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Original article

INDICATORS OF INTENSIVE CARE UNIT-ACQUIRED INFECTIONS AND MORTALITY: TRENDS IN FIVE ICUs IN CATANIA

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Summary

Background: Hospital-acquired infections (HAIs) pose a significant clinical and economic burden worldwide. Surveillance has been associated with a reduction of HAI rates in Intensive Care Unit (ICU) patients, although the particular reasons for this decrease are still difficult to determine. The present study was conducted in order to report HAI surveillance data during an eight-year period in five ICUs in Catania.

Methods: A patient-based HAI surveillance was conducted in the framework of the first four surveys of the Italian Nosocomial Infections Surveillance in ICUs network (SPIN-UTI) of the GISIO-SItI. Each survey consisted in a six-months surveillance conducted in: 2006-2007; 2008-2009; 2010-2011 and 2012-2013. During the study period, HAI cumulative incidence, incidence density and mortality were calculated overall and for each survey.

Findings: From 2006 to 2013, a total of 2070 patients were admitted in the five participating ICUs and were included in the study. The cumulative incidences of infected patients in each survey were: 13.3, 17.0, 18.9 and 8.9 *per* 100 patients, respectively. Accordingly, the risk of ICU-acquired infections increased in the third survey compared with the first (RR: 1.43; 95%CI: 1.06-1.92) but it decreased in the fourth survey compared with the second (RR: 0.64; 95%CI: 0.47-0.86) and the third (RR: 0.57; 95%CI: 0.43-0.76). A similar trend was observed considering incidence of infections and incidence density. Although mortality did not show a significant trend between the four surveys, the risk of death increased for infected patients.

Conclusions: The patient-based cohort design allowed us to analyze HAI indicators during an eight-years period, in five ICUs in Catania. Particularly, the risk of ICU-acquired infections increased in the third survey compared with the first, whereas it decreased in the fourth survey compared with the second and the third surveys. Furthermore, mortality remained unchanged, however the risk of death significantly increased for infected patients, in each survey. Surveillance data are useful to support policymakers and leaders to make evidence-based decisions in the healthcare setting, to plan and improve programs, services and interventions for preventing, managing and treating HAIs.

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Introduction

Hospital-acquired infections (HAIs) are one of the most common complications of hospitalization leading to increased morbidity and mortality and economic burden all over the world. The most frequently reported HAIs in Intensive Care Unit (ICU) are ventilator-associated pneumonia (VAP), catheter-related bloodstream infection (CR-BSI), and catheter-associated urinary tract infection (CA-UTI) (1). Factors such as demographic characteristics, underlying diseases, diagnosis and disease severity at ICU admission, exposure to antibiotics, types and duration of invasive procedures exposure and medical interventions, were surveilled as important risk factors for HAI acquisition. Moreover, several co-factors play a role in the poor outcome of ICU-patients: severity of illness, pre-existing conditions, and host response to infection (2).

Ongoing surveillance of HAIs is an essential component of hospital infection control programs. The goals are to assess the burden of HAIs, to identify important problems, to monitor the efficacy of specific interventions and to support hospital policies (3). In fact, it has become increasingly evident that hospital support for surveillance programs needs to be justified by improved outcomes. To accomplish these goals, surveillance programs must be closely linked to effective intervention strategies (4). Accordingly, the participation in a HAI surveillance system has been shown to decrease infection rates especially in ICUs, although the particular reasons for this decrease are still difficult to determine (5).

In this context, in 2005 the Italian Study Group of Hospital Hygiene (GISIO) of the Italian Society of Hygiene, Preventive Medicine and Public Health (SItI) established the Italian Nosocomial Infections Surveillance in Intensive Care Units (ICUs) network (Sorveglianza Prospettica delle Infezioni Nosocomiali nelle Unità di Terapia Intensiva, SPIN-UTI) (6-8). This project has adopted a protocol based on that from of the Hospitals in Europe Link for Infection Control through Surveillance (HELICS) network (6, 9), successively updated in accordance with the European Centre for Disease Control and Prevention (ECDC) HAIICU protocol (10).

The present study reports the results of the SPIN-UTI project, conducted during an eight-year period in five ICUs in Catania. Specific objectives are: a) to report HAIs surveillance data from 2006 to 2013 in five ICUs in Catania ; b) to explore changes of HAI indicators and mortality rates; and c) to perform a mortality analysis, estimating the risk of death for infected patients.

Methods

A patient-based HAI surveillance was conducted in the framework of the first four surveys of the SPIN-UTI project. Each survey consisted in a six-months of active surveillance conducted between the last quarter of one year and the first quarter of the following year. Particularly, the four surveys were conducted in: 2006-2007; 2008-2009; 2010-2011 and 2012-2013 in five medical and/or surgical ICUs in Catania. All patients admitted to the ICU during the surveillance period and whose ICU stay was longer than 48 hours were included.

The first two surveys adopted the HELICS-ICU protocol (6, 9), whereas in the following editions the protocol was updated using the ECDC HAIICU protocol, implemented in 2010 by the ECDC (10). The definitions proposed by the European protocols for pneumonia, bloodstream infections (BSIs), central venous catheter-related bloodstream infections (CRIs) and urinary tract infections (UTIs) were used (9, 11).

The four surveys were conducted by trained personnel using a web-based data collection procedure. Results were handled confidentially and codes for ICUs and patient identifiers were anonymous at the level of the surveillance network (6-8, 10).

HAI indicators, computed as cumulative incidence (number of HAIs or number of patients with HAI *per* 100 patients), incidence density (number of infections *per* 1000 patient-days), and mortality rates, were calculated overall, and separately for each survey and compared (6).

Statistical analyses were performed using the SPSS 22.0 statistical package. Data were compared using the Student's t-test for continuous variables and the χ^2 -test for categorical variables, considering $p < 0.05$ as statistically significant values. To compare HAI indicators, relative risk (RR) and rate ratio, with 95% confidence intervals (CIs), were determined.

Results

Participation of the five ICUs varied from a six-months surveillance period, one survey, to all four surveys. Particularly, four ICUs participated in all surveys while one ICU participated only in the last survey. **Table 1** reports the characteristics of the 2070 patients admitted to the ICUs for more than two days during the four surveys; the mean number of patients for each survey was 517.5 (range: 411-720). The mean age of the patients did not show significant changes between the four surveys. On the contrary, a significant increase in the mean Simplified Acute Physiology Score (SAPS) II score of patients was observed in the first three surveys ($p<0.001$), followed by a decrease in the fourth survey ($p=0.0198$).

Figure 1 shows the relative frequencies of the most frequently detected infection types during the four surveys. In the first survey the most frequently detected infection type was pneumonia, conversely, data of the further surveys showed an increased relative frequency of bloodstream infection.

Relative frequencies of the most commonly isolated microorganisms in ICU-acquired infections are reported in **Figure 2**. In the first survey, *Pseudomonas aeru-*

Characteristics	1st survey	2nd survey	3rd survey	4th survey
No. of patients	490	411	449	720
Mean age (years)	62.95	62.54	62.79	62.69
Male (%)	58.3	60.6	59.9	61.6
Mean length of ICU stay (days)	10.19	11.85	10.61	9.26
SAPS II score (mean)	37.37	40.84	44.78	35.13

Table 1 Main characteristics of patients included in SPIN-UTI surveys

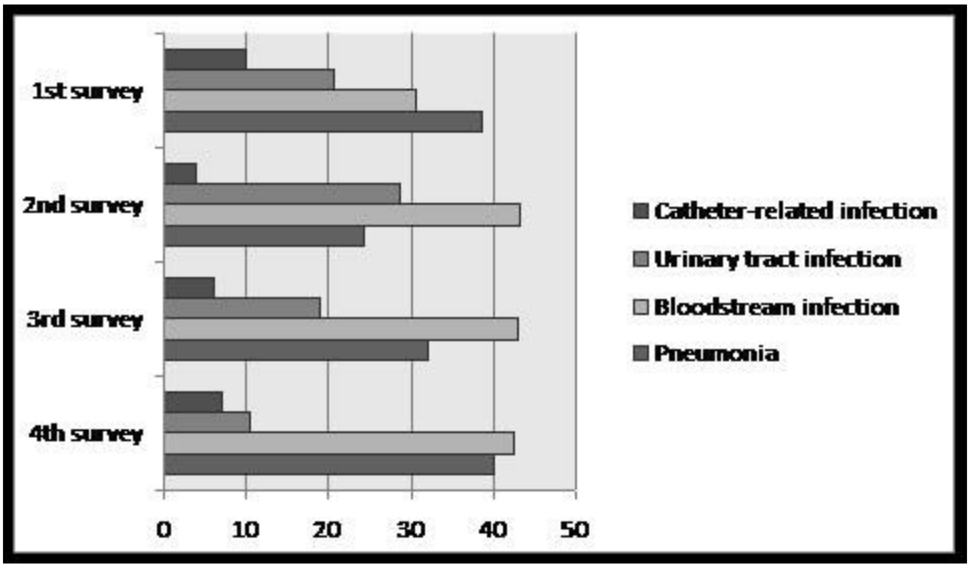

Figure 1 The most frequently reported infection types *per* 100 infections

ginosa was the most frequent microorganism (18.1%), whereas *Acinetobacter baumannii* and *Staphylococcus epidermidis* ranked second (15.5%) and third (14.7%), respectively. In the second survey, an increase in the frequency of isolation was reported for *A. baumannii* (20.1%), followed by *Klebsiella pneumoniae* (15.6%) and *P. aeruginosa* (12.3%). *A. baumannii* was confirmed the most frequently reported microorganism in the third survey (27.7%), while a frequency of isolation of 12.4% was reported both for *K. pneumoniae* and *S. epidermidis*. Finally, *K. pneumoniae* was the most frequently isolated microorganism in the fourth survey (26.3%), whereas *A. baumannii* and *P. aeruginosa* ranked second (21.8%) and third (12.3%), respectively.

The cumulative incidences of infected patients in each survey were: 13.3, 17.0, 18.9 and 8.9 *per* 100 patients, respectively. The risk of ICU-acquired infections increased in the third survey compared with the first (RR: 1.43; 95%CI: 1.06-1.92) but it decreased in the fourth survey compared with the second (RR: 0.64; 95%CI: 0.47-0.86) and the third (RR: 0.57; 95%CI: 0.43-0.76).

Table 2 shows a similar trend considering incidence of infection and incidence density; both incidence of infections and incidence density showed an increase in the third survey compared with the first, and a decrease in the fourth survey compared with the second and the third.

During the four surveys, mortality rates remained unchanged (17.4, 18.1, 20.6 and 19.5, respectively). However, the risk of death increased for infected patients in the first (RR: 2.72; 95% CI: 1.83-4.10), in the second (RR: 4.08; 95%CI: 2.79-5.96), in the third (RR: 3.34; 95%CI: 2.37-4.70) and in the fourth survey (RR: 3.10; 95%CI: 2.39-4.04).

Discussion

Scientific evidences show that ICU-acquired infections result in excessive length of stay, morbidity and resource use and in a significantly lower patient survival (11-13). Particularly, in previous clinical studies a strong relationship with length of ICU stay and mortality was reported, with a greater impact on patients admitted to the surgical ICU. Infection remained an independent risk factor for mortality after adjusting for prognostic scores, age, emergency surgery and other variables (14-15).

It is well established that reporting and analyzing surveillance data, with subse-

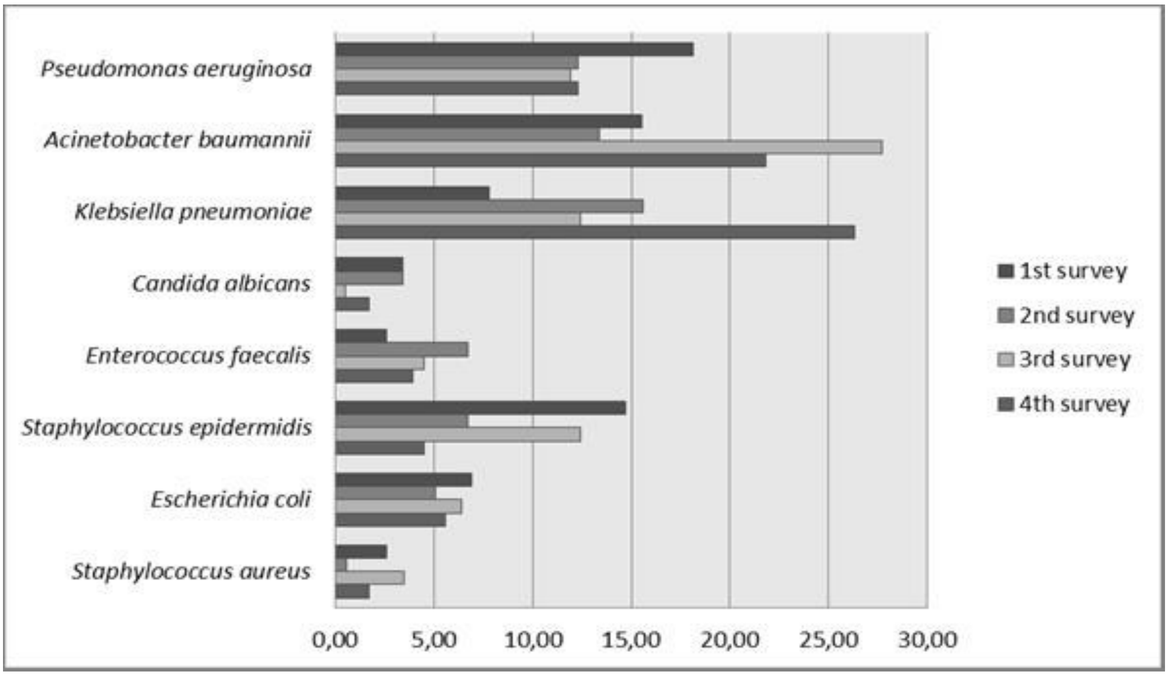

Figure 2 Relative frequencies of the most frequently reported microorganisms

					Comparison between:					
Indicators	1st survey	2nd survey	3rd survey	4th survey	2nd and 1st surveys	3rd and 1st surveys	4th and 1st surveys	3rd and 2nd surveys	4th and 2nd surveys	4th and 3rd surveys
Cumulative incidence of infections (*per* 100 patients)	22.7	37.2	37.4	19.7	1.64 (1.34-2.02)	1.65 (1.35-2.02)	0.87 (0.70-1.09)	1.01 (0.85-1.20)	0.53 (0.44-0.64)	0.53 (0.44-0.64)
Cumulative incidence of infected patients (*per* 100 patients)	13.3	17	18.9	8.9	1.28 (0.94-1.75)	1.43 (1.06-1.92)	0.82 (0.60-1.11)	1.11 (0.84-1.48)	0.64 (0.47-0.86)	0.57 (0.43-0.76)
Incidence density (*per* 1000 patient-days)	22.2	31.3	35.3	21.3	1.41 (1.09-1.81)	1.59 (1.24-2.04)	0.96 (0.74-1.24)	1.13 (0.90-1.41)	0.68 (0.54-0.86)	0.60 (0.48-0.76)
Mortality	17.4	18.1	20.6	19.5	1.04 (0.78-1.38)	1.21 (0.92-1.58)	1.12 (0.87-1.43)	1.14 (0.86-1.50)	1.08 (0.84-1.39)	0.95 (0.75-1.20)

Table 2 Comparison of infection indicators and mortality in the four surveys of the SPIN-UTI project

quent changes of infection control measures, can prevent HAIs (7). The Study of the Efficacy of Nosocomial Infection Control (SENIC) described that infection control activities could be efficacious tools to reduce HAIs (16) and other studies reported a reduction of the HAI rates in ICU patients as a result of surveillance (17-18). Furthermore, implementing infection control programs and protocol updates based on data obtained, together with the assessment of the compliance with infection control measures, significantly decrease the risk of UTI and BSI (19).

Our results obtained from five ICUs in Catania, were similar to those described by the Italian Network SPIN-UTI (7). Relative frequencies of the most commonly isolated microorganisms, reported in our study, confirmed the role of some pathogens, such as *A. baumannii, K. pneumoniae, P. aeruginosa* and *S. epidermidis* (4,6, 20-21). As previously described by the Italian Network SPIN-UTI (7), *P. aeruginosa* was the most frequently isolated microorganism in the first survey. Subsequently, an increase in the frequency of isolation of *A. baumannii* was reported in the second and third surveys. Instead, *K. pneumoniae* was the most frequently isolated microorganism in the last one edition.

The risk of ICU-acquired infections, estimated by computing the cumulative incidence and the incidence density, increased in the third survey compared with the first, confirming the national results (7). Interestingly, in the present study the risk of ICU-acquired infections decreased in the fourth survey compared to second and third surveys.

According to other studies, known factors such as severity of illness, presence of chronic underlying disease, and admission category were risk factors for long-term mortality (22). Our mortality analysis confirmed evidence of the Italian Network SPIN-UTI (7); although mortality remained unchanged, the risk of death significantly increased among infected than not infected patients, in each survey.

Our study has some limitations. Firstly, several other factors may have been considered, such as antibiotic consumptions and usage of invasive devices.

Furthermore, it was not entirely clear whether the high infection rates in our study were a cause of prolonged ICU stays of patients or a result instead, thus in the future, other analyses should be performed.

In conclusion, our study reports the changes of HAI incidence and mortality during the four surveys of the SPIN-UTI project conducted in five ICUs in Catania. Although the present study is not strictly population based, results should be readily generalizable to many other critically populations. The future purpose will be the management of potential target for infection control interventions and the implementation of strategic bundles in order to decrease the growing risk of HAI in the ICUs. Surveillance data are useful to support policymakers and leaders to make evidence-based decisions in the healthcare setting, to plan and improve programs, services and interventions for preventing, managing and treating HAIs.

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