



## Predicting in-hospital death among patients injured in traffic crashes in Saudi Arabia



Suliman Alghnam<sup>a,\*</sup>, Mari Palta<sup>b</sup>, Azita Hamedani<sup>c</sup>, Mohammad Alkelya<sup>a</sup>,  
Patrick L. Remington<sup>b</sup>, Maureen S. Durkin<sup>b</sup>

<sup>a</sup>King Abdullah International Medical Research Center, King Saud Bin Abdulaziz University for Health Sciences, KAIMRC, KSAU-HS, Riyadh, Saudi Arabia

<sup>b</sup>Population Health Sciences, University of Wisconsin-Madison, United States

<sup>c</sup>Emergency Medicine, University of Wisconsin-Madison, United States

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### ABSTRACT

**Introduction:** Traffic-related injuries are a major cause of premature death in developing countries. Saudi Arabia has struggled with high rates of traffic-related deaths for decades, yet little is known about health outcomes of motor vehicle victims seeking medical care. This study aims to develop and validate a model to predict in-hospital death among patients admitted to a large-urban trauma centre in Saudi Arabia for treatment following traffic-related crashes.

**Methods:** The analysis used data from King Abdulaziz Medical City (KAMC) in Riyadh, Saudi Arabia. During the study period 2001–2010, 5325 patients met the inclusion criteria of being injured in traffic crashes and seen in the Emergency Department (ED) and/or admitted to the hospital. Backward stepwise logistic regression, with in-hospital death as the outcome, was performed. Variables with  $p < 0.05$  were included in the final model. The Bayesian Information Criterion (BIC) was employed to identify the most parsimonious model. Model discrimination was evaluated by the C-statistic and calibration by the Hosmer–Lemeshow Goodness of Fit statistic. Bootstrapping was used to assess overestimation of model performance and obtain a corrected C-statistic.

**Results:** 457 (8.5%) patients died at some time during their treatment in the ED or hospital. Older age, the Triage-Revised Trauma Scale (T-RTS), and Injury Severity Score were independent risk factors for in-hospital death: T-RTS was best modelled with linear and quadratic terms to capture a flattening of the relationship to death in the more severe range. The model showed excellent discrimination (C-statistic = 0.96) and calibration (H–L statistic 4.29 [ $p > 0.05$ ]). Internal bootstrap validation gave similar results (C-statistic = 0.96).

**Conclusions:** The proposed model can predict in-hospital death accurately. It can facilitate the triage process among injured patients, and identify unexpected deaths in order to address potential pitfalls in the care process. Conversely, by identifying high-risk patients, strategies can be developed to improve trauma care for these patients and reduce case-fatality. This is the first study to develop and validate a model to predict traffic-related mortality in a developing country. Future studies from developing countries can use this study as a reference for case fatality achievable for different risk profiles at a well-equipped trauma centre.

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### Introduction

Many parts of the world suffer a heavy burden of traffic injuries, especially developing countries which contribute 90% of all traffic fatalities worldwide [1,2]. According to *The Global Burden of Disease 2010* report, traffic injuries now rank as the eighth cause of death

globally, up from tenth in 1990 [3]. By 2020, road traffic deaths are projected to increase by 83% in low- and middle-income countries and decrease by 30% in developed countries, relative to 2000 levels [2]. Consistent with this projection, traffic-related mortality fell in 2011 in the U.S. to the lowest level in more than six decades [4].

The U.S. success can be attributed to numerous public health interventions and to improvement in trauma care. To achieve similar success in developing countries, traffic crashes need to be recognized as a public health priority; otherwise, they are likely to continue to be a leading, preventable cause of injury death into the

\* Corresponding author. Tel.: +966 566639414.

E-mail address: [Ghnams@ngha.med.sa](mailto:Ghnams@ngha.med.sa) (S. Alghnam).

future [5]. Nonetheless, attention also needs to be directed towards trauma care, as previous studies suggest that the development of trauma systems was responsible for as much as 9% of the U.S. decline in traffic fatality [6,7].

Saudi Arabia, a high-income but nevertheless developing country [8], has struggled with excessive traffic-related death rates for decades [9–11]. In 2011, a total of 7153 people lost their lives due to traffic crashes among 39,000 injured in 544,179 crashes [12,13]. The Saudi traffic death rate of 29 per 100,000 is more than double that of the U.S. and other countries where improvements in highway safety and trauma care have been national priorities for decades [14]. Despite high fatality estimates compared to other countries, Saudi Arabia's rates are greatly underestimated. Specifically, the Saudi Department of Traffic counts as traffic fatalities only those who died at the scene or in transport to the hospital. [15] In contrast, the global standard for reporting traffic fatalities includes deaths within 30 days [16] of the crash, and data from other countries indicate that as many as 44% of injury-related deaths occur after hospital admission [17]. However, in-hospital mortality has not been estimated specifically in Saudi Arabia.

Improvement of trauma care requires that mortality risk be determined not only overall, but also for specific types of patients, so that risk profiles can be taken into account in evaluating outcomes and interventions. Although most deaths due to trauma occur in low and middle-income countries [2], existing prognostic models for in-hospital mortality are based on data from high-income developed countries [18]. Such models may not be applicable in developing countries due to differences in case-mix and demographics [19]. While many of the studies that derived previous prognostic models assessed the internal validity of those models, none did so using external datasets from developing countries. Therefore, applying these models to settings in developing countries may lead to bias in identifying patients at high versus low risk [20].

The focus of this paper is on traffic injuries in Saudi Arabia that result in hospital admission. The overall goals are to quantify the frequency of fatal outcomes after hospital admission for traffic injuries in a large Saudi hospital, and to develop and validate a model for predicting in-hospital death among such patients. The model we present here uses demographic data, trauma characteristic and clinical data from a major trauma centre in Saudi Arabia.

## Patients and methods

This is a retrospective study using a trauma registry of patients presenting to the Emergency Department (ED) at King Abdulaziz Medical City (KAMC) in Riyadh between January 2001 and December 2010 following a motor vehicle crash. A crash is defined in the KAMC dataset as any traffic-related collision involving a motor vehicle including: single vehicle (car or motorcycle), two vehicles or more, or pedestrian struck by a motor vehicle. Because bicycling is uncommon in Saudi Arabia, patients injured while riding bicycles were included as pedestrians.

Riyadh is the capital of Saudi Arabia and the largest city in the country with an estimated population of 5 million. A substantial proportion of the nation's motor vehicle crashes occur in Riyadh, representing about 30% of total crashes nationwide [13].

KAMC is one of the largest hospitals in Riyadh with a capacity of over 700 beds in the hospital and 132 beds in the ED. This hospital serves primarily eastern metropolitan Riyadh and surrounding areas within the province of Riyadh. KAMC provides free medical care for National Guard employees and their families including all doctors' visits, medical procedures and prescription medications. In addition, patients not affiliated with the National Guard receive free care if they seek medical care through the ED. As a result, the

hospital's ED receives over 200,000 visits annually [21]. About 35% of all ED visits lead to hospital admission.

The capacity and standards of KAMC make it equivalent to a level I trauma centre in the United States [1,22]. A level I trauma centre is distinguished by being equipped to treat complex injuries, offering comprehensive trauma care 24 h daily, and having access to specialized teams including emergency physicians and general and orthopaedic surgeons. It is important to note that KAMC is the only setting with such resources in Saudi Arabia. KAMC is also the only Saudi hospital designated by the American College of Surgeons to provide certified training in *Advanced Trauma Life Support* [23]. In addition, KAMC has accreditation under the Joint Commission International standards with excellent performance since December of 2006 [24].

## Dataset

KAMC's Trauma Registry is a prospectively recorded database that was established in 2001. The aim was to collect and analyze data on trauma patients in order to monitor the process of care, allocate needed resources and establish prevention strategies. The case definition of a trauma patient for the KAMC trauma registry is an injured person who requires urgent diagnosis and treatment of actual or suspected injuries by a multidisciplinary team of healthcare professionals, supported by appropriate resources, to diminish or eliminate the risk of death or permanent disability.

The determination of whether an injured patient is included in the registry is based on meeting at least one the following criteria: (1) presenting to the ED after an acute injury requiring admission to the hospital ward or intensive care unit; (2) transfer to surgery from the ED; (3) indirect admission (patient discharged from ED and asked to return later); or (4) declared dead after initial evaluation in the ED or prior to arrival. Those who were treated in the ED and then discharged are not included on the registry.

A structured data checklist is used to gather information on patients' demographic, physiologic, anatomic, and outcome variables. A nurse completes the checklist and then a trained research coordinator ensures completion of information, tracks missing data, and enters the information into the registry using *Microsoft Access* software. Data on post-discharge visits and information about comorbidities are not included in the trauma registry.

Some of the variables in the dataset are the following:

- Demographics (age, sex).
- Mechanism of injury (motor vehicle crash, fall, motorcycle, violence)
- Time of admission
- Mode of transportation to the hospital
- Vital signs upon arrival
- Severity measures
- Length of hospital stay and discharge status
- Procedures performed

## Patient population and selection

Trauma registry patients are included in the study if they were seen in the ED due to a crash-related injury (automobile occupants, pedestrians, or motorcyclists) between 2001 and 2010. Those who were declared dead upon arrival or had missing observations were excluded from the analysis. We were unable to determine if patients who arrived with cardiopulmonary resuscitation (CPR) in progress and died were counted in the registry as in-patient deaths or deaths on arrival, and therefore employ sensitivity analyses to examine the potential impact of this. Forty-three (0.8%) patients

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