Hospital-acquired infections before and after healthcare reorganization in a tertiary university hospital in Norway

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ABSTRACT

Background To evaluate hospital-acquired infections (HAIs) in somatic (all admissions other than psychiatric) and psychiatric patients admitted to a tertiary university hospital in Oslo, before and after reorganization of the Norwegian healthcare system in 2002.

Methods Point prevalence studies were conducted four times per annum and over the period from 1995 to 2007.

Results A total of 57 360 patients were studied over the whole time period: 80.5% in somatic wards and 19.5% in psychiatric wards. The HAI rate was 6.9%, of which 8.1% were somatic and 1.9% psychiatric. 13.4% of operated patients had HAI, including 6.2% due to surgical wound infections. In somatic wards, 0.6–1% were re-admitted with HAI, 15.2–23% had infections and 18–23% used antibiotics. There was a reduction in HAI until 2002. From 2003 on, HAI increased (P = 0.010) in somatic wards (P = 0.002), in non-operated patients (P = 0.024) and in extra costs.

In 2002, the Norwegian healthcare system was reorganized. This reorganization led to a 30% increase in somatic patients treated from 2003 to 2007 (P = 0.054), 27% increase in the total workload per work position (P = 0.024) and 23.5% decrease in internal service work.

Conclusion A declining trend of HAI was observed from 1995 to 2002 at the tertiary university hospital in Norway. In 2002, the Norwegian healthcare system was reorganized. From 2003 to 2007, HAI increased significantly as did the number of somatic patients and workload at our hospital.

Keywords extra costs, healthcare reorganization, hospital-acquired infection in somatic and psychiatric wards, hospital management, point prevalence, postoperative infections, re-admittances, staffing, work load

Introduction

Prevalence study is widely used to survey and document the presence of hospital-acquired infection (HAI).1–13 In general, the point prevalence (PP) rate is 8–10%, often with a mean of 13 extra days at hospital and up to 10% of the patients die directly or indirectly from their infection.1,2,6–8,14–16 Repeated PP studies can provide baseline information of HAI and are used to monitor effectiveness of hospital infection control.3,10 PP studies have been done over the last 25 years.4–19 In Norway, nationwide PP studies have been done since 1980.20–25 During the last 10 years, however, only four types of infections have been registered in Norway, thus not including the total prevalence.21,23 In three counties, Oslo, Hedmark and Oppland (15 hospitals and 3200 hospital beds), PP studies have been done four times per annum each year since 1996, including all types of HAI.22 In 2002, all public hospitals in Norway were transferred from the administration of the responsible county to five regional state enterprises to be more effective and economical.

The objective of this study was to analyze the development of hospital infections in somatic (all admissions other than psychiatric) and psychiatric wards: postoperative infections, use of antibiotics, re-hospitalization and extra costs, according to the workload per work position, before and after reorganization of the healthcare system in Norway.

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Materials and methods

Setting
Ullevål University Hospital is a tertiary, regional hospital located in Oslo, Norway. The hospital offers all medical and surgical subspecialty services, excluding solid-organ and bone-marrow transplantation. It has approximately 1200 beds, 80 single rooms, 24 contact isolation rooms and 41 negative pressure isolates (airborne infections), including 20 negative pressure isolates for children. 'Corridor beds' constitute 3–10% of all beds.

Infection control personnel
Three nurses and one doctor were responsible for infection control work and for the prevalence study.

Definitions of hospital-acquired (nosocomial) infections
The Centers for Disease Control and Prevention (CDC) defined hospital infection as follows:

Hospital-acquired infection (nosocomial infection) is the occurrence of infection after hospital admission, without evidence that the infection was present or incubating at the time of admission. A nosocomial infection usually occurs within 30 days after hospital stay or within 1 year in case of infection associated with insertion of a prosthetic device.

Types of HAI: All types were recorded. Infections in more than one site in the same person were registered as separate infections. The following 12 CDC clinical infection categories were adapted to and used in repeated PP studies in Norway:2,16,20,22

1. Urinary tract infection (excluding asymptomatic bacteriuria)
2.1. Upper respiratory tract infection
2.2. Lower respiratory tract infection
3. Gastroenteritis
4.1. Postoperative wound infection; incision site superficial
4.2. Postoperative wound infection, deep-seated
5.1. Skin and soft tissue infection, burn infection
5.2. Skin and soft tissue infection, other infections
6. Intra-abdominal infection
7. Osteomyelitis
8. Septicemia
9. Meningitis
10. Intravascular-access-device infection/infection in tracheal incision
11. Infections in newborns
12. Other

Registering
Four PP studies were performed each year on a Wednesday at a preset and nearly the same date each year in January, March, June and October from 1995. Before 1995, one or two studies were done each year. The study was done at 8 a.m. and included all patients admitted to each clinical department.22 Patients who were moved for surgery or other treatments were included in the number of patients at the clinical department where they were initially admitted. The doctor and nurse in charge at each clinical department collected and verified the category of hospital infection. Infection control personnel were available for questions, also at the ward. Data were recorded on specialty, number of patients at each department, number of patients in surgery, number of postoperative infections and postoperative wound infections, number of patients given antibacterial agents prophylactic or therapeutic, total number of patients with infections and with hospital infections, and patients re-admitted with infections and with hospital infections and types of microbes associated with infections.

The infection control nurse or contact person from each department was responsible for the distribution of the protocol in paper, on e-mail, intranet or fax and for returning the data to the infection control doctor. Problems and uncertain questions were discussed directly with healthcare personnel at the ward.

Extra costs
Extra costs were estimated from an overall bed price of Norwegian kroner (NKr) 5000 per day in somatic wards, 40 000 admittances per year and a mean of 4 extra days in hospital for each hospital infection.16

Statistical analysis
Data analysis was done with SPSS; a linear regression analysis was done in order to analyze whether the observed mean changes over time were significant. Data concerning discharges, days in hospital, polyclinic, day treatment and number of beds per work position per year, and different work positions are obtained from Statistics Norway (http://statbank.ssb.no).24

Reorganizing the Norwegian healthcare system
In 2002, the Norwegian healthcare system was reorganized in order to be more effective and economical. This meant that the financial and administrative management for all hospitals was transferred from the local counties to five regional state enterprises. Ullevål University Hospital continued to be the regional hospital for the new Region East (five counties) during the study period.
Results

The total study
A total of 57,360 patients were included in this study during the period 1991–2007: 80.5% in somatic wards (all admissions other than psychiatric) and 19.5% in psychiatric wards. Surgery was undertaken for 12,430 (21.7%) registered patients during this period. The total rate of hospital infections during this period was 6.9%: 8.1% in somatic wards and 1.9% in psychiatric wards. Hospital infections were registered in 13.4% of operated patients, including 6.2% due to surgical wound infections, and in 5% of non-operated patients. Operated patients had a nearly 3-fold higher risk of HAI than non-operated patients.

Development of hospital infections in somatic and psychiatric wards
Each year, 4000–4300 hospitalized patients were studied. The rate of hospital infections in somatic wards varied over the years, the rate being the lowest in 2002 (5.2%) (Fig. 1). Linear regression analysis showed a significant reduction of hospital infections in somatic wards before 2002 ($P < 0.001$) and a significant increase again after 2002 ($P = 0.002$). In psychiatric wards, there was a significant trend concerning reduction ($P = 0.026$) from 2000 to 2007.

Hospital infections in operated and non-operated patients
The yearly rate of postoperative infections, including all types, varied between 10% and 15.9% (Fig. 2). Linear regression analysis showed a significant increase in HAI after 2002 in non-operated patients ($P = 0.024$). Postoperative wound infections varied between 3.9% and 7.2%, the rate being the lowest in 2002. Postoperative deep wound infections dominated: 0.4–1.7% of all hospitalized patients, with some seasonal variation, most often with peaks in March (significantly more often than in June; $P = 0.049$). Superficial postoperative wound infections were registered in 0–1.2% of all hospitalized patients. Linear regression analysis showed that both deep and superficial postoperative wound infections decreased until 2002 ($P = 0.004$ and 0.006, respectively). An increasing trend after 2002 was not significant.

Re-admittances, total infection rate and use of antibiotics
A total of 0.6–1% of patients in somatic wards had been re-admitted because of HAI, compared with <0.1% in psychiatric wards. Re-admittances were mainly due to deep postoperative wound infections, especially after orthopedic surgery. The total infection rate, including community-associated infections, varied between 15.2% and 23% in somatic wards compared with <3% in psychiatric wards. A total of 18–25% of patients in somatic wards were on antibiotics, prophylactic or therapeutic, compared with <5% in psychiatric wards where a significant reduction over years was registered ($P = 0.023$). There was no statistical change in the proportion of antibiotics in somatic wards during this period. Microbes were isolated from 40% to 50% of all cases with hospital infections. *Staphylococcus aureus* predominated (~30% of all cases) and was isolated most frequently from wounds, followed by *Escherichia coli* (~20% of all cases) mostly from urine. Resistant bacteria, such as methicillin resistant *S. aureus* and extended-spectrum β-lactamase-producing gram-negative rods, were present in <1%.
Extra costs
During this period, costs estimated because of extra stay in hospital reduced from >80 to ~60 mill NKr per year (Fig. 3). Linear regression analysis showed a significant reduction in extra costs because of hospital infections until 2002 and a significant increase in extra costs from 2002 ($P < 0.001$ and $P < 0.001$, respectively).

The somatic activity data from 1998 to 2007 for Ullevål University Hospital were collected from the Statistics Norway. No data were available before 1998. The mean number per yearly work position at the hospital for the two periods, 1998–2002 and 2003–07, is compared with regard to beds, discharges, days in hospital, polyclinic patients and day treatments in addition to the number of different types of positions (Table 1). There was an increase in discharges and day-treatment patients after 2002 to 11% and 58.2%, respectively, with no change in the number of beds. There was nearly no change in the total number of positions or of nurse positions after 2002, whereas the numbers of medical doctors, and administration and office personnel increased to 11% and 12.3%, respectively, and the number of personnel responsible for service and technical functions decreased to 23.5% after 2002. There were 30% more somatic patients treated in 2007 (458 751) than in 2003 (318 428), including discharged, polyclinic and day-treatment patients, and the total workload per work position was 27% higher in 2007 than in 2003. Linear regression analysis showed a marked increase in somatic patients ($P = 0.054$) and a significant increase of total work load ($P = 0.024$) during the second period (Fig. 4).

Response to the new organization
During springtime in 2003, infection control personnel at Ullevål University Hospital registered an increase in hospital infections, mostly due to reorganization and fewer positions in direct patient care, fewer beds, overcrowded departments, understaffing and mixing of patients. The hospital health administration was warned of this development and the Public Health Supervision in the county requested documentation from the hospital.

Discussion
Main findings of the study
This study systematically surveyed hospital infections at a tertiary, 1200 bed university hospital in Oslo over the period

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**Table 1** Distribution of beds, numbers of days in hospital, polyclinic patients and day treatments per yearly work position at Ullevål University Hospital 1998–2007

<table>
<thead>
<tr>
<th>Category</th>
<th>1998–2002 (Period 1)</th>
<th>2003–07 (Period 2)</th>
<th>Change in percentage</th>
<th>Change: increase or decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number per yearly work positions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beds</td>
<td>0.2</td>
<td>0.2</td>
<td>0.0</td>
<td>Increase</td>
</tr>
<tr>
<td>Discharges</td>
<td>8.0</td>
<td>9.0</td>
<td>11.0</td>
<td>Increase</td>
</tr>
<tr>
<td>Days admitted</td>
<td>53.9</td>
<td>51.0</td>
<td>5.4</td>
<td>Decrease</td>
</tr>
<tr>
<td>Polyclinic patients</td>
<td>66.8</td>
<td>55.0</td>
<td>17.7</td>
<td>Decrease</td>
</tr>
<tr>
<td>Day-treatment patients</td>
<td>3.3</td>
<td>7.9</td>
<td>58.2</td>
<td>Increase</td>
</tr>
<tr>
<td>Number of positions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All positions</td>
<td>4944</td>
<td>5039</td>
<td>1.9</td>
<td>Increase</td>
</tr>
<tr>
<td>Medical doctors</td>
<td>711</td>
<td>799</td>
<td>11</td>
<td>Increase</td>
</tr>
<tr>
<td>Nurses</td>
<td>1548</td>
<td>1571</td>
<td>1.5</td>
<td>Increase</td>
</tr>
<tr>
<td>Administration and office personnel</td>
<td>697</td>
<td>795</td>
<td>12.3</td>
<td>Increase</td>
</tr>
<tr>
<td>Service and technical functions</td>
<td>830</td>
<td>635</td>
<td>23.5</td>
<td>Decrease</td>
</tr>
</tbody>
</table>
From 1995 on, four repeated PP studies were done each year. A total of 57,360 patients were surveyed: 46,194 patients in somatic wards and 11,166 in psychiatric wards. The total rate of HAI during this period was 6.9%: in somatic wards of 8.1% and in psychiatric wards of 1.9%. Surgery was performed in 12,430 patients. HAI was registered in 13.4% of operated patients, including 6.2% due to surgical wound infections. Only 5% of non-operated patients had HAI. In somatic wards, 0.6–1% were re-admitted with HAI, 15.2–23% had infections, including non-hospital infections and 18–23% used antibiotics.

The prevalence of hospital infections went down to the lowest level in 2002 ($P < 0.001$). From 2003 on, there was a significant increase of hospital infections ($P = 0.010$) in somatic wards ($P = 0.002$), in non-operated patients ($P = 0.024$) and in extra costs ($P < 0.001$). Thus, over time, hospital infections in somatic wards showed a reduction, associated with most types of hospital infections, down to a minimum level in 2002, with thereafter a significant increase when compared with infection in psychiatric wards.

There was a 30% increase of somatic patients treated in 2007 (458,751) compared with 2003 (318,428), including discharged, polyclinic and day-treatment patients ($P = 0.054$). During the same period, the total workload per work position was 27% higher in 2007 than in 2003 ($P = 0.024$). There also seemed to be some change in structure of the workforce after 2002 with an increase in administrative and office personnel and reduction of service and technical functions, including cleaning service, and no significant increase in nursing staff. Thus, as mentioned earlier, increase in total patient workload after 2002 was not followed by any increase in the patient-near, care-giving staff or internal service staff.

**What is already known on this topic**

From 2002 on, the Norwegian healthcare system was reorganized and the responsibility of each county for their public hospitals was transferred to a new regional, governmental public hospital health enterprise. This was done in order to be more effective and economical. A study from 2005 showed that this resulted in more corridor patients, lower staff: patient ratio and a total rate of re-admittances of 10%.25 In addition, there were 1000 fewer hospital beds in 2007 and there were also 1100 fewer beds in nursing homes to take care of hospital patients ready for transfer to nursing homes.24 The expenses to healthcare in Norwegian public hospitals have increased ever since 2002.24,25

It is well known that the burden of hospital infections is increasing, resulting in overuse of antibiotics and the spread of resistant microbes.22,26–28 Surveillance systems are important methods to document this burden, risk factors, extra costs and the effect of infection control.3,6,10,11,14–16 In Europe, the prevalence is reported to be between 4.4% and 14.8%.5–13,18–20,22,27–35 Basic principles of hygiene are not enough to stop infections when pathogenic and resistant microbes are spread by overcrowding, understaffing, and transfer of patients and personnel between departments and institutions.30,31,36–40 Patients should be admitted to single rooms each with its own anteroom and bathroom, to separate their microbes from others, and there should be sufficient hospital beds and single patient rooms.

**What this study adds**

Monitoring infection rates in hospitals by repeated PP studies may lead to the detection of changes over time that may be associated with changes in hospital activity and management. In this study, the hospital infection rate increased at the same time when there was a reorganization of the healthcare system in Norway. The hospital infection rate increased significantly and nearly parallel with the increase of the total workload per work position and with the reduction of internal service and technical activity, including personnel for cleaning.

**Limitation of the study**

The total prevalence of HAI in Norway is not known, since only four infection types have been included in the national surveys over the last 10 years.21,23 Statistical analyses confirming the total rate of hospital infections in Norway is therefore not available. The study covers only HAI registered when the patients were admitted to the hospital. Comparisons are difficult to make between surveys that do not include all types of HAI. For example, some restrict
their studies to the historically most common infections.21,23 Therefore, valid comparisons of overall prevalence cannot be made, although specific infection comparison can be made.

Conclusion

Reorganization of healthcare may have an impact on infection control and HAI if it results in an increase in the total workload per work position. This may be of special importance for patient-near staff and internal service in hospitals with a high total burden of infections, high use of antibiotics, corridor patients and mixing of patients in overcrowded rooms with common bathrooms.

References


