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Preventable trauma deaths

ABSTRACT

OBJECTIVE: To describe methods of estimation and assess preventable deaths and types of errors related to health care.

METHODS: A systematic review of articles on preventable trauma deaths published between 2000 and 2009 was conducted. Lilacs, SciELO and Medline databases were searched using the keywords "trauma," "avoidable," "preventable," "interventions" and "complications" and the health sciences descriptors "death," "cause of death," and "hospitals."

RESULTS: A total of 29 articles published during the study period were selected. Most were retrospective studies (96.5%). The most common methods used to define avoidability of death were expert panel and injury severity scores. Deaths were categorized as follows: preventable; potentially preventable; and not preventable. The mean preventable death rate was 10.7% (SD 11.5%). The most commonly reported errors were inadequate care management of injured patients and evaluation and treatment errors.

CONCLUSIONS: Inconsistent terms were used to categorize deaths and related noncompliances. It is suggested to standardize the terminology for the classification of deaths and types of errors.

DESCRIPTORS: Wounds and Injuries, complications. Trauma Severity Indices. Cause of Death. Review.

INTRODUCTION

Preventable deaths are a concept first applied in the 1970s by Rutstein et al,[33] defined as deaths that are totally or partially avoidable given effective health care. These deaths are a sentinel event to be investigated as it allows assessing the overall quality of care and can be used to evaluate care protocols and health care systems, and be a major indicator of performance and adequacy of management among trauma patients.[36]

Trauma is a serious health condition and can be defined as a harmful event resulting from the effect of mechanical, chemical, thermal, and electrical energy and/or radiation.[27] Traumatic wounds and injuries accounted for 23,960 deaths during hospital admission in the national health system (*Sistema Único de Saúde*, SUS) in Brazil in 2010. Trauma injuries accounted for around 6% of deaths during the same year.[a]

Death is considered avoidable when it meets the following three criteria: the individual survives trauma injuries and its consequences; care provided did not follow treatment guidelines; and errors in patient management contributed directly or indirectly to an individual's death.[6]

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[a] Ministério da Saúde (BR). Datasus. Informações de saúde. Estatísticas de mortalidade: óbitos por ocorrência segundo causas externas do Brasil. Brasilia (DF); 2010 [cited 2010 Jun 12]. Available from: http://tabnet.datasus.gov.br/cgi/tabcgi.exe?sim/cnv/ext10uf.def

The analysis of these sentinel events is hindered by resistance of health services in accepting responsibility for their own failures and the need to develop best practices to identify these events.

To establish the avoidability of a trauma death the patient's complete medical history including type and severity of injuries as well as information on care provided after the trauma event are required.[26] Studies have proposed criteria to be established and estimated such as the proportion of preventable deaths, expressed by the proportion of preventable deaths over total trauma deaths.

International guidelines including Advanced Trauma Life Support® (ATLS®), Pre-hospital Trauma Life Support® (PHTLS®) and Advanced Trauma Care for Nurses® (ATCN®) have been developed to ensure a systematic approach for the management of trauma patients. Failure to adhere to these recommendations may be considered care-related errors.

The approaches currently used for identification and classification of avoidable trauma deaths are impaired by the multidisciplinary care team failure to record information and lack of a standard method to determine avoidability of death. Inaccurate records lead to loss of information about injury severity and care treatment in the retrospective analysis of deaths and undermine the identification of their avoidability. The lack of a standard method prevents its development and comparison of results.

In view of inconsistencies in the analysis of avoidability of trauma deaths and its results the present study aimed to describe methods of estimation and assess preventable deaths and types of errors related to health care.

METHODS

A systematic literature review was conducted based on the following inclusion criteria: clinical research study in English, Portuguese or Spanish carried out from January 2000 to December 2009 reporting data on preventable trauma deaths. Book chapters, doctoral theses and dissertations and literature review and update articles were excluded.

Medline, Lilacs and SciELO databases were searched for articles published from August 2009 to February 2010 using the keywords "trauma," "avoidable," "preventable," "interventions," and "complications" and health sciences descriptors "death", "cause of death" and "hospitals."

Abstracts were selected by the title and full papers were obtained for those meeting the inclusion criteria. If there were not enough information available the article would be advanced to the next step of selection.

The following information were collected from the articles: journal, number of authors, country, language, year of publication, design and scope of the study (national or international multicenter or institutional), study country, target population (adult, children or both), data source (databases, autopsy reports, pre-hospital management, hospital and police records, and/or death certificates), and study period, type of sample (random, non-random), and sample size, classification of preventable deaths used by the authors in the articles and the method used to define avoidability of deaths: trauma severity scores (Trauma and Injury Severity Score [TRISS], Injury Severity Score [ISS], Abbreviated Injury Scale [AIS], Glasgow Coma Scale [GCS]); presence of specific clinical conditions associated with preventable deaths; and an expert panel. The expert panel is preferably composed of a multidisciplinary team with clinical experience that by consensus defines based on evidence avoidable deaths.[6]

The process of selection of articles included in the review is outlined in Figure 1.

Errors related to preventable deaths that were identified and classified in the studies were categorized as follows:

- inadequate trauma care: failure to successfully provide timely adequate care to injured patients due to inadequate or understaffed facilities.[23] Trauma

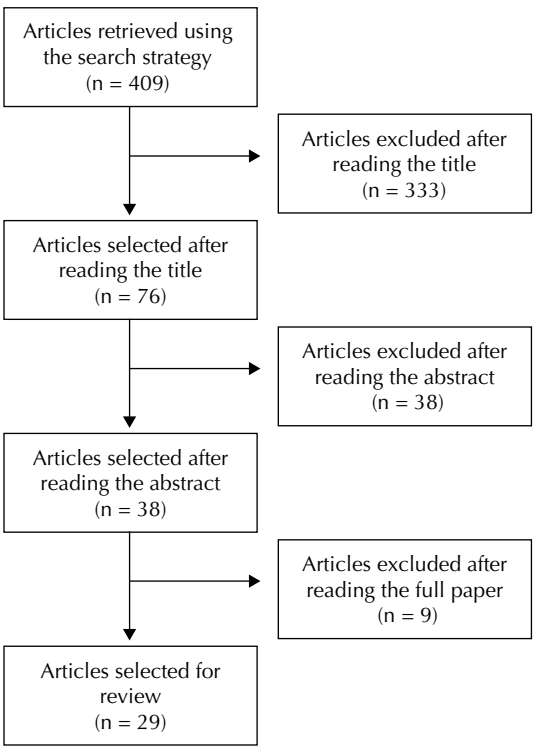

Figure 1. Flowchart of article selection. Medline, Lilacs and SciELO databases, 2000–2009.

care system is a network of services that provide definitive treatment to injured patients and should include prevention, ease of access, hospital care, rehabilitation and research activities;1

- evaluation/treatment errors: diagnosis, management or patient care not compliant with care guidelines;
- medical procedure errors: procedural error while establishing a diagnosis or management by a multidisciplinary team;
- diagnostic errors: diagnostic error due to misinterpretation, inadequate or incomplete medical evaluation or diagnostic procedure, and
- delay in diagnosis: a timely diagnosis is not made in the context of the patient's general conditions.[23]

Abstracts and full articles were read by two researchers separately and then the study variables were discussed and categorized. In the case of disagreement, a third researcher was consulted.

Measures of central tendency (means and medians) and dispersion (standard deviation) were estimated to characterize preventable deaths described in the studies. The data were analyzed in Excel 2003.

RESULTS

There were selected a total of 29 articles published in 11 different international publications between 2000 and 2009.[2-5,7-9,11,12,14-17,21,22,24-26,28-32,34-39] Most articles were published in English-speaking countries, especially in the United States (51.7%), England (17.2%), and Australia (13.8%). They were mostly published in English (96.6%) and the largest number of authors in a study was 12. There were no studies on the subject published in 2006 (Table 1).

Of the articles reviewed, 68.9% were national multicenter and 31.0% were institutional. The target population was adults in 41.4%, and adolescents in 27.6% (3.4% did not have information available). The most common data sources were hospital (82.2%), autopsy (72.4%) and pre-hospital management records (48.5%) followed by police reports (20.7%), death certificates (6.9%), and state databases of trauma patients (10.3%), Institute of Forensic Medicine (6.9%) and hospitals (3.4%).

Most studies were conducted in North America, mostly in the United States (37.9%). There were also found studies conducted in South America (Colombia), Europe (Italy, Denmark, Greece, Northern Ireland and the UK), Asia (Korea and Iran), and 24.1% of the studies on preventable death in trauma patients were developed in Australia (Table 2).

The sample sizes ranged from 34 to 35,311 and study periods ranged from one day to 16 years.

Table 1. Publication characteristics of the articles reviewed. Medline, Lilacs and SciELO, 2000–2009. (n = 29)

Publication characteristics	n	%
Publication name		
British Journal of Anaesthesia	1	3.5
British Journal of Surgery	2	6.9
Emergency Medicine	1	3.5
Emergency Medicine Australasia – EMA	2	6.9
European Journal of Epidemiology	1	3.5
Injury	2	6.9
Journal of Trauma	15	51.7
Journal of Clinical Neuroscience	2	6.9
Prehospital and Disaster Medicine	1	3.5
Rev Salud Pública	1	3.5
The American Surgeon	1	3.5
Year of publication		
2000–2001	4	13.8
2002–2003	9	31.0
2004–2005	7	24.1
2006–2007	6	20.7
2008–2009	3	10.3
Number of authors		
Up to 3	5	17.2
≥ 3 and < 6	12	41.4
≥6	12	41.4

The authors classified avoidability of death into two or three categories (Table 3). Most criteria used for this classification were established based on an analysis of care provided (89.7%), injury severity (62.1%), and survival rate (55.2%). Some studies used different criteria such as presence of comorbidities (3.4%), physiological condition on arrival at the hospital (3.4%), and patient's refusal to follow the treatment plan (3.4%).

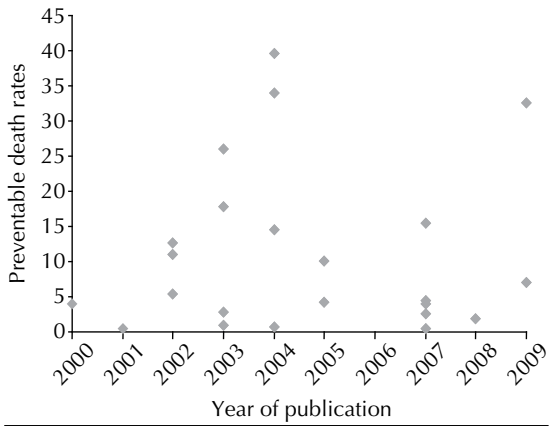

Figure 2. Preventable death rates by year of publication of the articles reviewed. Medline, Lilacs and SciELO, 2000–2009. (n = 24)

Table 2. Methods used in the articles reviewed. Medline, Lilacs and SciELO, 2000–2009. (n = 29)

Method characteristics	n	%
Study design		
Retrospective nonrandomized cohort	26	89.7
Retrospective randomized cohort	2	6.9
Prospective nonrandomized cohort	1	3.5
Study country		
North America	13	44.8
South America	1	3.4
Europe	6	20.7
Asia	2	6.9
Oceania	7	24.1
Sample size		
Up to 500	18	62.1
≥500 and <1000	6	20.7
≥1000 and <5000	-	-
≥5000 and <10000	2	6.9
≥10000	3	10.3
Study period		
Up to 5 years	17	58.6
≥5 and <10 years	7	24.1
≥10 and <15 years	2	6.9
≥15 years	2	6.9
Not available	1	3.4
Method for preventable death classification		
Expert panel	12	41.4
Expert panel and injury severity scores	10	34.5
Injury severity scores	5	17.2
Presence of specific clinical conditions associated with preventable deaths	2	6.9

Table 3. Classification of preventable deaths in the articles reviewed. Medline, Lilacs and SciELO, 2000–2009. (n = 29)

Death classification	n	%
Preventable, potentially preventable and non-preventable	14	48.3
Definitely preventable, possibly preventable and non-preventable	3	10.3
Preventable, probably preventable and non-preventable	1	3.5
Frankly preventable, potentially preventable and non-preventable	1	3.5
Certainly preventable, probably preventable and non-preventable	1	3.5
Preventable and non-preventable	4	13.8
Potentially preventable and non-preventable	4	13.8
Possibly preventable and non-preventable	1	3.5

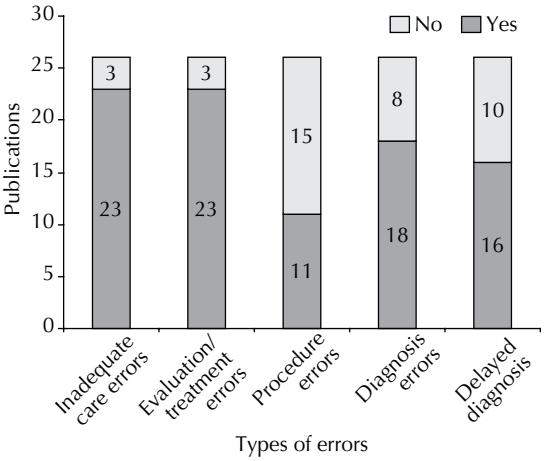

Figure 3. Types of errors identified for preventable trauma deaths in the articles reviewed. Medline, Lilacs and SciELO, 2000–2009. (n = 26)

The proportion of preventable deaths was reported in 24 articles (82.8%). All other studies (17.2%) described avoidability of death into three categories and its rate was estimated by the sum of two categories (preventable and potentially preventable) without providing information on the frequency of avoidable events. The mean preventable death rate in 24 studies was 10.7% (SD: 11.5%; median: 4.9%, and range: 0.4% to 39.6% (Figure 2).

Twenty-six articles reported errors identified in the analysis of preventable deaths (Figure 3).

DISCUSSION

There was found a small number of articles on preventable trauma deaths published from 2000 to 2009 (approximately three per year) in view of the global impact of external causes of deaths and their consequences, and technological advances in interventions to reduce preventable deaths.

Studies on preventable trauma deaths are mostly developed and published in the United States. Some factors may explain this fact: the country's pioneering spirit to analyze the incidence of adverse events related to health care; the creation of the American College of Surgeons Committee on Trauma in 1922 recognizing trauma as a medical condition and proposing injury prevention actions and principles for care improvement; and the publication of the Journal of Trauma Injury, Infection and Critical Care, which is internationally recognized.

Preventable trauma deaths are a subject that has attracted interest among researchers from different continents, except from Africa where no study has been conducted.

An article on preventable trauma deaths was published in Brazil in 2007, but it only reported on current quality control programs to evaluate injured patients10 and did not meet the inclusion criteria proposed in the present study. This suggests a lack of research on this subject in Brazil, and the need to investigate trauma care provided to injured patients and their progression in order to improve quality of care.

Most articles reviewed had three or more authors. Five studies identified as authors a panel of experts involved in the classification of preventable deaths.[5,24,26,29,32] The study of preventable deaths usually involves several researchers as trauma care is provided by integrated care systems comprising several specialties.[20]

Age restrictions were applied in nine studies: adolescents[7] or adults only.[2,3,9,12,14,24,26,35] The upper age limit for defining avoidable trauma deaths was not described in the studies reviewed and can be a limitation since the aging process may affect an individual's response to treatment. Recent studies that have classified deaths from other diseases take the age of 75 as the upper limit of avoidability.[20]

Most studies with small populations (up to 500 individuals) had a shorter study period (up to five years). Four studies[16,30,34,38] investigated more than 5,000 patients during a short study period (≤ 3 years) and half of them specifically analyzed state trauma databases.[30,38] It stresses the importance of having a regional trauma database for analyzing epidemiological and care data over a short period of time, which can provide a situational snapshot.

Preventable death rates are designed to capture the performance of health care services and assess their effectiveness considering the resources available (or accessible) in a given time and place. The causes of preventable deaths should be analyzed taking into consideration the knowledge and technology available to health care by geographic areas and in time.[19]

A retrospective cohort with non-random sampling was the most common design used and only one study prospectively analyzed 300 patients.[9] Prospective studies usually deal with smaller samples due to the difficulty of monitoring patient progression. However, these are valuable studies compared to retrospective ones as the latter may have weakness and failure to provide care may not be recorded and their determination and analysis is directly dependent on the investigator's experience and quality of medical records.

The most used method to classify avoidability of deaths was an expert panel. TRISS, ISS and AIS were the most used scores to define preventable deaths. The cutoffs considered for preventable deaths ranged from 50 to 75 for TRISS; 50 to 59 for ISS; and AIS equal to 6 in any area of the body or equal to or greater than 5 for the head.[2,5,7,24-26,28,32]

Two studies relied on the presence of specific clinical conditions for the classification of preventable deaths, e.g., failure to identify aortic rupture4 and delayed control of exsanguination..[37]

The concomitant use of two methods including an expert panel and injury severity scores can help determining more reliably avoidable deaths because it allows comparing the analysis of clinical experts against scores.

Hoyt & Coimbra13 assessed the effectiveness of trauma systems and quality of care to injured patients and found in the literature no class I (prospective controlled randomized) and class II studies (prospective or retrospective controlled cohort or case control). Several class III studies (panel studies, case series and records in databases) can be currently found.

The lack of class I and II studies was corroborated in the current study. The only prospective study found used a nonrandomized sample and an expert panel and is thus a class III study. Class I and II studies on preventable trauma deaths are needed.

The classification of preventable deaths into two categories (preventable; non-preventable) is often clear. However, when there are three categories, it is crucial to understand the authors' criteria for classification. Preventable, potentially preventable and non-preventable were the most common terms used (48.3%) and are based on the classification as described by Mackenzie et al18 in 1992: non-preventable death occurs when there is a lethal injury; potentially preventable death is determined based on three criteria including non-lethal injury, suboptimal care, and management error as a direct or indirect cause of death; and a preventable death occurs when a care error was clearly the cause of death.

The adverbs "definitely," "possibly," "certainly," "probably," and "frankly" are used in the classifications as a personal choice of the authors. Standard terms and criteria for the classification of preventable deaths may help improve the ability of researchers to examine study samples, and allow result comparisons.

Preventable death rates showed great variability though most studies (51.7%) reported rates lower than 10.0%. Three studies showed high values rates —32.5%, 34.0% and 39.6%— and assessed the reliability of a proposed software for death classification compared to a expert panel;29 causes of deaths after pelvic surgery;9 and emergency care following the earthquake in Athens in 1999, respectively.28

The implementation of trauma systems has led to a significant reduction in the number of preventable

deaths after injury. A preventable death rate lower than 2.0% is acceptable for a trauma center13 and five research studies have reported 0.4%, 0.5%, 0.6%, 1.0% and 1.9%, which is consistent with the desired rate.4,8,14,30,36

Studies comparing preventable deaths at different time points, i.e., before and after the implementation of a death reduction strategy, are critical. These studies have showed improved care for trauma patients.7,26

The most common errors reported in the studies reviewed were evaluation and treatment errors and inadequate trauma care. Hypoxia related to inadequate airway control and blood loss related to ineffective bleeding control were major avoidable factors associated with deaths. It stresses the importance of team training in the identification and management of potentially fatal injuries, provided in internationally recognized trauma programs such as ATLS®, PHTLS® and ATCN® by the American College of Surgeons, Society of Trauma Nurses and National Association of Emergency Medical Technicians. These training programs are updated every four years based on international research studies and focus on evidence-based practice. They constantly receive suggestions from their collaborators in over 50 countries.

The main failures of treatment associated with inadequate trauma care included inadequate pre-hospital care, ineffective communication and delayed referral due to system breakdown. The same is seen in Brazil where violence is a major issue and the system is overwhelmed and cannot respond to the demand for care for injured patients.

These findings call for the development and implementation of training strategies to prevent recurrence of errors.10

There is a need to increase the number of studies on preventable trauma deaths to better identify their causes, improve their determination and minimize their occurrence. Education, training and public policies aimed at prevention through behavior change are needed to address this public health issue. Trauma patients are more likely to survive than any other patients if they receive appropriate care.27

This systematic review pointed out major failures of trauma care. However, other studies are needed, especially in Brazil where this issue has not been explored.

For further studies there is a need to standardize the terminology used for the classification of deaths and types of errors. In addition a regional database should be created. The method of assessment of preventable deaths should be improved and include an expert panel evaluation together with injury severity scores. Other methods should also be developed especially based on class I and II studies.

Preventable death rates and different types of errors should be monitored by geographic areas and time periods to help the development of interventions for optimal quality of trauma care.

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