Nosocomial infections in an Italian hospital: prevalence and risk factors

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Summary

Objectives. In order to obtain an overview of the planning of infection control policies, ten repeated prevalence studies were carried out from 1998 to 2003, enrolling 3,537 adult patients, 748 of whom (7.8%) developed nosocomial infections.

Materials and Methods. The main types of nosocomial infection were analysed with univariate and multivariate logistic models, to identify the risk factors for the urinary tract, for lower respiratory tract, for surgical site infections, and for bacteriaemia and sepsis.

Results. Urinary tract infections were the most frequent (14.3%), followed by surgical site infections (4.3%), infections of the low respiratory tract (1.0%) and bacteriaemia and sepsis (0.8%). The overall prevalence showed a significant decreasing trend during the survey period.

Conclusions. Prevalence studies were shown to be able to produce several useful outcomes. They can be used: 1) to identify groups of patients at risk of avoidable infections; 2) to estimate the size of the problem and the spread, across a hospital, of procedures associated with risk; 3) to make control policies more visible and comprehensible to health professionals and managers; 4) to evaluate the impact of the specific control measures implemented; 5) to monitor the quality of the information available from clinical records.

KEY WORDS: *nosocomial infections, prevalence, risk factors, control policies.*

Introduction

Active surveillance of nosocomial infections (NIs) is central to any valid hospital infection control programme (1). Prevalence and incidence studies of hospital-acquired infections can furnish very useful information about patient care and trends of NIs. However, incidence studies are very expensive and time-consuming, whereas prevalence studies are less expensive, but require greater organisational efforts. In general, hospitals prefer to devote most of their attention to specific high-risk wards, such as intensive care units (ICUs) or to certain types of infection, such as those related to surgical sites or to the use of urinary catheters.

Although prevalence studies present several familiar problems (2, 3), repeated prevalence surveys have long been recommended (4, 5) and may be used not only to document trends over time, but also to increase knowledge about the problem (6, 7). Therefore, periodic repetitions of prevalence analyses can be helpful for inferring information about NIs, particularly regarding: a) the risk wards/areas; b) the most frequently affected tissues and organs; c) the microorganisms involved; d) the qualitative and quantitative use of antibiotics and its consequence on possible resistances; e) the identification of the most important risk factors; f) the evaluation of control and prevention policies.

Hence, even though they take time and involve considerable costs, repeated prevalence surveys may be helpful in estimating the frequency of a given infection in a given ward over time and consequently influence the planning of control measures. To verify

infection trends over time and also to study possible effects on the prevalence of NIs, we carried out ten consecutive prevalence surveys in an Italian hospital. The aims of the study were to estimate the prevalence of hospital infections and to identify the most important risk factors.

Materials and methods

Patient Selection

Between 1998 and 2003, and using the guidelines of the "Studio Italiano di Prevalenza delle Infezioni Ospedaliere" (SIPIO) (8), ten periodical prevalence studies were carried out in the public hospital of Alessandria (Ospedale SS. Antonio e Biagio e Cesare Arrigo – Piedmont, Italy), which has 700 beds. During the study period, the hospital beds were divided into five different therapeutic areas (intensive care, general and specialist medicine, general and specialist surgery).
The surveys included all patients admitted to acute care wards for more than 24 hours, and excluded those admitted as day-hospital patients, and those discharged on the day of the survey.

Survey organisation

The study protocol was based on the SIPIO guidelines, and was used to carry out ten consecutive prevalence surveys, which took place on the following dates: 1) November 1998; 2) June 1999; 3) January 2000; 4) June 2000; 5) November 2000; 6) June 2001; 7) October 2001; 8) June 2002; 9) January 2003; 10) June 2003.
The wards involved in the surveys were informed by means of an introductory letter explaining the purpose of the study, and asking for their cooperation. Data were obtained through examination of official clinical data of all eligible patients, from urine culture results (according to the study protocol) and through direct examination of surgical wounds. All data collected were recorded on specific ward cards and subsequently entered into a computer database. On average, two wards were visited each day, so that the prevalence for each ward was measured over a single day.
Infection prevalence and the distinction between nosocomial or community origin, were established by investigators on the basis of the clinical information gathered and by applying standardised case definition criteria (9).

Statistical analysis

All data were submitted to quality control and analysis: descriptive analysis was carried out calculating absolute and relative frequencies. Prevalence was estimated as the number of infected patients and the number of infections per 100 admitted patients. Infection prevalence was stratified for various patient characteristics such as age, gender, reason for hospitalisation, type of ward and presence of other risk factors. In particular, cases were classified into four main categories of NI: urinary tract infections (UTIs), surgical site infections (SSIs), lower respiratory tract infections (LRTIs) and bacteriaemia/sepsis (BS).
Risk factors were studied with univariate analysis (Pearson's test or Fisher's exact test when appropriate), whereas association between infection and presence of known or suspected risk factors (including possible interactions and confounders) was analysed applying a logistic multivariate model, which allowed the choice of the most suitable equation for each type of infection; the comparison between models was carried out with the likelihood ratio test (LRT).
The statistical analysis was carried out using Stata/SE 9.2. Statistical significance was assumed when $p < 0.05$. All tests were two-tailed.

Results

Patient characteristics

In the course of the ten consecutive surveys, 3,537 adult patients, 1,705 females (48.2%), and 1,832 males (51.8%) were enrolled in the study. Their median age was 65 years (range: 16 to 97). While patients admitted for elective reasons (1,908) were evenly distributed across age groups, the ones in emergency care (1,629) were generally older.
The underlying pathologies observed during the ten surveys were: vasculopathy, diagnosed in 1,320 pa-

tients (37.3%), cancer in 650 patients (18.4%) and metabolic diseases in 352 patients (10.0%); 842 patients (23.8%) did not show any pathology.

Prevalence of nosocomial infections

Infections were identified in 748 cases (21.2% of patients): 471 (63.0%) of these were community infections and 277 (37.0%) were NIs.

The prevalence of infected patients was 7.8%, ranging from 10.4% (observed in the second survey) to 5.8% (in the seventh survey), and showed a significant decreasing trend (test for trend: $p < 0.0005$).

Figure 1 describes the temporal trend of infected patients and that of the four main types of NI identified from 1998 to 2003.

Among the 277 patients presenting NIs, 61 developed a second NI, and four developed a third. The total NI rate was 9.7%.

Among the known risk factors for hospital infections we identified the following diagnostic and therapeutic procedures: 807 patients (22.8%) underwent closed bladder catheterisation, 820 (23.2%) had a peripheral venous catheter and 346 (9.8%) a central venous catheter; oxygen therapy was used in 210 patients (5.9%) and 48 patients (1.4%) were intubated; tracheotomy was carried out in 71 (2.0%) and pulmonary ventilation was used in 94 subjects (2.7%). On average, about 2.5 risk factors were counted for each patient.

Bladder catheterisation was mainly carried out in intensive care (76% of patients), geriatrics (37%), and orthopaedics (50%); central venous catheters were used mainly in intensive care (70%) and haematology (66%); arterial catheterism in intensive care (41%). Intensive care was also the therapeutic area where pulmonary ventilation was more frequent (60%).

Risk factors for main nosocomial infections

Urinary tract infection

Among the subjects at risk, the prevalence of UTIs was 14.3% (115 out of 807 patients with a bladder catheter) and showed a significant decrease over time (test for trend: $p = 0.0048$). Having a urinary catheter was significantly associated with this type of infection ($\chi^2_1 = 378.7$; $p < 0.0005$); age represented a significant risk factor ($\chi^2_6 = 16.8$; $p = 0.010$), whereas the presence of an underlying pathology did not play a role in determining the infection ($\chi^2_1 = 0.27$; $p = 0.605$).

The therapeutic area was found to have a significant influence on the infection (Fisher's exact test: $p = 0.001$), as was being female ($\chi^2_1 = 19.7$; $p < 0.0005$). Antibiotic prophylaxis did not show any significant association with infection ($\chi^2_1 = 2.3$; $p = 0.1276$).

A logistic model including gender, age (continuous), and antibiotic prophylaxis as independent variables and presence/absence of UTIs as response variable was fitted (Table 1).

Low respiratory tract infections

Among the 3,537 patients, 36 cases of LRTI were observed (1.02%). The prevalence did not show any change over time (test for trend: $p = 0.0549$); the therapeutic area showed a significant influence on this infection (Fisher's exact test: $p < 0.0005$).

Being male was positively associated with LRTI ($\chi^2_1 = 7.8$; $p = 0.005$) as were intubation ($\chi^2_1 = 42.7$; $p < 0.0005$), mechanical ventilation ($\chi^2_1 = 213.9$; $p < 0.0005$), oxygen therapy ($\chi^2_1 = 4.1$; $p = 0.042$), tracheotomy ($\chi^2_1 = 290.8$; $p < 0.0005$) and surgery ($\chi^2_1 = 17.8$; $p < 0.0005$). In general, any invasive procedure or surgery significantly increased the risk of developing a LRTI ($\chi^2_1 = 3322.8$; $p < 0.0005$), whereas the length of preoperative hospital stay did not influence this risk (Fisher's exact test: $p = 0.379$). Moreover, the presence of at least one invasive respiratory procedure increased the risk of LRTI ($\chi^2_2 = 272.7$; $p < 0.0005$).

A multivariate logistic model including length of preoperative hospital stay, number of procedures, age and gender as independent variables was fitted. Age and number of procedures showed a significant association with LRTI adjusted for gender and length of hospital stay (Table 1).

Surgical site infections

Among the 822 patients undergoing surgery, 35 (4.25%) developed SSIs. The prevalence did not vary significantly between surveys (Figure 1).

Excluding patients who had undergone surgery during previous hospitalisation, the type of intervention showed a non significant association with SSIs

Table 1. Odds Ratios (OR), corresponding 95% confidence intervals ($CI_{95\%}$) and statistical significance (p) for independent variables according to main nosocomial infection localisation.

Localisation and independent variables	OR	$CI_{95\%}$ (OR)	*p*
UTI			
gender (male vs female)	0.42	0.27-0.65	$p < 0.0005$
age (years)	1.02	1.01-1.04	$p = 0.006$
antibiotic prophylaxis (done vs not done)	0.63	0.37-1.06	$p = 0.082$
LRTI			
gender (male vs female)	1.85	0.49-6.98	$p = 0.361$
age (years)	1.08	1.02-1.14	$p = 0.011$
hospital stay (2-5 days vs 1 day)	2.31	0.56-9.56	$p = 0.247$
hospital stay (6-9 days vs 1 day)	0.35	0.03-3.55	$p = 0.374$
hospital stay (10+ days vs 1 day)	1.76	0.38-8.15	$p = 0.471$
procedures (1 vs no procedures)	14.40	2.79-74.32	$p = 0.001$
procedures (2+ vs no procedures)	60.57	15.29-239.9	$p < 0.0005$
SSI			
gender (male vs female)	1.37	0.64-2.94	$p = 0.411$
age (years)	1.02	0.10-1.05	$p = 0.080$
preoperative hospital stay (days)	1.04	1.02-1.06	$p < 0.0005$
surgery (clean-contaminated vs clean)	0.97	0.37-2.53	$p = 0.947$
surgery (contaminated vs clean)	2.59	0.98-6.87	$p = 0.056$
surgery (dirty vs clean)	0.90	0.11-7.08	$p = 0.925$
BS			
gender (male vs female)	2.06	0.90-4.70	$p = 0.087$
age (years)	0.99	0.97-1.01	$p = 0.243$
catheter (peripheral vs absent)	7.89	2.09-29.86	$p = 0.002$
catheter (central vs absent)	35.81	10.47-122.5	$p < 0.0005$

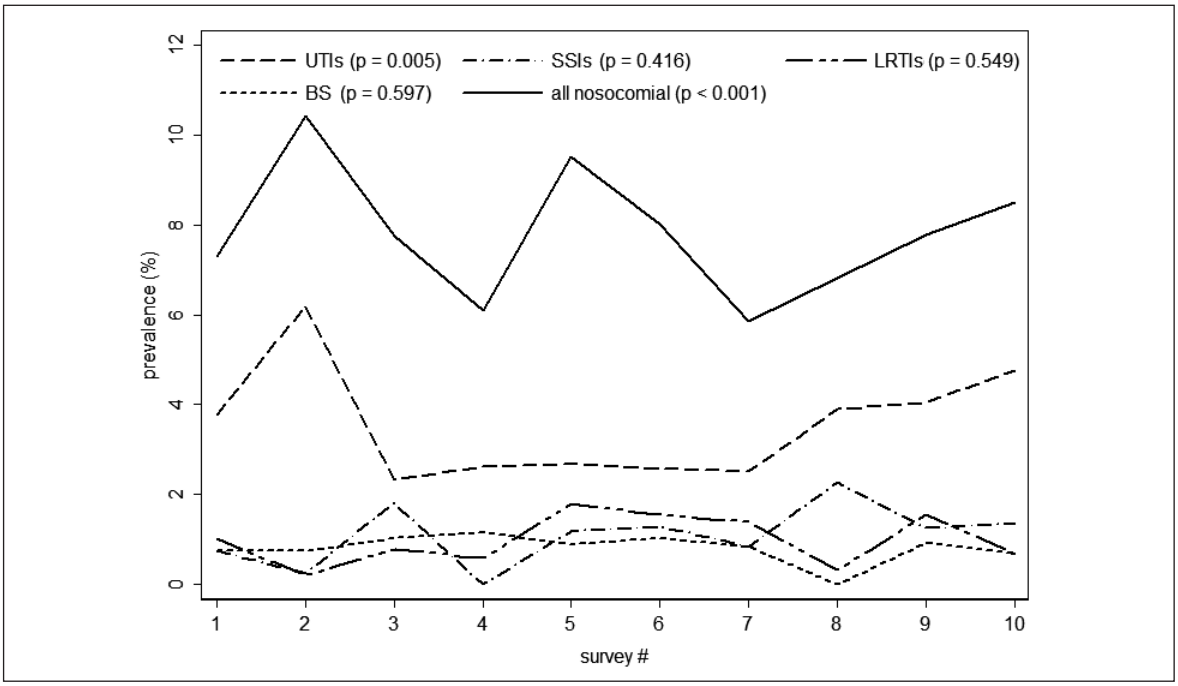

Figure 1. Temporal trend of the prevalence of nosocomial infections, and of the four main types among adult patients (first infections only). UTIs = urinary tract infections; SSIs = surgical site infections; LRTIs = low respiratory tract infections; BS = bacteriaemia/sepsis. P-values refer to test for trend of each type of infection.

(Fisher's exact test: $p = 0.064$), although contaminated operations seemed to be the most at risk, with a 10.1% prevalence of episodes.

The presence of a pathology showed a significant association with the development of a surgical infection (Fisher's exact test: $p = 0.007$), whereas gender ($\chi^2_1 = 0.7$; $p = 0.416$) and age group (Fisher's exact test: $p = 0.056$) did not.

The prevalence of SSI was not found to be different in general surgical compared to specialist surgical wards ($\chi^2_1 = 0.0003$; $p = 0.986$) and (after stratification based on type of operation) did not show significant differences due to reason for hospitalisation (emergency vs planned surgery) ($\chi^2_3 = 1.2$; $p = 0.760$).

A significantly different prevalence was found when patients were grouped by preoperative length of stay (Fisher's exact test: $p < 0.0005$); in detail, each preoperative day determined an average increase of the odds of infection by a multiplicative factor of 1.11 ($CI_{95\%}$ from 1.070 to 1.148). This means that a subject hospitalised for seven days before the intervention doubled his/her baseline risk of developing a SSI.

A logistic multivariate analysis, fitted using age, gender, length of preoperative hospital stay, and type of surgical intervention as independent variables, showed that the only variable maintaining its significant effect was the lenght of preoperative stay. The type of surgical intervention did not contribute to risk, even though contaminated surgery tends to be the most risky intervention (Table 1).

Bacteriaemia and sepsis

Among the 3537 patients, 29 (0.82%) developed BS. This prevalence did not vary significantly between surveys (Figure 1).

Age group did not show any specific effect on risk of BS (Fisher's exact test: $p = 0.085$) and neither did the presence of an underlying pathology (Fisher's exact test: $p = 0.274$), surgery ($\chi^2_1 = 3.5$; $p = 0.060$), or the presence of a bladder catheter ($\chi^2_1 = 3.7$; $p = 0.054$), whereas gender ($\chi^2_1 = 5.0$; $p = 0.026$), type of care (Fisher's exact test: $p = 0.005$) and both arterial and venous catheters (respectively $\chi^2_2 = 43.4$; $p < 0.0005$, and $\chi^2_3 = 91.9$; $p < 0.0005$) did show a significant association with BS. Of the different kinds of intravascular catheter, central ones were significantly more linked to sepsis than peripheral ones (Fisher's exact test: $p < 0.0005$).

The most efficient logistic model included age, gender, and intravascular catheterisation; it showed that only peripheral and central vascular catheters were significant predictors of BS (Table 1).

Discussion

This study aimed to increase knowledge of major risk factors for the four types of NI and to support preventive policies. In the course of the prevalence surveys, infections affected 748 patients, nearly one fifth of the examined population: 277 (nearly one third of all infected patients) had NIs, while the remaining two thirds (471 cases) had community infections. Nosocomial infections affected, on average, 7.8% of the hospitalised population (range from 5.8% to 10.4%).

The prevalence of nosocomial acquired infections has been measured by many studies performed in different countries and in various settings. In Germany (10), data from 72 acute care hospitals showed a mean rate of 3.5%, ranging from 0% to 8.9%; a national prevalence survey involving 71 Norwegian hospitals (11) in 1997 found a rate of 6.1%; repeated multi-centre prevalence surveys in Greek hospitals (12,13) showed a rate of infection of 9.3%, while in a Swiss study (14) the observed prevalence was 11.3%; in the Lebanon (15) a one-day prevalence survey in 1997 showed a rate of 6.8%, and in France the rate was 6.1% in a prevalence study lasting four years (16). Any comparison across different studies, anyway, must be treated with caution because even when similar methods are applied (standardized case definitions, etc.) the risk patterns of different patients in different settings are heterogeneous.

Considering localisation of infection, in our repeated prevalence surveys the main groups were: UTIs (14.3% of the catheterised patients), SSIs (4.3% of the patients undergoing surgery), LRTIs (1.0%) and BS (0.8%).

Our patient population was old, about 50% of both the males and females being aged over 65 years, and this could have affected the amount of identified events, as seen in the multivariate analysis.

In the course of the ten surveys many at–risk situa-

tions for patients were identified. On average, patients were exposed to about 2.5 infection risk factors: many of these were unavoidable, like gender or, especially in emergency situations, the type of surgical operation. On the other hand, we identify several other risk factors that could be avoided or, at least, limited.

In the light of these results a number of preventive policies were implemented in the hospital. For example, since the length of preoperative hospitalisation had been shown to play an important role in the onset of SSIs, efforts were made, on an organisational level, to reduce, to a minimum, the duration of hospitalisation prior to surgery.

Looking at urinary tract catheter infections, age and therapeutic area (geriatrics, neurology, oncology, orthopaedics) were the main risk factors identified by the surveys. A number of control measures targeting the safe management of catheters were implemented in those areas starting from the year 2000. These measures produced a significant decrease in the UTIs recorded in the subsequent surveys.

Specific surveillance studies were started in intensive care units looking at ventilator assisted patients, who had been identified by the prevalence surveys as being the group most at risk of LRTIs, similarly patients with central catheters were actively surveyed in haematology wards.

The use of prevalence surveys for the control of NIs was introduced in the US and in several European countries in 1970. In Italy the first attempts to control hospital-acquired infections were prompted by a national prevalence survey in 1983. Since then a number of studies and local initiatives have taken place and a national policy for the control of hospital-acquired infections was endorsed by the Italian National Health Service in its 1998-2000 Health Plan.

All the subsequent Health Plans have highlighted the role of NI surveillance and prevalence surveys have been indicated as the easiest means of estimating the frequency of NIs.

In conclusion, these repeated prevalence studies were shown to be able to produce several useful outcomes, making it possible: 1) to identify groups of patients at risk of avoidable infections; 2) to estimate the size of the problem and the spread, across hospitals, of procedures associated with risk; 3) to make control policies more visible and comprehensible to health professionals and managers; 4) to evaluate the impact of the specific control measures implemented (like those against UTI); 5) to monitor the quality of information available through clinical records.

In spite of their methodological limitations, prevalence studies have shown themselves to be useful in starting and monitoring control policies, thereby producing a general picture of risk factor distributions in hospitals and allowing for the identification of policy priorities.

Acknowledgments

The authors wish to thank Mr Franco Piccio and Ms Maria Carla De Stefani, infection control nurses, for data collection and management.

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