original article

Burden of traumatic injuries in Saudi Arabia: lessons from a major trauma registry in Riyadh, Saudi Arabia

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BACKGROUND AND OBJECTIVES: In Saudi Arabia (SA), injuries are the second leading cause of death; however, little is known about their frequencies and outcomes. Trauma registries play a major role in measuring the burden on population health. This study aims to describe the population of the only hospital-based trauma registry in the country and highlight challenges and potential opportunities to improve trauma data collection and research in SA.

DESIGN AND SETTINGS: Using data between 2001 and 2010, this retrospective study included patients from a large trauma center in Riyadh, SA.

PATIENTS AND METHODS: A staff nurse utilized a structured checklist to gather information on patients' demographic, physiologic, anatomic, and outcome variables. Basic descriptive statistics by age group (≤14 vs >14 years) were calculated, and differences were assessed using student *t* and chi-square tests. In addition, the mechanism of injury and the frequency of missing data were evaluated.

RESULTS: 10 847 patients from the trauma registry were included. Over 9% of all patients died either before or after being treated at the hospital. Patients who were older than 14 years of age (more likely to be male) sustained traffic-related injuries and died in the hospital as compared to patients who were younger than or equal to years of age. Deceased patients were severely injured as measured by injury severity score and Glasgow Coma Scale ($P<.001$). Overall, the most frequent type of injury was related to traffic (52.0%), followed by falls (23.4%). Missing values were mostly prevalent in traffic-related variables, such as seatbelt use (70.2%).

CONCLUSION: This registry is a key step toward addressing the burden of injuries in SA. Improved injury classification using the International Classification of Disease-external cause codes may improve the quality of the registry and allow comparison with other populations. Most importantly, injury prevention in SA requires further investment in data collection and research to improve outcomes.

Traumatic injuries are a significant threat to public health worldwide. By 2020, injuries are expected to surpass communicable diseases on a global level as the leading cause of disability-adjusted life years lost.[1] Developing countries, in particular, lack sufficient data to conduct research, assess trauma challenges, and test interventions to reduce injuries.[2] This may explain why developing countries still lag behind in terms of injury prevention programs.[3]

Saudi Arabia (SA) is among many developing countries that have suffered a major burden of morbidity and mortality due to injuries.[4-6] Preventable injuries are the second leading cause of death, accounting for about a fifth of all reported fatalities in the country.[7] Because SA is a relatively young country (40% of the population is 19 years old and younger), injuries can have significant implications on the country's health and prosperity.[8] According to the Global Burden of Disease report, traumatic injuries represent 22.6% of years of potential life lost in SA.[9]

Accurate data reflecting incidence and prevalence of traumatic events are essential for health care planning and public policy. For instance, incidence rates guide researchers to prioritize studies and public health pro-

fessionals to design proper interventions. Furthermore, evaluating information about injuries and their outcomes in SA is also important to assess the effectiveness of the existing injury prevention strategies. Yet, little is known about the burden of traumatic injuries in SA due to the scarcity of data. Prior injury-related literature focused on traffic injuries using data from the Department of Traffic.[10-12] Such sources have countless limitations, especially, in terms of the description of injury severity.

Alternatively, hospital-based surveillance systems offer more detailed data to learn about trauma causes and outcomes.[13] Trauma registries, in particular, can provide information on injury patterns and allow statistical modeling of trauma-related variables to identify public health threats and prioritize interventions.[14-16] Additionally, registries can help monitor the epidemiology of serious injuries, track a hospital's performance over time, and benchmark outcomes between hospitals and regions.[15,17]

We aim in this study to describe the population of a hospital-based trauma registry at a single health care institution in SA. In addition, we describe the potential use for this registry, limitations, and opportunities for improving future trauma registries and research in SA.

DESIGN AND SETTINGS

This is a retrospective descriptive study using data from King Abdulaziz Medical City (KAMC) in Riyadh. This hospital is one of the largest in the country with a 700--bed and an additional 132-bed emergency department (ED) to manage emergency visits. KAMC serves primarily the eastern metropolitan of Riyadh and surrounding areas within the Riyadh province.

The capacity and standards of KAMC make it equivalent to a level-I trauma center in the United States.[18] A level-I trauma center is distinguished by being equipped to treat complex injuries, offering comprehensive trauma care 24 hours daily, and having access to specialized teams including emergency physicians and general and orthopedic surgeons.

KAMC Trauma Registry

The Department of Surgery initiated the trauma registry in 2001 to monitor the frequency of injuries and to establish prevention priorities. The team treating a patient determines the classification of a condition as injury-related. Among those classified as injured, the case definition of a trauma patient is that the person requires urgent diagnosis and treatment of actual or suspected injuries by a multidisciplinary team of health care professionals, supported by appropriate resources, to diminish or eliminate the risk of death or permanent disability.

PATIENTS AND METHODS

Subjects

To be included in the KAMC trauma registry, injured patients have to meet at least one of the following criteria: admitted to the hospital ward or intensive care unit from the ED, taken to surgery from the ED, indirectly admitted (patient discharged from ED and asked to return later) or pronounced dead after reaching the ED or upon arrival.

Surveillance tool

Once a patient meets the eligibility criteria to be in the registry, his or her information is collected and entered into the registry in 2 stages. First, a nurse completes a structured checklist to gather demographic, anatomic, physiologic, and outcome variables. Second, a trained research coordinator ensures that it is complete, tracks missing data, and enters the information into the registry using "Microsoft® Access software 2000". Patients meeting the inclusion criteria are assigned an injury type: blunt, penetrating-gunshot, penetrating-stab, or "other" category. Then, each patient is assigned an injury mechanism on the basis of the cause of the injury. In the KAMC trauma registry, injury mechanisms are classified as of the following 12 groups:

1) Motor vehicle accident
2) Motorcycle accident
3) Pedestrian (includes bicyclist)
4) Fall
5) Burn due to fire or flames
6) Scald or burn due to liquid
7) Drowning, submersion, suffocation
8) Mechanical equipment
9) Poisoning
10) Homicide and injury purposely inflicted
11) Suicide and self-inflicted injury
12) Other/Unspecified

This pre-determined classification was not based on international standards (i.e., International Classification of Disease-external cause [ICD-E] codes), but rather on the standardized data collection sheet used at KAMC. While not ideal, the department of surgery data collection sheet was designed to mirror trauma registries in North American hospitals such as those reporting data to the National Trauma Data Bank (NTDB) in the United States.[13] In addition, data collected was selected to gain insight into the frequency and importance of such injuries in the Saudi community.

Some of the variables available in this dataset are the following: age, sex, mode of transportation (i.e., ambulance), vital signs upon arrival (i.e., pulse), length of hospital stay, procedures performed, and hospital disposition.

Severity measures

Additionally, the registry includes variables that measure the anatomic and physiologic severity of traumatic injuries. These measures include Glasgow Coma Scale (GCS), Injury Severity Score (ISS), and Triage Revised Trauma Scale (T-RTS). GCS is a measure of physiological severity of an injury on the basis of the level of consciousness[19] on an ordinal scale ranging from 3 (deep coma) to 15 (normal). It is obtained by adding 3 individual scores corresponding to motor response, verbal response, and eye opening.[20]

ISS is a measure of anatomical severity of an injury. In the registry it was calculated on the basis of Abbreviated Injury Scale (AIS) codes.[21] Only the highest AIS score in each area of the body is used to compute the injury severity score. The areas of body considered in scoring this measure include: head and neck, face, chest, abdomen, extremities, and external structure. ISS ranges from 0 to 75 with higher scores indicating more severe injury.[20]

T-RTS is a measure of the physiological severity of an injury on an ordinal scale. It combines 3 variables: the GCS, systolic blood pressure, and respiratory rate. The 3 variables are categorized into intervals and produce a score ranging from 0 to 12 with a higher score indicating better physiological status.

Statistical analysis

STATA version 12 for Mac (STATA Corp., College Station, TX) was used for all statistical analyses. We compared patients in this study by age group (≤14 vs >14) on demographics, severity measures, and the process of care. These variables were selected on the basis of previous literature describing the epidemiology of traumatic injuries and their outcomes.[1,22-24] To examine differences in patient characteristics by age group, we used Student *t* tests to compare means of continuous variables; to compare categorical variables and proportions between the two groups, we used and chi-square tests.

In addition, we tabulated injury mechanisms to examine the frequencies of injury patterns and associated case fatalities. Case fatality is defined as the proportion of deaths within a designated injury mechanism.[25] We also checked variables in the registry for missing observations by age group. The statistical significance level was set to $P<.05$. This study has been reviewed and approved by the Institutional Review Board at KAMC.

RESULTS

10 847 patients were included in the KAMC trauma registry between 2001 and 2010. Patients were mostly males (77.9%) and young adults (mean age=25). The mean hospital length of stay for those included in the study period was 19 days (**Table 1**). Fifty-five patients (0.5%) were transferred to other hospitals and thus had unknown discharged deposition. In the registry, 1033 (9.5%) were pronounced dead at any point, before or after reaching the hospital.

Older patients (>14 years of age) were more likely to be male, injured in traffic-related incidents, and severely injured (as indicated by both severity measures—ISS and GCS [$P<.001$]) than younger patients (14 years or younger). As shown in **Table 1**, traffic-related injuries were the most frequent type of injury (52.0%), followed by falls (23.4%). The drowning, submersion, and suffocation injury mechanism had the highest case-fatality (25.6%) followed by poisoning (20.8%). About 9% of injured patients had an injury mechanism attributed to "other/unspecified" (**Table 2**).

Missing values were present in a number of variables. Systolic blood pressure and respiratory rate were both missing in about 3.2% of injured patients (**Table 3**). Among patients injured in motor vehicle crashes, missing values on passenger seatbelt and position in the vehicle were substantially high (70.2% and 45.3%, respectively). Closer to half of those older than 14 years of age had missing information on passenger position; however, younger patients (<14 years of age) had higher percentage of missing values related to seatbelt use than older patients.

DISCUSSION

KAMC trauma registry is the first initiative to collect injury data and to recognize injuries as a preventable public health problem in Saudi Arabia. We found patients older than 14 years to have higher mortality than younger patients, which was similar to findings from other developing countries.[26] In addition, population level estimates from countries like the USA indicate higher mortality rates among similar age groups.[27] Over 9% of patients from KAMC registry were either pronounced dead before or died after admission to the hospital. This estimate is higher than mortality reported in developed countries like the UK (3.7%)[28] and the USA (5.9).[29] These findings highlight a higher mortality burden of traumatic injuries on the Saudi population.

Traffic-related injuries were more prevalent (52%)

Table 1. Patient characteristics stratified by age group.

Variable	Age ≤14 N= 3484	Age >14 N=7363	KAMC N=10 847	*P* value
Traffic-related N (%)[c] Falls N (%) Other injuries N (%)	1149 (32.9) 1130 (32.4) 1205 (34.6)	4492 (61.0) 1415 (19.2) 1456 (19.7)	5641 (52.0) 2545 (23.4) 2661 (24.5)	<.001[a]
Male N (%)	2412 (69.2)	6045 (82.1)	8457 (77.9)	<.001[a]
ISS Mean (SD)	8.7 (14.2)	13.8 (16.7)	12.2 (16.1)	<.001[b]
GCS Mean (SD)	13.5 (4.2)	12.6 (4.2)	12.9 (4.2)	<.001[b]
T-RTS Mean (SD)	11.0 (2.4)	10.8 (2.7)	10.8 (2.6)	<.001[b]
Head injuries N (%)	1130 (32.4)	2229 (30.2)	3359 (30.9)	.02[a]
Mortality N (%)	203 (5.8)	830 (11.2)	1033 (9.5)	<.001[a]
Hospital stay (d)	10	22	19	<.001[b]

[a]Chi-square test; [b]Student *t* test; [c]Includes occupants, drivers, pedestrians, and motorcyclists.

ISS: Injury Severity Score (higher indicates worst injuries); GCS: Glasgow Coma Scale (higher indicates better physiological status); T-RTS: Triage-Revised Trauma Scale (higher indicates better physiological status).

Table 2. Injury mechanism and related mortality.

Mechanism	Injury frequency N (%)	Case fatality[a] N (%)
Traffic related Occupants/Drivers Pedestrians Motorcycle	 4128 (38.0) 1281 (11.8) 232 (2.1)	 534 (12.9) 228 (17.8) 5 (2.1)
Fall	2545 (23.4)	60 (2.3)
Burn due to fire or flames	329 (3.0)	52 (15.8)
Scald or burn due to liquid	424 (3.9)	4 (0.9)
Drowning, submersion, suffocation	203 (1.8)	52 (25.6)
Mechanical equipment	28 (0.2)	0 (0.0)
Poisoning	24 (0.2)	5 (20.8)
Homicide or injury purposely inflicted	643 (5.9)	52 (8.0)
Suicide and self-inflicted injury	36 (0.3)	6 (16.6)
Other injuries	973 (8.9)	35 (3.6)

[a]Chi-square test; *P*<.01.

than other injury mechanisms in the KAMC trauma registry. The evidence of high traffic injuries was consistent with published statistics from the Ministry of Health.[7] While this finding was lower than reported from developing countries like Indonesia (80%),[30] it was considerably higher than that reported from other countries, such as India (39.2), Iran (31.9%), and Oman (29.6%).[31-33] Further research is desperately needed to address the growing threat of traffic injuries in SA and to ultimately improve the population health.

The drowning and suffocation category had the highest mortality of all injury mechanisms at KAMC. This finding is important to explore further to examine if it is consistent with the population level estimates and to plan appropriate prevention strategies. However, patient classification in the KAMC's registry does not allow differentiation between injuries due to drowning or suffocation. This is a major limitation because interventions aimed at lowering drowning cases may differ substantially from those aimed at decreasing suffocation. For example, drowning cases may be more responsive to environmental interventions, while educational programs for new parents may help prevent suffocation among children.

Several variables in KAMC's registry had missing values with traffic-related data (e.g., seatbelt use) having a higher percentage than other variables in the registry. Large trauma registries from developed countries like the NTDB in the USA and the Trauma Audit & Research Network in the UK have fewer missing values compared to KAMC.[34,35] Previous studies from the NTDB indicate that the highest percentage of missing values was in the variable "insurance status" (about 20% of patients), which remains lower than missing rates in KAMC.

The High frequency of missing values among traffic-related variables in KAMC's registry could be due to a number of reasons. Language barrier between the nurse filling the data collection sheet and patients or their families could play a role in the ability to capture correct information. Another potential explanation has to do with the fact that some information is originally collected at prehospital settings, and the registry coordinator or nurse did not have access to these sources. The quality of police records may also be another barrier, as previous studies indicate major limitations in data reliability and validity.[36]

A multisectorial approach has more potential to improve the quality of data capturing traffic-related injuries and associated mortalities in SA. Indonesia presents an example of a developing nation that used such approach to address under-reporting of traffic fatalities. In 2009, the Indonesian government passed a law to authorize collecting data from multiple sources (i.e., insurance companies, hospitals) to obtain a more accurate estimate of traffic fatality. The 2010 estimates of traffic fatality showed over 10 000 deaths higher than the pervious year, which may be attributed to improved data quality.[37]

KAMC trauma registry has been a valuable source to fill some of the existing gaps in the literature on traumatic injuries in SA.[38-40] Using this dataset, Al-Habib

et al. examined causes and patterns of adult traumatic head injuries among adult patients (>18 years). Similar to our study, traffic-related incidents was a major cause of severe injuries.[40] In another study, Alnasser et al. examined the seasonal pattern of traffic injuries during the holy month of Ramadan among the pediatric population.[41] In addition, Al-Jazaeri et al examined the role of seating position and restrain use in determining injury pattern among motor vehicle occupants.[42] This study highlights the importance of proper restrains to reduce the burden of traumatic injuries among vehicle occupants. Clearly, KAMC trauma registry has many potential uses for clinical researchers and epidemiologists to answer many questions about traumatic injuries and their outcomes in SA.

Many limitations may have affected our findings, one of which is in the registry's case definition. For example, one of the inclusion criteria for patients is when someone is admitted to the ED, discharged, and then asked to return later to be admitted to the hospital. This scenario does not constitute a clear criterion and may lead potentially to selection bias. A more systematic definition of a case is warranted to improve the quality of the registry. This will allow a more clear study base and facilitate comparison with other countries.

About 9% of the patients included in the registry had an underlying cause of "other unspecified" injuries. This can be problematic because such classification does not provide sufficient information to allow introducing appropriate prevention strategies. A way to address this is by incorporating the ICD-E codes, which allow a more specific classification of injuries.[43] This classification system is consistent with international standards used by major trauma registries like the NTDB and may enable comparisons to other populations.

Another issue is the limited knowledge on long-term outcomes, such as permanent disability and quality of life.[44] This is a prevalent problem of most trauma registries in developing countries and contributes to the significant shortage of literature on long-term outcomes. The use of standardized methods to collect data from health care providers, including information on independence and quality of life, can improve the quality of data gathered by health authorities in SA. Health care settings in SA also can collaborate with the KAMC to identify prior barriers affecting trauma data collection and identify ways to avoid them.

Table 3. Percentages of missing data in in KAMC trauma registry.

Variable	Age ≤14 N= 3484 Missing %	Age>14 N= 7363 Missing %	Total N=10 847 Missing %
Injury Severity Score	0.1	0	0.1
Systolic blood pressure	2.4	3.6	3.2
Respiratory rate	3.3	3.1	3.2
(Motor vehicle crashes)	N=458	N= 3670	N=4128
Passenger position (front, driver, rear)	32.3	46.9	45.3
Seatbelt	76.6	69.4	70.2

KAMC: King Abdulaziz Medical City.

It is unknown whether the KAMC trauma registry captures all patients meeting the inclusion criteria. Future work may perform quality assurance studies assessing this area among others to ensure adherence to the highest standards. Also, it is noteworthy to recognize that the descriptive data illustrated in this study may not generalize to the national level because the data only reflect injury patterns at a single hospital. However, with the absence of nationally representative data, this study provides some insights on the burden of injuries to prioritize public health interventions at the local level and to conduct further studies.

In conclusion, KAMC trauma registry is a major step to defy the growing burden of traumatic injuries in SA. It represents a unique source to gain insights about patient demographics, injury characteristics, and their outcomes. Because injuries remain as a major threat to public health in SA, further investment in data collection is desperately needed. Therefore, a national trauma registry, based on international standards, is an essential step in the path to decrease the burden of traumatic injuries.

Conflict of interest

All authors of this manuscript are affiliated with King Abdulaziz Medical City (KAMC) in Riyadh.

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