Infections acquired in intensive care units: results of national surveillance in Belgium, 1997–2010

K. Mertens*, I. Morales, B. Catry

Scientific Institute of Public Health, Brussels, Belgium

SUMMARY

Background and aim: To describe the methodology and output of the Belgian surveillance for infections acquired in intensive care units (ICUs) between 1997 and 2010.

Methods: Since 1997, ICUs in acute care hospitals in Belgium have been encouraged by federal law to participate in a national multi-centre prospective observational surveillance programme. A protocol and software tool for data collection was developed, and the case definitions and methodology follow those of the European Centre for Disease Prevention and Control.

Findings: For 2010, 18 hospitals provided data on 59 observation quarters, 6478 ICU patients and 52,593 ICU patient-days. The mean incidence rates of ICU-acquired pneumonia and intubation-associated pneumonia were 13 per 1000 patient-days and 12 per 1000 intubation-days, respectively. The mean incidence rates of ICU-acquired bloodstream infections, central vascular catheter (CVC)-associated bloodstream infections and CVC-associated primary bloodstream infections were 3.2 per 1000 patient-days, 2.6 per 1000 catheter-days and 2.3 per 1000 catheter-days, respectively. Between 1997 and 2010, stable trends in ICU-acquired pneumonia and bloodstream infections were observed, together with decreasing trends for intubation-associated pneumonia and CVC-associated bloodstream infections, and a stable trend for CVC-associated primary bloodstream infections.

Conclusions: In Belgium, national surveillance of ICU-acquired infections allows acute care hospitals to track the incidence of infections at local level, enabling comparison with national and European reference data. Between 1997 and 2010, the incidence of ICU-acquired infections increased and the incidence of device-associated infections decreased.

© 2013 The Healthcare Infection Society. Published by Elsevier Ltd. All rights reserved.

Introduction

The risk of acquiring a healthcare-associated infection (HAI) is higher in intensive care units (ICUs) than other hospital wards due to the patients’ severe underlying health conditions, and increased exposure to medical interventions and invasive devices.1–3 The association of infection with morbidity and mortality in ICUs is also substantially higher compared with other wards.4 Surveillance of HAIs is defined as continuous and systematic collection, analysis and interpretation of data on the occurrence of these infections, their risk factors and outcome parameters. Surveillance is widely acknowledged as a valuable component in a strategy for the prevention and control of HAIs.5–7 This paper aims to describe...
the methodology and output of the Belgian surveillance for bloodstream infections and pneumonia in ICUs between 1997 and 2010.

**Materials and methods**

**Legal context**

The protocol for the national surveillance of ICU-acquired infections was developed in 1997 by the National Programme of Healthcare-associated Infections (NSIH) of the Scientific Institute of Public Health in close collaboration with the Belgian Society of Internal Medicine, and launched with a financial incentive to encourage participation. In 2004, the protocol was modified according to the European project ‘Hospitals in Europe Link for Infection Control through Surveillance’ (HELICS).8

Since 2007, Belgian surveillance of HAI’s has been encouraged by federal law, and includes, as well as the surveillance of ICU-acquired infections, seven other HAI surveillance protocols. The objective of national surveillance is: (1) to provide the necessary standards, definitions and tools for the organization of surveillance and the follow-up of results within the healthcare setting (local objective); and (2) to set up a national database of surveillance data (national objective). This enables participating hospitals or wards to compare their results with those from the national population (benchmarking), and allows national stakeholders (Belgian Antibiotic Policy Coordination Committee) to monitor national trends.9

**Data collection**

Collection of infection data is performed prospectively and over a minimum observation period of three months. Relevant infections are pneumonia, bloodstream infections, urinary tract infections and catheter-related infections. An infection is defined as an ICU-acquired infection when it occurs at least two days after admission to an ICU. Infections occurring after discharge from an ICU are excluded as organizing this type of surveillance is extremely time consuming. Device-associated infections are defined as cases with a relevant invasive device in situ during the two days preceding the onset of infection, with relevant devices being endotracheal intubation for pneumonia and central vascular catheters (CVCs) for bloodstream infections. For bloodstream infections, the origin of the infection (unknown, catheter, secondary) is encoded, thus allowing calculation of the number of primary bloodstream infections (catheter or unknown origin). Case definitions are those implemented in 2004 by the HELICS project, and subsequently adopted by the European Centre of Disease Prevention and Control (ECDC) in 2007.

Surveillance data also include denominators that can be collected in two ways. In the light version of the protocol, aggregated denominators such as patients admitted and patient-days are specified directly, whereas in the standard version, they are calculated through data on each individual patient staying in the ICU for more than two days (for whom risk factors and outcome variables at admission, during hospital stay and at discharge are recorded, irrespective of development of an infection). All surveillance data entry is performed by means of the locally installed NSIHwin software, which was developed by the NSIH programme, is updated regularly and is freely available to participants.

**Output variables and analysis**

Both the light and standard versions of the protocol allow calculation of the cumulative incidence (number of newly infected patients out of the total number of patients) and the incidence density (number of new infections per 1000 patient-days) for each infection type, as well as the incidence densities of intubation-associated pneumonia per 1000 intubation-days, CVC-associated bloodstream infections per 1000 CVC-days, and CVC-associated primary bloodstream infections per 1000 CVC-days. The standard version of the protocol allows finer adjustment of the incidence of infection for the case mix of the ICU population and the degree of usage of invasive devices. In this paper, indicators for the incidence of infection, mean length of ICU stay and use of invasive devices have been aggregated nationally and annually using the annual pooled database mean. Participating hospitals receive a confidential feedback report shortly after sending their data to the NSIH programme.

**Cohort analysis**

In order to analyse the evolution of particular indicators within a stable group of hospitals, a cohort of hospitals that participated in at least half of all surveillance periods was established. A trend analysis was performed on the database mean of the incidence density for each type of infection, and using a logistic regression model for the linear (on the logarithmic scale) trend of the daily odds of infection on patient- or device-day-discretized data, using year as a single ordinal predictor. To correct for variability in the incidence of infection between hospitals, separate models were fitted for the hospital mean, including a cluster effect on the hospital, and fit by the generalized estimating equations technique.10 Similar trend analyses were performed on the mean length of ICU stay using linear regression, and for the daily odds of invasive device use (intubation and CVCs) using logistic regression. Each model’s coefficient for the annual trend was recalculated to represent the change for the whole period (1997–2010).

All data were analysed using STATA (StataCorp LP, College Station, TX, USA).

**Results**

In total, 18 acute care hospitals participated in the NSIH-ICU surveillance in 2010, encompassing 59 observation quarters, 6478 ICU patients, 52,593 ICU patient-days, 12,792 intubation-days and 24,763 CVC-days. Although participation has decreased steadily since 1998, the number of surveillance periods illustrates relatively intense or continuous monitoring by participating units (Figure 1). Participation denotes the number of hospitals, with several hospitals including data for more than one ICU (data not shown).

Figure 2 shows the annual evolution of mean length of ICU stay, use of invasive intubation and use of CVCs. The mean length of ICU stay increased substantially over the years, from 6.5 days in 1997 to 8.1 days in 2010. A relatively stable trend was seen for use of invasive intubation, from 318 to 389 days
per 1000 patient-days between 1997 and 2010. For CVC use, a decreasing trend from 742 to 615 CVC-days per 1000 patient-days was seen between 1997 and 2001, and a steady increase occurred afterwards to reach 751 CVC-days per 1000 patient-days in 2010.

In 2010, the mean cumulative incidence of ICU-acquired pneumonia was 8.5% and the mean incidence density was 13 per 1000 patient-days. There were 12 cases of intubation-associated pneumonia per 1000 intubation-days. The long-term evolution for the incidence of pneumonia (Figure 3) suggests a stable trend in ICU-acquired pneumonia, with incidence rates ranging between 7 and 15 per 1000 patient-days. For the incidence of intubation-associated pneumonia, a substantial decrease was seen from 27 (in 1997) to 12 (in 2010) per 1000 intubation-days.

The mean cumulative incidence of ICU-acquired bloodstream infections in 2010 was 2.5%, and the mean incidence density was 3.2 per 1000 patient-days. There were 2.6 CVC-associated bloodstream infections per 1000 CVC-days, and 2.3 CVC-associated primary bloodstream infections per 1000 CVC-days. Figure 4 shows stable long-term evolution of ICU-acquired bloodstream infections in the range of 2–4 per 1000 patient-days. The evolution of the incidence of catheter-associated bloodstream infections suggests a decreasing trend from 4.7 (1997) to 2.6 (2010) per 1000 CVC-days. A lesser decreasing trend was seen among CVC-associated primary bloodstream infections, from 3.0 (1997) to 2.3 (2010) per 1000 CVC-days.

For both intubation-associated pneumonia and catheter-associated bloodstream infections, a low point in incidence (especially median) was reached directly after the introduction of the new HELICS case definitions in 2004. During a transient period, missing data were seen for the new variable ‘invasive device use’ upon which the definition of intubation or catheter association was based (data not shown), and which could explain this lower incidence.

Twenty-two hospitals participated for at least eight years between 1997 and 2010. Hospital types were similar to the national distribution, with 85% general, 10% teaching and 5% university hospitals. Annually, this cohort contributed between 5000 and 7000 ICU admissions with at least two days of ICU stay, and between 30,000 and 50,000 corresponding patient-days in the ICU. On average, hospitals in this cohort contributed data for at least three observation quarters per year of participation. Table I shows the results of the trend analysis. The mean length of ICU stay shows a steady annual...
increase, with a total increase of 1.8 days for the entire period. The use of invasive intubation in the cohort showed a 9% decrease in odds, while CVC use showed a 20% increase in odds for the whole period. The evolution of mean infection rate of the cohort is largely in line with those of the total group of participants, with a 50% increase from 1997 to 2010 for ICU-acquired pneumonia, a 30% increase for bloodstream infections, a 37% decrease for intubation-associated pneumonia, a 22% decrease for CVC-associated bloodstream infections, and a stable trend for CVC-associated primary bloodstream infections (10% increase). These periodic trends were similar in the models for database mean and hospital mean. However, as the cohort had substantial variability in rates across hospitals, none of the periodic trends for the hospital mean (except mean length of ICU stay) achieved statistical significance.

Discussion

Over the last 20 years, many European countries have implemented regional or national surveillance of ICU-acquired infections. Most of these networks use a standardized protocol that was derived or adapted from the HELICS methodology. As results are reported annually to the ECDC, the epidemiological reports allow valid comparisons between networks as well as against a European reference. The incidence of pneumonia as estimated by the Belgian NSIH-ICU surveillance is higher than the overall European estimates for 2009, with 7.1% ICU patients with pneumonia, and incidence rates for ICU-acquired pneumonia and intubation-associated pneumonia of 7.8 and 14.5 per 1000 intubation-days, respectively. Belgium has a relatively low average length of ICU stay (in 2009: 7.8 days in Belgium vs 10.4 for Europe), and a low rate of invasive intubation (37.4 per 100 patient-days in Belgium vs 54.9 for Europe).

The incidence of ICU-acquired pneumonia and bloodstream infections underwent a slight increasing trend between 1997 and 2010, but over this period, the mean length of stay of patients that were followed for this surveillance increased substantially. The incidence of both intubation-associated pneumonia and CVC-associated bloodstream infection, often the focus of targeted infection prevention programmes, showed a decreasing trend over the years. For pneumonia, this was accompanied by a decrease in the use of intubation over the years, while for bloodstream infections, increased use of catheterization was seen. The incidence of CVC-associated primary bloodstream infections [excluding infections of secondary origin, and therefore focusing on the (most) preventable fraction] showed a decreasing trend in the overall group of
participants, but this was not seen in the cohort of hospitals that participated most frequently.

While interpreting these results, the following points need to be taken into account. Firstly, participation in the NSIH-ICU surveillance has decreased over the years, and this may influence the interpretation of national incidence rates as data may have been contributed by a potentially selective subset of hospitals. One reason for this decline in participation is the increased number of hospital mergers, which has lowered the number of eligible acute care hospitals over the years. To illustrate this, when national surveillance commenced in 1997, 170 hospitals were eligible for participation; this was reduced to 116 hospitals in 2011. Simultaneously, since 1997, other surveillance requirements have been added to the list of national surveillance programmes. Annual participation in the surveillance of both meticillin-resistant *Staphylococcus aureus* and *Clostridium difficile* became mandatory, thereby prioritizing these over other national programmes such as ICU surveillance. Other factors such as the availability of local systems and pressure from consumer organizations to force public disclosure may also have resulted in lower participation. The limited but steady number of participants should be interpreted positively, as hospitals participating under an optional regime are likely to be more motivated compared with the previous situation when surveillance was mandatory in certain regions of the country.

Secondly, the overall evolution of the incidence of infection among the total group of hospitals was confirmed in the cohort of hospitals that participated in at least half of all surveillance periods. However, while such cohort analysis does not suffer from biases due to hospitals with infrequent participation and contributing extreme incidence rates, it remains driven by the limited number of hospitals that participated in recent years.

Thirdly, the relevant percentiles (25th, 50th, 75th) of the annual national distribution of hospital means for each indicator were not presented, but showed substantial variation in annual rates between hospitals. This is confirmed by the trend analysis of the cohort data, where none of the significant

![Graph](image)

**Figure 4.** Evolution of the incidence of intensive care unit (ICU)-acquired bloodstream infections (●), central vascular catheter (CVC)-associated bloodstream infections (○) and CVC-associated primary bloodstream infections (△) in Belgium. Source: National Surveillance of Healthcare-associated Infections.

### Table I

<table>
<thead>
<tr>
<th>Trends of incidence of hospital-acquired infections, device-associated infections, mean length of stay and use of invasive devices in intensive care units in Belgium, 1997–2010</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pooled mean</strong></td>
</tr>
<tr>
<td>Me/OR (95% CI)</td>
</tr>
<tr>
<td>Length of stay (mean days)</td>
</tr>
<tr>
<td>Invasive device use (daily odds)</td>
</tr>
<tr>
<td>Intubation</td>
</tr>
<tr>
<td>CVC</td>
</tr>
<tr>
<td>Pneumonia (daily odds)</td>
</tr>
<tr>
<td>ICU-acquired</td>
</tr>
<tr>
<td>Intubation-associated</td>
</tr>
<tr>
<td>Bloodstream infections (daily odds)</td>
</tr>
<tr>
<td>ICU-acquired</td>
</tr>
<tr>
<td>CVC-associated</td>
</tr>
<tr>
<td>CVC-associated primary</td>
</tr>
</tbody>
</table>

*Me/OR*, mean increase in length of stay for the whole period in days/odds for device use or infection ratio for all other indicators; CI, confidence interval, type I error level (*P*-value) of null hypothesis test of trend coefficient; ICU, intensive care unit; intubation, endotracheal intubation; CVC, central vascular catheter.

Results derived from a cohort (22 acute care hospitals) analysis on data from the national surveillance of ICU-acquired infections in Belgium, Scientific Institute for Public Health 2012.
trends in the pooled national means were confirmed by analysis of the hospital means. Such variation is also informative for further improvement in the prevention of hospital-acquired infections in a multi-centre context.

Hospitals participate in the underlying surveillance project to decrease infection rates. However, looking at the trends presented in this article, this objective is only partly fulfilled. When trying to evaluate the added value of national surveillance, the following points need to be made. First, the evidence surrounding the hypothesis that 'surveillance reduces infection rates' defines surveillance as periodic monitoring accompanied by discussion and interpretation of the results. The national surveillance project in itself only guarantees the first part of this process, because no information was collected on how participants used the collected data internally. Second, improved case finding as well as variation in case mix may have influenced the observed trends. Third, evaluation of the long-term impact of a national surveillance programme should not only be based on the change in rates of the targeted infection types, but equally on the impact of these infections on mortality and morbidity outcomes. Fourth, analysis of the group of participating hospitals does not constitute a correct impact assessment as a proper control group is lacking. None of the mentioned points were the objective of this study.

In summary, acute care hospitals in Belgium are encouraged to participate in national surveillance. Standardized tools allow the incidence of ICU-acquired infections to be tracked at local level, and enable hospital data to be compared with national and European reference data. Between 1997 and 2010, a stable trend in the incidence of ICU-acquired infection and a decreasing trend in the incidence of device-associated infection were seen for the total group of participating hospitals.

Acknowledgements

The authors wish to thank Dr Carl Suetens, the participating hospitals and their dedicated healthcare workers.

Conflict of interest statement
None declared.

Funding source
This study was funded by the Federal Public Service Health, Food Chain Safety and Environment.

References


