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Article

Article

Patient and hospital characteristics that influence incidence of adverse events in acute public hospitals in Portugal: a retrospective cohort study

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Abstract

Objective: To analyse the variation in the rate of adverse events (AEs) between acute hospitals and explore the extent to which some patients and hospital characteristics influence the differences in the rates of AEs.
Design: Retrospective cohort study. Chi-square test for independence and binary logistic regression models were used to identify the potential association of some patients and hospital characteristics with AEs.
Setting: Nine acute Portuguese public hospital centres.
Participants: A random sample of 4250 charts, representative of around 180 000 hospital admissions in 2013, was analysed.
Intervention: To measure adverse events based on chart review.
Main Outcome Measure: Rate of AEs.
Results: Main results: (i) AE incidence was 12.5%; (ii) 66.4% of all AEs were related to Hospital-Acquired Infection and surgical procedures; (iii) patient characteristics such as sex (female 11%; male 14.4%), age (≥65 y 16.4%; <65 y 8.5%), admission coded as elective vs. urgent (8.6% vs. 14.6%) and medical vs. surgical Diagnosis Related Group code (13.4% vs. 11.7%), all with $p < 0.001$, were associated with a greater occurrence of AEs. (iv) hospital characteristics such as use of reporting system (13.2% vs. 7.1%), being accredited (13.7% vs. non-accredited 11.2%), university status (15.9% vs. non-university 10.9%) and hospital size (small 12.9%; medium 9.3%; large 14.3%), all with $p < 0.001$, seem to be associated with a higher rate of AEs.
Conclusions: We identified some patient and hospital characteristics that might influence the rate of AEs. Based on these results, more adequate solutions to improve patient safety can be defined.

Key words: patient safety, adverse events < patient safety, hospital care < setting of care, public health < health-care system, health-care associated infections < complications

Introduction

The identification and measurement of adverse events (AEs) is crucial for enhancing patient safety, hierarchizing priorities for intervention, defining important research areas, and evaluating the impact of the developed solutions in improving safety and quality of care.

In the last 15 years, several studies have been developed with the aim of estimating the rate of adverse events and characterizing their nature, impact and preventability in several countries, including Portugal [1–4]. In response to the results of those studies, patient safety strategies, programmes and interventions have been implemented with a view to improving patients' outcomes by reducing the harm associated with the health-care delivered. However, globally, the problem of patient harm continues to exist and turning the problem around has proven difficult.

More recently, some comparative longitudinal studies within the same group of hospitals have been published [5–9], comparing AEs between countries [10], evaluating the costs associated with AEs [11, 12]; analysing the reliability of the research methods based on medical record reviews [13–15], and making comparisons of AEs between hospitals and departments [9, 16].

A small number of those studies have included some analyses regarding patient complexity/case mix (e.g. the Charlson Comorbidity Index) and some characteristics of hospitals (e.g. university vs. non-university, accredited vs. non-accredited hospitals) [17, 18]. However, there is limited information regarding the extent to which specific patient and hospital characteristics can influence the differences in the rates of adverse events. This knowledge is of most value in helping leaders and health-care professionals define and implement specific strategies and approaches, according to patient risks, and in contributing to the improvement of hospital conditions towards an environment of safer care.

The aims of this study were to analyse the variation in the rates of adverse events between acute public hospitals in Portugal and to explore the extent to which some patient and hospital characteristics are associated with rates of adverse events. In this study, we also estimated costs related to the additional length of stay due to the occurrence of AEs.

Methods

This work was based on a retrospective cohort study and was carried out at nine acute public hospital centres in Portugal. Although the participating hospitals were selected by convenience, they reflect the major characteristics of other public hospitals in Portugal regarding dimension (number of beds), 24-h emergency department, intensive care unit, medical and surgical departments, and case mix index of patients treated. No specialist hospitals (e.g. Paediatric, Oncology and Obstetric) were included in the study.

The sampling frame included all admissions of patients over 18 years old who had a minimum stay in hospital of 24 h. Hospital admissions with a primary diagnosis related to psychiatry were excluded. The samples were stratified per hospital cluster, based on the total number of inpatient episodes per year. Taking into consideration hospital size (inpatient episodes per year), and through the use of percentiles (cut-offs: P33 and P66), three groups/clusters of hospitals were defined: small hospitals, those that have up to 10 000 inpatient episodes per year; medium-size hospitals, from 10 001 to 18 000; and large hospitals, with over 18 001 inpatient episodes per year. The global sample size was 4250 medical charts, assuming a margin of error of 1%, a 95% confidence level and an expected AE rate of 11.1% [4, 19], representative of around 180 000 hospital admissions (which corresponds to around 24% of all adult hospital admissions in Portuguese public hospitals for the period under analysis—01 January to 31 December 2013). After that, taking into consideration the proportions of admissions in each type of hospital (small, medium and large), the final sample sizes were: 2 small hospital centres sampling 290 medical charts each; 3 medium-size hospital centres sampling 470 medical charts each; and 4 large hospital centres sampling 565 medical charts each. Random numbers per hospital were then generated [19] and the corresponding medical charts were identified and included in the study.

The methods and main definitions used in this study were based on the protocol used in the Harvard Medical Practice Study [20] with the subsequent modifications introduced in a Canadian study [1]; this latter protocol was used in a pilot Portuguese study [4]. A two-stage structured retrospective medical records review was done based on the use of 18 screening criteria. In the first stage, a group of 38 nurses (composed of two to four from each hospital and with a minimum of 5 years experience in clinical audits) assessed the medical records, in order to find the presence of at least one of the 18 screening criteria for the presence of a potential adverse event. In Stage 2, a group of 26 physicians (with a minimum of 5 years experience in clinical codes and in clinical audits) reviewed each positive record in order to confirm the presence of an adverse event, estimate its impact and determine its preventability according to a previously established definition. The degree of agreement between the reviewers in each stage was calculated by using the kappa coefficient. Agreement rate was calculated by dividing the total number of concordant answers by the number of total answers.

International Classification of Diseases (ICD) codes in main and secondary diagnoses and procedures were collected from all patients. Based on the main and secondary diagnoses, we estimated the Charlson Comorbidity Index (CCI) for each patient sample. Hospital characteristics, such as accreditation status, the existence of an AE report system and an electronic drug-prescribing system, type of hospital—university vs. non-university—and the size of hospitals (based on the number of admissions per year) were also considered.

As a first approach, global and per hospital rates were computed while considering the incidence of adverse events, preventability rates, the proportion of AEs without harm or with minimum injury and the proportion of deaths. Confidence intervals were computed using a conventional formula for relatively large samples ($n > 30$). Moreover, the proportion of AEs that caused extra bed days and the mean of extra bed days were estimated together with the consequential additional costs. The costs related to the additional length of stay were estimated based on official accounting data from the NHS hospitals, providing information on daily costs.

Chi-square independency tests and binary logistic regression models (method: enter) were used to characterize potential associations of AEs with patient characteristics (e.g. age, sex, medical vs. surgical DRG code, urgent vs. elective admission) and hospital characteristics (e.g. existence of an AE report system, accreditation status, electronic drug-prescribing system, university vs. non-university, and size). The *t*-test was used to compare Charlson Comorbidity Index means, considering both AE and no AE event groups. SPSS (version 22) was used for data processing and for statistical analysis. All tests were performed with a level of statistical significance of 0.05. The study was approved by the Ethics Committee of the hospitals.

Results

A total of 4225 admissions from nine hospital centres were analysed. One or more of the criteria for an adverse event were identified in 1029 reviewed medical records (24.3%). Of these 1029 records that passed to the second screening, a total of 529 (51.4%) were confirmed as an AE, representing an overall incidence rate of 12.5% (529/4225) with a 95% CI (11.5%; 13.6%). Of the AEs identified, 39.7% (210/529) were hospital-acquired infection, 26.7% (141/529) were related to surgical procedures, 9.8% (52/529) were due to drug errors, and 7% (41/529) were falls. The remaining 17% were related to pressure ulcers, accidental burns and diagnostic errors.

Most of the AEs (66.1%—350/529) occurred in patients aged 65 or over. Comparing groups with and without AEs, age presents a mean difference of 8.2 years (mean ± standard deviation: 68.7 ± 17.2 vs. 60.5 ± 20.4 years old, respectively).

Most of the AEs (67.4%—356/529; CI 63.4–71.4) resulted in no or minimal physical impairment or disability, and were satisfactorily resolved during the admission, or within one month of discharge. We estimated that 3.0% (16/529; CI 1.5–4.5%) of the AEs resulted in permanent disability according to the pre-established definition [1, 4] and 12.5% (66/529; CI 9.7–15.3%) resulted in death. With regard to preventability, 39.9% (211/529; CI 35.7–44.1%) were classified as preventable.

The reliability of the assessment of screening criteria performed by nurses was considered moderate (k = 0.58; CI 0.41; 0.74 and p = 0.000; 82% agreement). In the second stage, the inter-rater agreement for the determination of AEs by doctors was considered good (k = 0.77; CI 0.53; 1.01, p = 0.000, 89% agreement).

We also found that 60.8% (322/529; CI 56.6–65.0%) of the patients who experienced AEs incurred extra bed days in hospital (a total of 3091 extra days, at an average of 9.6 days per patient, ranging from 1 to 73 days), with an additional estimated cost of €1.9 million for the NHS. Of these 1.9 million, around 1.1 million were associated with AEs considered avoidable.

Table 1 shows some descriptive statistics of the total rate of AEs, distributions per sex, preventability, death and prolonged length of stay (LOS), computed based on hospital-level aggregated measures.

Bivariate analysis

Some patient characteristics were associated with large rates of AEs, such as being male (14.4%), aged over 65 years old (16.4%), admissions coded as urgent (14.6%) and medical DRG type (13.4%). The Charlson Comorbidity Index (with a mean of 3.05 in the AE group vs. 2.27 in the no AE group, $p < 0.001$) also showed statistical pertinence (Table 2).

As regards hospital characteristics, the following categories presented higher rates of AEs, with statistical relevance ($p < 0.001$): the use of a reporting system (13.2%), accredited status (13.7%), university type (15.9%) and the size of the hospitals (small 12.9%, medium 9.3% and large 14.3%) (Table 3).

Table 4 shows the strength of the associations of those patient and hospital characteristics with the occurrence of AEs.

In terms of patient characteristics, male gender (OR = 1.36; p = 0.001), age >65 years old (OR = 2.10; $p < 0.001$), urgent cases (OR = 1.83; $p < 0.001$) and CCI score (OR = 1.21; $p < 0.001$) all presented higher probabilities of suffering an AE. With regard to hospital characteristics, the existence of a reporting system (OR 2.01; $p < 0.001$), being accredited (OR = 1.54; p = 0.014), medium size (OR = 0.69; p = 0.012) and teaching status (university hospital, OR = 1.54; $p < 0.001$) all present higher probabilities of AEs.

Discussion

In this study, reviews of medical records were performed in order to assess the variation in the incidence, nature, and clinical and economic impact of adverse events between hospitals. The study also aimed to provide some insights into the relationship between the rate of those events and some of the patient and hospital characteristics.

The total rate of AEs was 12.5%, which is in line with previous studies [3, 4, 16]. The majority of AEs (66.1%) occurred in patients aged 65 or older. This is an important finding because it allows us to identify a particularly vulnerable population that is more likely to have several health conditions, receive multiple treatments, be often prescribed a wide range of medication and stay longer periods in hospital [17, 18, 21], i.e. a population at a higher risk of suffering an AE. Moreover, this demographic shift towards an older population associated with the complexity of care delivery creates a new potential for error and harm and, for that reason, a challenge for patient safety [22].

Of all AEs, 39.7% were related to hospital-acquired infections, followed by 26.7% associated with surgical procedures and 9.8% related to medication. Similarly to other studies, these three types of occurrences represent 76.2% of all AEs—over three-quarters of the total number of identified AEs [3, 5, 10, 14]. The identification and prioritization of areas to be enhanced, based on their casuistic and clinical, economic and social impact, is a very rational strategy for quality and safety improvement. Therefore, the adoption of good practices, some of them very simple, such as the use of bundles for insertion and maintenance of central venous and urinary catheters, the strict compliance with the five moments of hand hygiene, the use of surgical checklists and medication reconciliation, will be translated into huge safety gains [23–26].

The majority of AEs (67.4%) did not result in any significant physical impairment or disability, and were resolved during the in-hospital period. However, a small but significant proportion of patients died or experienced a permanent disability as a result of

Table 1 Descriptive statistics of AEs rates, sex, preventability, death and prolonged LOS, using hospital-level information

	Total AE (%)	AEs in female group (%)	AES in male group (%)	Preventability (%)	Death (%)	Prolonged LOS (%)
Min	6.8	5.4	7.7	5.9	4.5	48.1
Max	20.0	16.7	22.9	68.4	23.5	82.4
Mean	11.3	10.3	12.7	38.8	13.1	60.3
SD	4.8	3.9	6.0	20.1	7.2	12.3
Median	10.0	9.3	10.8	41.5	11.9	55.6

SD, standard deviation.

Table 2 Association between AE and patient characteristics

Patient characteristics	Total (*n*)	AE, *n* (%)	Without AE, *n* (%)	*p*-value
Sex				
Male	1896	273 (14.4%)	1623 (85.6)	0.001
Female	2328	256 (11%)	2072 (89%)	
Age				
<65 years old	2084	178 (8.5%)	1906 (91.5%)	<0.001
≥65 years old	2141	351 (16.4%)	1790 (83.6%)	
Elective vs. urgent				
Elective	1470	126 (8.6%)	1344 (91.4%)	<0.001
Urgent	2755	403 (14.6%)	2352 (85.4%)	
Medical vs. surgical				
Medical	2075	278 (13.4%)	1797 (86.6%)	<0.001
Surgical	1866	218 (11.7%)	1648 (88.3%)	
CCI (Charlson Comorbidity Index)	4225	529	3696	<0.001
		3.05[a]	2.27[a]	

[a]Independent-samples *t*-test (comparing means).

Table 3 Association between AE and hospital characteristics

Hospital characteristics	Total (*n*)	AE, *n* (%)	without AE, *n* (%)	*p*-value
Reporting system				
Yes	3731	494 (13.2%)	3237 (86.8%)	<0.001
No	494	35 (7.1%)	459 (92.9%)	
Accreditation status				
Yes	2297	314 (13.7%)	1983 (86.3%)	<0.001
No	1928	215 (11.2%)	1713 (88.9%)	
Type of hospital				
University	1356	216 (15.9%)	1143 (84.1%)	<0.001
Non-university	2866	313 (10.9%)	2553 (89.1%)	
Hospital dimension				
Small (<10 000 admission/year)	721	93 (12.9%)	628 (87.1%)	<0.001
Medium (from 10 001 to 18 000 admissions/year)	1321	123 (9.3%)	1198 (90.7%)	
Large (≥18 001 admissions/year)	2183	313 (14.3%)	1870 (85.7%)	
Electronic prescribing drug				
Yes	2239	295 (13.2%)	1943 (86.8%)	0.183
No	1987	234 (11.8%)	1753 (88.2%)	

their AE (12.5% and 3.0%, respectively). This is a similar percentage to that reported in other studies [1, 2].

Our findings show that the majority of patients (60.8%) who experienced AEs prolonged their length of stay in hospital by on average 9.6 days, with an estimation of additional costs of €1.9 million, of which 1.1 million were associated with preventable AEs. This is an underestimated value as it does not take into account costs related to additional ambulatory treatment or other hospitalizations related to the same AE. Moreover, it does not account either for other indirect and social costs (e.g. premature death, absence from work). As other studies have highlighted, there is an urgent need for more detailed and rigorous analyses in order to achieve robust results regarding the economic impact of AEs [12, 27].

The inter-rater agreement, for identifying a positive criterion and for the confirmation of an AE were considered moderate and good, respectively. These results are in line with those found in other studies [1, 13].

This study gives some insights into patient and hospital characteristics that can influence the rate of AEs. In the bivariate analysis, all the five patient covariates studied present differences that are statistically significant. The occurrence of AEs was higher in males, patients aged 65 or older, urgent admissions, surgical cases and patients with greater CCI scores. Elderly patients, due to natural physiological and physical changes associated with aging, present frailer and weaker health conditions, have a higher number of risk factors and co-morbidities, which results in the need to receive several treatments (in some situations of high complexity), take multiple medication and stay longer periods in hospital to recover from their illness [14, 21, 28]. Therefore, the risk of slips, falls, acquiring an infection, being a victim of a medication error or having an adverse drug reaction is higher.

Patients who were admitted as urgent admissions, those with higher CCI scores and those that were submitted to surgeries present, in general, more severe and acute clinical conditions that require a more complex and riskier health-care delivery [17, 28].

With regard to hospital characteristics, those that have a reporting system, are accredited and have the status of university hospitals present a higher rate of AEs with differences that are statistically significant. One plausible explanation is the fact that those hospitals have a stronger culture of risk awareness and also a systematic practice of data collection and analysis [29, 30]. These results are in line with other studies that state that the estimated rates of AEs are only

Table 4 Strength of associations (OR) of patient and hospital characteristics with AE

		OR	95%CI	*p*-value
Patients characteristics				
Sex (Female[a])	Male	1.36	1.13–1.63	0.001
Age (<65 y[a])	≥65 y	2.10	1.73–2.54	<0.001
Elective[a]	Urgent	1.83	1.48–2.26	<0.001
Medical[a]	Surgical	1.17	0.96–1.41	0.105
CCI		1.21	1.15–1.26	<0.001
Hospital characteristics				
Reporting system (No[a])	Yes	2.01	1.40–2.86	<0.001
Accreditation status (No[a])	Yes	1.26	1.05–1.32	0.014
University hospitals (No[a])	Yes	1.54	1.28–1.86	<0.001
Hospital dimension (small[a])	Medium	0.69	0.52–0.92	0.012
	Large	1.13	0.88–1.45	0.334
Electronic prescribing drug (No[a])	Yes	0.88	0.73–1.06	0.17

[a]Reference class.
OR, odds ratio; CI, confidence interval.

the 'tip of the iceberg', as the magnitude of the problem is much larger [14, 31]. Nevertheless, better quality of data and better use of the same will contribute to the designing of safer systems, and to reducing the frequency of AEs.

Some studies have also found that university hospitals have higher rates of AEs. The fact that university hospitals have more advanced technology, enabling them to provide specialized services, and treat rare diseases and severely ill patients, means that they receive the most critical cases and, therefore, provide more complex and riskier care [29, 32]. Moreover, due to the teaching status (medical education and training of other health-care professionals) of these hospitals, the large number of students that come into contact with patients, carrying with them different levels of knowledge and safety culture awareness, may contribute to the large variation in processes and impacts on health outcomes.

In order to have more robust information to help policymakers, health managers, health-care professionals, patients and their families to develop and adopt measures that will improve safety and quality of care, additional research is needed to explore organization, patient and care characteristics that may contribute to higher rates of AEs.

This study presents some limitations, starting with those underlying retrospective studies, such as information bias and hindsight bias. In our analyses, we didn't account for possible bias related to different levels of hospital awareness of the occurrence of AE that can influence the results obtained, namely the use of an electronic drug-prescribing system, accreditation status and a reporting system. At the time the study was being developed, the introduction of electronic drug-prescribing systems was just starting and the reporting system for AEs was in an early stage in some hospitals.

It would be good to use, in future studies, larger samples and complementary methods, namely qualitative approaches, in order to obtain more comprehensive and robust results. Despite the weaknesses and limitations present in this type of study, retrospective analyses of medical charts still represent the most used and the gold standard method for assessing the incidence and monitoring frequency of AEs [1, 3, 5, 8, 10, 13, 15].

We assume that the effects of the patient and hospital variables studied partly reflect the most relevant collected characteristics that could influence the rate of AEs. Future research is, therefore, needed in order to provide a stronger body of knowledge that will allow optimal adjustment for the patient case mix and hospital specificities to be obtained. Only with such data will it be possible to tailor safety procedures/solutions that will result in the improvement of care for different groups of patients according to their risk of suffering an AE.

Conclusion

Despite some limitations, this study adds some interesting insights related to patient and hospital characteristics that can influence the frequency of AEs in Portuguese public acute care hospitals and also the burden of injury resulting from the same.

These results could be seen as a small but important step toward enhancing safety in the care provided in Portuguese public acute hospitals. Knowledge of a set of characteristics related to the population treated and to the structure of such hospitals, where care is delivered, is crucial in helping to develop and implement strategies and solutions aimed at reducing AE rates and, therefore, in moving towards a culture and practice of quality and safety of care.

Hospital adverse events continue to be an important public health issue. They constitute a burden in terms of clinical, economic and social impact and, for that reason, they are a challenge for the health system not only in Portugal but also worldwide.

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