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In-hospital deaths attributable to healthcare-associated infections

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BACKGROUND

It is estimated that approximately one-third of in-hospital deaths in Norway are attributable to adverse events, while the proportion caused by infection is unknown. Oslo University Hospital provides a full range of medical specialties on a national and regional level while serving as a local hospital for a population of approximately 300 000. We wished to investigate in-hospital deaths associated with fatal adverse events, and healthcare-associated infections in particular.

MATERIAL AND METHOD

The study is based on a review of the medical records for all patients who died in Oslo University Hospital's somatic units in 2011. Infections were classified according to the criteria of the Centers for Disease Control and Prevention, USA.

RESULTS

Out of a total of 82 341 admitted patients, 1 126 died while in hospital. We identified life-shortening adverse events in 128 (11.4 %) of these. The 87 patients at Ullevål hospital had a mean age of 73 years, while the 41 patients at Rikshospitalet/the Norwegian Radium Hospital had a mean age of 62 years. A total of 108 patients (9.6 %) died from a healthcare-associated infection, 49 of whom had a predicted survival of more than four weeks (4.4 % of the fatalities). Fifty-eight patients had pneumonia.

INTERPRETATION

The proportion of deaths that were attributable to adverse events was lower than previously estimated in Norway. Oslo University Hospital, with its combined functions and broad patient base, can provide representative figures for healthcare-associated infections with fatal outcome in Norwegian hospitals.

Healthcare-associated infections represent a significant cause of in-hospital deaths (1). Previous estimates suggest that approximately one-third of deaths in Norwegian hospitals are attributable to adverse events, while the proportion caused by infections has not been specified (2). That study was based on Global Trigger Tool methodology, which involves recording a wide range of adverse events of varying character and severity and estimating mortality based on a pre-determined percentage (3).

Oslo University Hospital is a large hospital with a wide patient base. Many of its demanding tasks involve patients who are exposed to infection. We wished to provide validated figures for fatal adverse events, including healthcare-associated infections, in Oslo University Hospital's somatic units, based on a review of the patient records of all those who died in the hospital in 2011.

Material and method

The study's patient base was retrieved from the PasDoc digital patient records system. In 2011, a total of 82 341 unique patients were admitted to Oslo University Hospital on one or more occasions. Many of them had conditions and/or were undergoing treatment that carry a considerable risk of infection (cancer treatment, organ transplants, life-threatening injuries, etc.) A total of 1 126 patients (1.4 %) died while in hospital.

We chose to conduct a complete review of all patient records in order to secure the best possible register of infections, including their classification, type and impact on the patient care pathway (retrospective case record review) (4– 9). All patient records, except for those of six premature neonates (our methodology is not considered suitable for these patients) (10), were reviewed by one (PHB) or two (PHB, EL) of the authors. We defined an adverse event as an unintended injury which in our assessment would be life-shortening and which was associated with the healthcare provided rather than with the patient's disease (10). We recorded healthcare-associated infections as well as other types of adverse events.

We defined healthcare-associated infection as a localised or systemic infection that arises during a stay in hospital and that was not detectable at the time of admission. This definition is based on the criteria set by the Centers for Disease Control and Prevention (CDC) (11). However, we included clinical pneumonia without radiologically established infiltrate in some cases, if there was a short life expectancy, thereby accepting the clinicians' diagnosis as recorded, despite not completely fulfilling the CDC criteria. It would be inappropriate to classify respiratory tract problems, clinically referred to as pneumonia, as a fatal healthcare-associated infection in patients with late-stage disease who were admitted to receive terminal care. It is therefore important to assess the findings in relation to the prognosis (4, 12). For this reason, we have chosen to focus on the group of patients who were expected to live for longer than four weeks.

We made a clinical assessment of the severity of the infection, postoperative complications and other events. We used the McCabe method to assess the patient's prognosis (13). This method was originally introduced in order to study Gram-negative bacteraemia in patients, and involves three main classifications: rapidly fatal, ultimately fatal (within four years) and non-fatal disease. Underlying disease(s) with diagnosis and pathological stage are the most important elements. A clinical assessment is made in which age and medical conditions such as organ failure, cardiovascular status and malignancy are included, as well as notes on prognosis.

By referring to a Dutch study, we were able to specify more prognosis categories than McCabe (4). The prognoses were split into five groups: < 4 weeks, 4 weeks–6 months, > 6 months–2 years, > 2 years and indefinite/indeterminate. Leukaemia is an example of the latter category (indeterminate), because there is potential for recovery after treatment. The classification has to be somewhat arbitrary, as noted by McCabe, and is based on the severity of the underlying disease rather than the specific diagnosis.

We have not studied adverse events in the remaining patient population (81 215 individuals). Patients who died after being discharged from hospital have not been included in the study. The project was approved as a quality assurance initiative at Oslo University Hospital.

Results

A total of 1126 patients died while in hospital. After excluding six highly premature neonates, 1120 cases were assessed. Adverse events which we considered to be significant to the fatal outcome, were identified in 128 patients (11.4 %), 75 men and 53 women. A total of 108 patients died (9.6 % of all deaths) with a healthcare-associated infection (table 1). A total of 59 patients with healthcare-associated infections had a prognosis of < 4 weeks (table 2). Among 65 patients with a prognosis of four weeks or more, or an indefinite prognosis, 49 died of a healthcare-associated infection (table 2) and 16 as a result of other events. Pneumonia and bloodstream infections were the most common. Among 21 patients with a fatal bloodstream infection, 14 had a malignant disease, six of whom had late-stage cancer and eight had leukaemia or lymphoma. There were 15 patients for whom a bloodstream infection had been identified without known organ dysfunction, while three had pneumonia combined with a bloodstream infection, and three had a surgical wound infection combined with a bloodstream infection.

Table 1

Number of adverse events which we considered to be significant to the fatal outcome, in 1 120 patients who died at Oslo University Hospital in 2011. Patients grouped by prognosis.

Prognosis	All events	How many of the events were caused by infection
< 4 weeks	63	59
4 weeks or more	65	49
4 weeks – 6 months	41	36
> 6 months–2 years	10	6
> 2 years	4	2
Indeterminate	10	5
Total number	128	108

Table 2

Types of healthcare-associated infection in 108 of 1 120 patients who died at Oslo University Hospital in 2011. Patients grouped by estimated prognosis.

Classification of infections	Number of patients	Prognosis				
		< 4 weeks	4 weeks – < 6 months	> 6 months – 2 years	> 2 years	Indeterminate
Pneumonia with/without bloodstream infection	58	36	19	1	1	1
Bloodstream infection	15	3	8	2		2
Clinical septicaemia[1]	11	8	2			1
Surgical wound infection (deep/organ) with/without bloodstream infection, or infection related to invasive procedures	17	6	7	2	1	1
Other infections	7	6		1		
Total	108	59	36	6	2	5

[1]This category is based on clinically diagnosed septicaemia without conclusive blood culture results and therefore does not conform with the CDC criteria in this respect.

At Ullevål hospital, 800 patients died. Life-shortening adverse events were identified in 87 patients (10.9 %). Mean age at the time of death was 73 (range 1–102 years, median 77 years). A malignant disease was established in 33 of them (37.9 %). Healthcare-associated infections arose in 74 patients (85.1 % of all who suffered adverse events). Thirty of them (including eight with a malignant disease) had an estimated prognosis of more than four weeks, 3.8 % of all deaths. Bloodstream infections were identified in nine patients, seven of whom had an estimated prognosis of more than four weeks.

At Rikshospitalet/the Norwegian Radium Hospital, 320 patients died. Life-shortening adverse events were identified in 41 patients (12.8 %). Mean age at the time of death was 62 (range 1–87 years, median 66 years). A malignant disease was identified in 28 patients (68.3 %). Healthcare-associated infections arose in 34 patients (82.9 % of deaths associated with adverse event). Of these, 19 patients had a prognosis of more than four weeks, 5.9 % of all in-hospital deaths. Bloodstream infections were identified in 12 patients, 10 of whom had an estimated prognosis of more than four weeks.

There was a variety of bacteriological findings for the documented bloodstream infections. Findings of resistant bacteria were not frequent (data not shown).

We found serious non-infectious events in 20 patients, of which 16 had a predicted prognosis of more than four weeks, 1.4 % of all deaths. These events included unexpected cardiac arrest, aspiration, surgical complications, thromboembolic episodes and opioid overdose.

Discussion

The size of Oslo University Hospital and its patient base could provide data for calculating the rate of in-hospital mortality caused by healthcare-associated infections in Norway. We found that 11.4 % of all deaths can be related to adverse events, and that healthcare-associated infections accounted for approximately 84 % of these (9.6 % of all deaths). Determining whether a patient dies from or with an infection (or another adverse event), is particularly difficult for multi-morbid patients (14). The prognosis for most patients with a

fatal healthcare-associated infection was considerably reduced due to advanced age, malignant disease or organ failure.

Some patients with late-stage disease are hospitalised in order to receive terminal care. This is particularly the case at Ullevål. Limited resources are put into pneumonia prevention for terminal patients and antibiotics are not always administered. It would be somewhat inappropriate to classify respiratory tract problems, clinically referred to as pneumonia, as a fatal healthcare-associated infection in these patients. However, we chose to include clinical pneumonia without radiologically proven infiltrate, despite the fact that this does not meet the criteria set by the Centers for Disease Control and Prevention. We would otherwise have ended up with lower pneumonia figures for the group of patients whose prognosis was less than four weeks, but only for this particular group. It is important to consider findings in relation to prognosis, as discussed by Flaatten et al. (12).

We have based our prognoses on the McCabe classification which involves an assessment based on age, diagnosis, stage, type of malignancy and severity of organ failure. This can be advantageous when judging prognoses, because the relevant information is most often found in the patient records. The Charlson system uses a numbered risk score for certain diagnoses and conditions (15). Despite a certain popularity, medical developments may suggest that the Charlson system is no longer a suitable tool for classifying prognoses, particularly in cases of lymphoma, leukaemia and HIV infection (16, 17).

Data published by the Norwegian Research Centre for Health Services and based on the Global Trigger Tool suggested that approximately 4723 patients died as a consequence of in-hospital trauma in 2010. This accounted for 32.7 % of all in-hospital deaths in Norway (2). The figures attracted significant public and political attention. They differ markedly from the international experience (4), and from our own findings for the same period. In our opinion, surrogate estimates based on the Global Trigger Tool method should not be used. In a case review study of all 372 patients above the age of 18 who died at Nordland Hospital in 2013, the researchers found, using a modified Global Trigger Tool method, a somewhat larger proportion of adverse events with a fatal outcome than we did (18). Approximately half were respiratory tract infections. Two other Norwegian studies, with considerably higher numbers of patients included, coincide with our findings (12, 19). These studies also involved a review of the medical records of patients who died in hospital, but they did not present figures specifically for infections.

Our choice of methodology is supported by a Dutch study which included 3 983 deaths at 21 hospitals of varying size and category (4). They found that 4.1 % of fatalities were caused by preventable adverse events, but did not specify infection rates. It is our opinion that a study of fatal adverse events, particularly infections, should be conducted by instigating a full case review of patient records, including access to all relevant clinical data as well as microbiology, histopathology, radiology and clinical chemistry findings, and in some cases autopsy records. This would be a time-consuming exercise, but has been achieved in some large-scale studies (6–9). An American study found that healthcare-associated infections accounted for one-third of unexpected deaths, but the threshold for 'unexpected' was set to six months (9). If we had set a six-month threshold, the proportion of infections in our material would have been higher (13/24).

Studying your own institution comes with a risk of bias. The figures from Oslo University Hospital are on a par with, or somewhat higher than, those of comparable studies (4, 12, 19, 20). Our infection data are based on accepted criteria (11). This carries less risk of bias than the recording of adverse events generally (5, 8, 21, 22). Our data reflect underlying diseases as well as treatment methods. Modern treatments include methods that expose patients to infection, such as immunosuppression, cytostatic drugs, organ transplants, extensive cancer surgery and demanding traumatology. We have presented some of the data from the Ullevål and Rikshospitalet hospitals separately. The differences primarily reflect these hospitals' dissimilarities in terms of patient base. Among patients with pneumonia we found that the majority had a prognosis of less than four weeks (62 %). Among patients with

bloodstream infections, there was a wider range of estimated prognoses. The fact that there was a greater prevalence of bloodstream infections at Rikshospitalet/the Norwegian Radium Hospital, can be explained by differences in the patient base. Both pneumonia and sepsis prophylaxis are difficult conditions in high-risk patients (14). The range of microbiological findings in bloodstream infection cases may point to the endogenous flora being an extra challenge in cases of prophylaxis. Weakened barriers and bacteraemia secondary to processes in another body site are common. The patient records did not include sufficient information for us to assess the connection with central venous or peripheral catheters.

Our figures and assessments of comorbidity coincide with the data presented by others and show the justification for grouping patients according to their predicted prognosis (14). Researchers in Canada also accentuate pathological stage when assessing in-hospital morbidity (23). In our data, patients with a malignant disease make up a large group. As pointed out by Weinstein: 'Nosocomial infections typically affect patients who are immunocompromised because of age, underlying diseases, or medical or surgical treatments' (24).

We have not attempted to estimate how many infections could have been prevented. Advancing age and serious conditions, such as organ failure and malignant disease, as in our patients, make this a difficult exercise (25). As evidenced in the Netherlands, the potential for prevention is greatest if the prognosis is more than six months (4). Few of our patients were in this category. It is also possible to overestimate the potential for prevention (7).

Care must be taken when estimating how many deaths are preventable, as this is difficult to establish (26–28). The complexity of modern hospital treatment is a point to be considered, and considerable variation has been found in the assessments of different researchers (26, 27). A recent Canadian publication maintains that genuinely preventable deaths are rare (29).

MAIN FINDINGS

In our material, infections caused the majority of deaths associated with adverse events.

In-hospital mortality following a healthcare-associated infection, mostly pneumonia and bloodstream infections, was particularly high among elderly patients with serious underlying disease and a significantly reduced prognosis.

Deaths attributable to adverse events were considerably less prevalent than in the estimate published by the Norwegian Research Centre for Health Services.

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