**	Admission and Identity Data	Extracted from Date Admitted and Date of Birth
Patient Origin	**Ward in this/other hospital** **Other ICU** **Community:** Patient came from home, via emergency or not. **Long term care/nursing home**	Admission and Identity	Admitted from
Admission date in the hospital	**Date of admission in the hospital**	Admission and Identity Data	Date admitted to this hospital
SAPS II score on admission	**Simplified Acute Physiology Score at admission**	Severity of Illness	
APACHE II score on admission	**Acute Physiology, Age, Chronic Health Evaluation score**	Severity of Illness	
Type of admission	**Medical** No surgery within 1 week of admission to ICU **Scheduled surgical** Surgery was scheduled at least 24 hours in advance +/- 7 days ICU admission **Unscheduled surgical** Patients added to the operating room schedule within 24 hours of the operation)	Diagnoses/History (Nature of surgery and Surgery in 7 days prior to admission)	
Trauma	**Trauma:** ICU admission resulting from blunt or penetrating traumatic injury to the patient, with or without surgical intervention	Diagnoses	Apache diagnosis-"system failing"
Impaired immunity	**Impaired Immunity:** <500 PMN/mm3 (<0.5 x 10^9PMN per litre), due to treatment (chemotherapy, radiotherapy, Diagnosis immune suppression, corticosteroids long duration or high doses recently) or due to disease (leukaemia, lymphoma, AIDS). [Apache II definition]	Diagnosis	SICS diagnosis coding Severity of Illness Blood Tests
Antimicrobial treatment within 48 h around admission (<>48h)	**"Yes"** - if any antibiotic therapy in the 48 hours *preceding* ICU admission (Antibiotic therapy for an infectious event around ICU admission. Exclude antifungal and antiviral treatment) has been given; ***This does NOT include:*** *Antimicrobial prophylaxis* *Selective Digestive Decontamination* *Local treatment*	Hospital Acquired infection - Surveillance	Antimicrobials around critical care admission: Antimicrobials in 48 hours prior to admission in critical care

Data	Item Definition	Location within Ward Watcher	Data Item within Ward Watcher
Acute coronary care	All acute non-surgical cardiac disease. Larger than coronary suffering. E.g. acute heart failure without acute coronary symptoms as well. (Included for use in the pneumonia/BSI risk score)	Hospital Acquired infection-Surveillance	Acute Care Admission
Surgery in 30 days before admission	Y:if the patient had surgery in the last 30 days before ICU admission including the day of admission, and if so, specify the surgery site: Coronary surgery Other cardiac Other thoracic Other vascular Neurosurgery Other surgery 2 variables provided for 2 possible sites	Hospital Acquired infection-Surveillance for 2 possible sites	Surgery in the 30 days prior to this critical care admission (Y/N) Surgical Site 1 Surgical Site 2
Glasgow coma score, estimated	Use the lowest value in first 24 hours; record both the "original"=estimated GCS, i.e. if the patient is sedated, record the estimated Glasgow Coma Score before sedation (=component of both SAPS II and APACHE II score)	Severity of Illness Neurological Function	
Glasgow coma score, measured	The "measured" GCS, i.e. if the patient is sedated, record measured status at that moment		Severity of Illness
Date in ICU	Day in the ICU for which daily exposure data are recorded		HAI Daily Details
ICU Exposure	**CVC=Central venous catheters:** Specify whether >=1 CVC was present in this patient on that day; CVC = vascular access device that terminates at or close to the heart or one of the great vessels; excluded: arterial catheters, external pacemaker, implanted chambers; included: v. subclavia, v. jugularis, v. basilica, v. cephalica, v. femoralis, v.umbilicalis, other veins, dialysis catheters, Swann-Ganz.	ACP Details	
	INT=Intubation: Patient has oro-tracheal or naso-tracheal intubation or tracheotomy , even if intermittent during the day (1 hour is counted as 1 day)	ACP Details	
	UC=Urinary catheter: Urinary catheter use: Suprapubic catheters are included Iterative urinary catheterisation excluded (e.g. for urinary sampling or in case of urine retention)	HAI Daily Details	
	NIT=Naso-oro intestinal tube without feeding in ICU: Specify whether patient had a naso-oro intestinal tube without feeding in the ICU	ACP Details/HAI Daily Details	Extracted from: ACP Details -Nutrition -Enteral Nutrition HAI Daily Details -Naso or Oro Gastric tube *in situ*
	FNIT=Naso-oro intestinal tube with feeding in ICU: Specify whether patient had a naso-oro intestinal tube with feeding in the ICU	ACP Details/HAI Daily Details	Extracted from: ACP Details -Nutrition -Enteral Nutrition HAI Daily Details - Naso or Oro Gastric tube *in situ*)

Data	Item Definition	Location within Ward Watcher	Data Item within Ward Watcher
	PN=Parenteral nutrition in ICU: Specify whether patient had parenteral nutrition in the ICU =patient receives minimum 2 nutritional elements via perfusion (2 out of 3: proteins, fats and sugars)	ACP Details	Nutrition -Parenteral Nutrition
`	**NIV=Non-invasive mechanical ventilation:** Patient is ventilated (any form of mechanical respiratory assistance of inspiration and/or expiration) without intubation e.g. Bi Level Positive Airway Pressures (BiPAP) and Continuous Positive Airway Pressure (CAPAP).	ACP Details	Respiratory Management
	VEN=Invasive mechanical ventilation: Patient is ventilated (any form of mechanical respiratory assistance of inspiration and/or expiration) with intubation. Includes tracheostomy and ETT	ACP Details	Respiratory Management
	REINT=Re-intubation: Patient was extubated and re-intubated on that day (at least once)	HAI Daily Details	Re-intubated on this day
Infection Date	Date onset infection (date of sample if appropriate);	HAI Daily Details	Date
Infection Site	PN1-5; BSI-A/B; CRI1-3 Categories assigned by Ward Watcher in compliance with the HELICS definitions.	HAI Daily Details Infection Details	
Micro-organism 1	Select organism from group and organism list If no micro-organism is available, specify either: -Micro-organism not identified or not found -Examination not done -Sterile examination	HAI Daily Details Infection Details	
Antimicrobial resistance1	Required: Oxacillin resistance in *S. aureus*	HAI Daily Details Infection Details	
Invasive device in 48 hours preceding infection	Presence of ventilator Presence of central venous catheter Presence of urinary catheter	ACP ACP HAI Daily Details	
Antimicrobial Treatment	*Patient received antimicrobial treatment for this infection (incl. antiviral and antifungal treatment);*	*HAI Daily Details*	*Antibiotic/antifungal/for this antivirals administered*

Appendix II

Case definitions of ICU-acquired infections

II(a) CASE DEFINITION OF BLOODSTREAM INFECTION

CODE: BSI

BSI-A:

- 1 positive blood culture for a *recognised pathogen*

OR

- Patient has *at least one* of the following signs or symptoms: fever (>38°C.), chills, or hypotension

AND

- 2 positive blood cultures for a common skin contaminant (from 2 separate blood samples drawn within 48 hours).

  Skin contaminants:

  Coagulase-negative staphylococci
  Micrococcus spp.
  Propionibacterium acnes
  Bacillus spp.
  Corynebacterium spp.

BSI-B:

- Patient has *at least one* of the following signs or symptoms: fever (>38°C), chills, or hypotension

AND EITHER

- 1 positive blood culture with a skin contaminant in patient with an intravascular line in place and in whom the physician instituted appropriate antimicrobial therapy.

OR

- Positive blood antigen test :

  Haemophilus influenzae
  Streptococcus pneumoniae
  Neisseria meningitidis
  Group B *Streptococcus*

II(b) CASE DEFINITION OF PNEUMONIA

CODE: PN

X-Ray

Two or more serial chest X-rays or CT-scans with a suggestive image of pneumonia for patients with underlying cardiac or pulmonary disease. In patients without underlying cardiac or pulmonary disease one definitive chest X-ray or CT-scan is sufficient.

Note: This definition has been adapted for use in the UK, CXRs are not required to make the diagnosis of a pneumonia, for surveillance purposes.

***AND at least one** of the following*

Symptoms

- Fever > 38 °C with no other cause
- Leukopenia (<4000 WBC/mm^3) or leucocytosis (³ 12 000 WBC/mm^3)

***AND at least one** of the following*
***OR at least two** of the following if clinical pneumonia only [PN 4 and PN 5]*

- New onset of purulent sputum, or change in character of sputum (color, odor, quantity, consistency)
- Cough or dyspnea or tachypnea
- Suggestive auscultation (rales or bronchial breath sounds), ronchi, wheezing
- Worsening gas exchange (e.g. O_2 desaturation or increased oxygen requirements or increased ventilation demand)

AND according to the used diagnostic method

Microbiology

a – Bacteriologic diagnostic performed by :

Positive quantitative culture from minimally contaminated LRT[1] specimen **(PN 1)**

- Broncho-alveolar lavage (BAL) with a threshold of > 10^4 CFU[2] /ml or ³ 5 % of BAL obtained cells contain intracellular bacteria on
  direct microscopic exam (classified on the diagnostic category BAL).
- Protected brush (PB Wimberley) with a threshold of >10^3 CFU/ml
- Distal protected aspirate (DPA) with a threshold of > 10^3 CFU/ml

Positive quantitative culture from possibly contaminated LRT specimen **(PN 2)**

- Quantitative culture of LRT specimen (e.g. endotracheal aspirate) with a threshold of 10^6 CFU/ml

b – Alternative microbiology methods **(PN 3)**

- Positive blood culture not related to another source of infection
- Positive growth in culture of pleural fluid
- Pleural or pulmonary abscess with positive needle aspiration
- Histologic pulmonary exam shows evidence of pneumonia
- Positive exams for pneumonia with virus or particular germs (*Legionella*, *Aspergillus*, mycobacteria, mycoplasma, *Pneumocystis carinii*)
  - Positive detection of viral antigen or antibody from respiratory secretions (e.g., EIA, FAMA, shell vial assay, PCR)
  - Positive direct exam or positive culture from bronchial secretions or tissue
  - Seroconversion (ex : influenza viruses, *Legionella, Chlamydia*)
  - Detection of antigens in urine (*Legionella)*

c – Others

- Positive **sputum** culture **or non-quantitative LRT specimen** culture **(PN 4)**
- **No positive microbiology** **(PN 5)**

Note: PN 1 and PN 2 criteria were validated without previous antimicrobial therapy

Comment: The subdivision of the pneumonia definition in five categories allows for the comparison of similar entities of pneumonia. *It is essential that PN4 and PN5 (clinical pneumonia without microbiological evidence) are reported in order to achieve overall comparability, even if a microbiological exam was performed and yielded negative results.* It is also advised, both for clinical and surveillance purposes, that microbiological confirmation (PN1-3) is promoted as a routine practice in the ICU.

[1] LRT + Lower Respiratory Tract
[2] CFT + Colony Forming Units

II(c) Case DEFINITION OF CVC-RELATED INFECTION

CODE: CRI

A central venous catheter-related infection relies on:

CRI1: Local CVC-related infection (no positive blood culture)

- Quantitative CVC culture ³ 10^3 CFU/ml or semi-quantitative CVC culture > 15 CFU

AND

- pus/inflammation at the insertion site or tunnel

CRI2: General CVC-related infection (no positive blood culture)

- Quantitative CVC culture ³ 10^3 CFU/ml or semi-quantitative CVC culture > 15 CFU

AND

- clinical signs improve within 48 hours after catheter removal

CRI3: CVC-related BSI

- BSI occurring **48** hours before or after catheter removal

AND positive culture with the same micro-organism of **EITHER**:

- Quantitative CVC culture > 10^3 CFU/ml or semi-quantitative CVC culture > 15 CFU
- Quantitative blood culture ratio CVC blood sample/peripheral blood sample> 5 [1]
- Differential delay of positivity of blood cultures[2]: CVC blood sample culture positive 2 hours or less before peripheral blood culture (blood samples drawn at the same time)
- Positive culture with the same micro-organism from pus from insertion site

ICU-acquired:
An infection is considered as ICU-acquired if it occurs later than 48 hours following admission to the ICU. However, details of all infections occurring in the ICU should be are reported irrespective of when they occur. HPS will report only those infections occurring 48 hours after admission to the ICU to be acquired in the ICU.

Second infection episode:
The combination of 1) new signs and symptoms AND 2) radiographic evidence (for pneumonia) OR other diagnostic testing is required.

[1] LRT + Lower Respiratory Tract
[2] CFT + Colony Forming Units

Appendix III

Antibiotics and Antifungals for which Defined Daily Dose Data were collated

ANTIBIOTICS

- **Penicillins**
  - Penicillin
  - Flucloxacillin
  - Amoxicillin
  - Co-amoxiclav
  - Tazocin
- **Cephalosporins**
  - Cefotaxime
  - Ceftriaxone
  - Ceftazidime
  - Cefuroxime
  - Other
- **Carbapenems**
- **Tetracyclines**
- **Aminoglycosides**
- **Macrolides**
- **Clindamycin**
- **Anti-Staph**
  - Chloramphenicol
  - Fusidate
  - Vancomycin
  - Teicoplanin
  - Linezolid
  - Synercid
  - Colistin
- **Sulphonamides**
  - Co-trimoxazole
  - Trimethoprim
- **Anti-TB**
  - Rifampicin
  - Other
- **Metronidazole**
- **Quinolones**
  - Ciprofloxacin
  - Other
- **Nitrofurantoin**
- **Other**

ANTIFUNGALS

- Amphotericin
- Caspofungin
- Fluconazole
- Flucytosine
- Itraconazole
- Voriconazole

Appendix IV

Surveillance of ICUAI Working Group Members

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