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# Firearm injuries in rural Saudi Arabia: incidence, patterns, management, and cost

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## Abstract

**Background:** A retrospective study from 2013 to 2017 was conducted to evaluate the incidence of small firearms and air gun injuries, social demographics of victims, severity of injuries, patterns, length of stay, and cost of hospitalization in highly populated central rural Al Kharj region of Saudi Arabia.

**Results:** In total, the study included 102 cases. The incidence of firearms and air gun injuries in Al Kharj region was 3.13/100,000. Most of the victims were young-aged males (98 cases; 96.1%). The males were absolute majority with the rate of males to females 23.5:1. There were no fatal injuries in this study and no suicides. Majority of the cases were accidents or usage of firearms as toys. The most common site of entry was the lower limb (44 cases; 43.1%), the abdomen (20 cases; 19.6%), and the upper limbs (16 cases, 15.7%). Handguns were the cause of injuries in 66 cases (64.7%) and air guns in 36 cases (35.3%) respectively. The median Injury Severity Score was 15. The total length of stay due to injuries over the study period was 514 days and was estimated for the local economy downfall of 285,000 Sadi Riyals as a cost of hospitalization. Twenty-six (25.4%) patients had to be readmitted to the hospital due to various complications. Thirty-seven (36.3%) patients had long-term disability. The mean length of stay in the hospital was 5 days (range = 1–9 days). The length of stay was positively correlated with Injury Severity Score, and significant increase was identified when the patients had ISS more than 20 ($p < 0.04$).

**Conclusion:** The results from this study support the current tight gun law regulations in Saudi Arabia, which aims to reduce the number of firearm-related morbidity and mortality in the society. There is a necessity for better education in Saudi Arabian communities in relation to firearms and their use in order to reduce the number of firearm accidents and related injuries.

**Keywords:** Small firearms, Firearm injuries, Saudi Arabian province, Firearm injury incidence, Firearm forensic aspects

## Background

Firearms in peace time and non military conflict areas cause near 1.2 million deaths and injure more than 10 million people annually worldwide (Rawson 2002). Statistical analysis from the Geneva Declaration 2006 source shown that about 1000 people each are killed each day and hundreds of thousands are wounded. There is no reduction in the violent usage of small firearms and a number of victims and related injuries as estimated by international studies (Geneva Declaration on Armed Violence and Development Secretariat 2006; Geneva Declaration 2008; Bringing the Global Gun Crisis Under Control 2006).

It is estimated that about 75% of 875 million firearms in the world are in the hands of the civilian population (Karp 2007).

Thus, there are more guns in the world than passenger vehicles by near 29%. Each year, more firearms and ammunition are manufactured enough to shoot every person in the world twice with an estimated legal international trade exceeding the US$7 billion each year (Renner 2008).

According to the Global Status Report on firearm incidents, it is one of the leading causes of mortality and remains a significant mechanism of fatality and disabling

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injuries after motor vehicle accidents (MVA) and industrial-related injuries among trauma events (Miller et al. 2002).

Peace time gunshot injuries due to domestic violence or unintended firearm "accidents," as a result of playing with firearms of air guns, are relatively rare in Saudi Arabian communities compare to the USA, Europe, South America, most African countries, and other Middle East regions. This is mostly attributed to the strict gun laws in the Kingdom of Saudi Arabia (KSA).

Studies by the University of Sydney international research on Gun Policy Facts shown that the number of estimated privately owned firearms held by civilians in Saudi Arabia has a rate of 35.0 per 100 of population. In 2007, a comparison of the number of privately owned guns in 178 countries indicated that Saudi Arabia is ranked at no.16 (www.GunPolicy.org, The University of Sydney international research on Gun Policy Facts). At the same time, according to Waiselfiz 2015, the rate of all gun-related deaths in KSA is 82/100,000 (Waiselfiz 2015).

Firearm injuries are a significant cause of disability and mortality, with a higher prevalence both in developing countries and to develop ones depending on the gun's access, law, and regulations as well as cultural specifics (Streib et al. 2007). Among the other developed countries, Saudi Arabia is ranked as one of the lowest in firearm personal possession with strict country gun law regulations, compared to the other developed countries such as in Europe and North America (Christoffel 2007).

Although the human cost as a result of firearm-related deaths and injuries in KSA is significantly low, compare to motor vehicle accidents (MVA), which claim an extremely high annual cost of 6 billion US dollars, it has not been calculated for firearm injuries (Al-Atawi et al. 2014).

The Saudi Arabian Law has mandated that firearm acquisition must be limited to public. However, at this stage, there is no unified registry of firearm-related deaths and injuries established in KSA. There is a necessity for efforts to document and audit firearm-related injuries data to exclude discrepancies between police records and information available from health system. Although reports of firearm deaths and related injuries in some areas of KSA exist in medical literature, the number of such reports is small. Majority of the civilian doctors in KSA will rarely have a chance to manage firearm injuries. Mostly, these types of injuries reside with military surgical services or regional hospitals and trauma centers. The incidence and patterns of firearm injuries in Al Kharj province of Saudi Arabia have not been previously studied.

According to the Health Care Utilization Project (HCUP) USA, firearm injuries posed the largest overall hospitalization cost burden with total annual hospitalization costs nearly US$183 million (Peek-Asa et al. 2017). There were no previous reports on the hospitalization cost as a result of firearm-related injuries from Saudi Arabia, which cause significant burden to the local economy, the country health system, and the society reported from other developed countries.

The aims of this study included evaluation of incidence, the patterns of firearm injuries, and their correlation to Injury Severity Score (ISS), Glasgow Coma Scale (GCS), and the need for blood transfusion as well as the cost of hospitalization in Al Kharj province, which is a highly populated central rural region of Saudi Arabia.

## Materials and methods

The design of this retrospective study was based on data obtained from the Department of Surgery at King Khalid Hospital, which is a major teaching hospital for public admissions in Al Kharj Governorate of Saudi Arabia with a population over 650,000 people.

The medical records of 102 patients collected over the period of 5 years (2013–2017 inclusive), who presented and admitted to the surgical department with the firearm and air gun injuries, were reviewed for demographic data of the victims, including sex and occupation, the type of weapon used (firearm or air gun), the pattern of injury (anatomical area affected), Injury Severity Score, Glasgow Coma Scale on presentation, the degree of shock, and the length of the hospital stay. The confidentiality of the patients was ensured through the anonymous data entry from medical records. The collected data were organized and analyzed using the SPSS version 23 (Statistical Package for the Social Sciences), and Excel for Mac 2016 computer software programs was used to analyze data in this study. Mean and standard deviation were calculated and applied for comparison analysis from the data, and the independent $t$ test was used to identify significant differences in numerical variables, where $p < 0.05$ was considered as statistically significant. This retrospective study was part of the trauma research approved by the Scientific Research Committee of the Prince Sattam bin Abdulaziz University, Al Kharj, KSA.

## Results

Taking into consideration the population of the Al Kharj Governate region that is exceeding 650,000, from the latest census, the incidence of firearm injuries in the Al Kharj region was estimated as 3.13 per 100,000 of the population per year.

Medical records of 102 patients presented were included in this study, showing 82 (80.3%) were Saudis and 20 (19.7%) non-Saudi respectively. All patients were exposed to a small firearm or air gun injuries with various body parts affected. The majority ($n = 98$, 96.1%) of the patients were males and only 4 were females.

**Table 1** Distribution of demographic factors

| Demographic factors | | Patients (*n*) | Percentage |
|---|---|---|---|
| Gender | Male | 98 | 96.1 |
| | Female | 4 | 3.9 |
| Nationality | Saudi | 82 | 80.4 |
| | Non-Saudi | 20 | 19.6 |
| Age groups | < 20 years old | 42 | 41.2 |
| | 20–30 years old | 44 | 43.1 |
| | 31–40 years old | 8 | 7.85 |
| | > 40 years old | 8 | 7.85 |

Median age of the firearm and air gun victims was 32 ranging from 4 to 60 years old. The demographic distribution is shown in Table 1.

There were significant correlations identified between the patient's nationality, gender, and age with the use of firearms or air gun injuries. Fifty-four of Saudi patients (65.9%) were shot by firearms, receiving different severity of bullet injuries, in comparison to 12 (60%) of non-Saudi ($p = 0.02$). Men were absolute majority, receiving injuries by firearms (bullet injury) compare to women, with only 4 out 54 of all bullet injuries ($p < 0.01$).

The majority of injured patients in this study were students or employees of young age ($p < 0.04$).

The percentage of the social status of injured patients is represented in Fig. 1.

Sixty-six (64.7%) out of 102 patients had injuries caused by a small firearm caliber bullet (Cal 22, 25 ACP) and 36 (35.3%) by air gun (BB 4.5 mm or 1.77 caliber pellet) respectively, which is less likely cause life-threatening, deep tissue, or organ-penetrating injuries due to low velocity and energy transmission. Ninety-six patients had a single shot, and 6 patients had double shot injuries. Soft tissue injuries took place in 98 out of 102 cases (96%). The distribution of injuries to anatomical areas is shown in Table 2.

The most common site of injuries was the lower limb (44 cases; 43.1%), which was followed by abdominal and upper limb injuries in 20 cases (19.6%). In 16 cases (15.7%), the site of injury was the upper limb. A small number of affected anatomical areas were the gluteal area and the back, 4 cases each (3.9%) respectively. There were only two head injuries, both with air gun pellets, which were causing only superficial soft tissue damage without cranial bone involvement. There were statistically significant differences between the lower limb and the other anatomical parts affected by injuries in this study ($p < 0.03$).

All the injuries caused by firearms or air guns were the results of domestic violence or unintentional fire. However, there was no correlation identified between the incidents of firearms used and psychiatric history of the offenders or their victims due to lack of information in the medical records.

There was no mortality reported over the study period of time. Only 4 injuries were found to have entry and exit points in the body, 2 in abdominal soft tissues and 2 in the leg soft tissues, which indicated that the shots were done at the close range using a firearm of a small caliber.

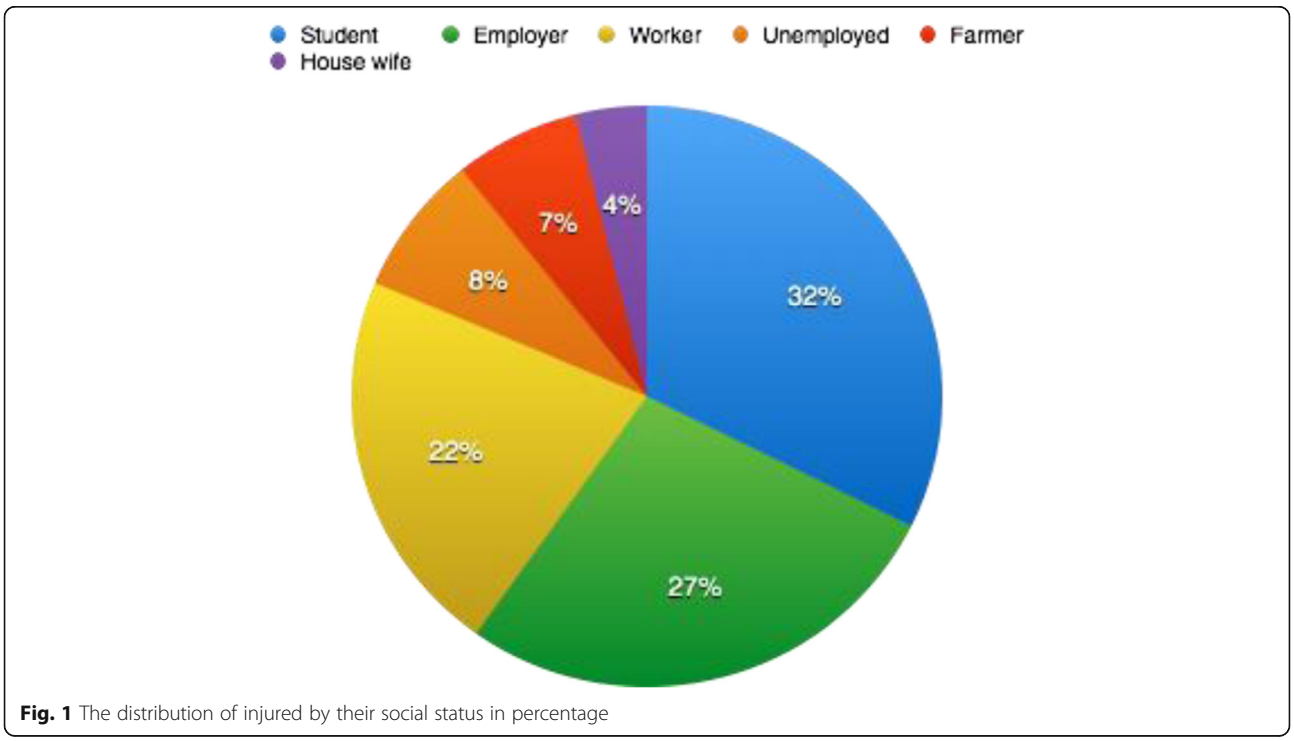


**Fig. 1** The distribution of injured by their social status in percentage

**Table 2** Anatomical patterns of firearm injuries in patients ($n$ = 102)

| Patients ($n$) | Percentage | |
|---|---|---|
| Head | 2 | 1.9 |
| Chest | 12 | 11.8 |
| Abdomen | 20 | 19.6 |
| Back | 4 | 3.9 |
| Upper limb | 16 | 15.7 |
| Lower limb | 44 | 43.1 |
| Gluteal area | 4 | 3.9 |

Twelve patients (11.7%) who sustained penetrating abdominal injuries were required laparotomy for damage control.

Eighty-six patients (84.3%) had formal soft tissue repair, depending on the damage, which included hemostasis from bleeding injured blood vessels and repair of important anatomical structures such as nerves and tendons. In 83 (81.3%) patients, the bullets or pellets were removed, while in the rest of the cases ($n$ = 19, 18.7%), they were left alone because of deep localization in the soft tissues without causing any affects.

Eighteen patients (17.7%) received soft tissue injuries without any significant effect on their health and were discharged from the hospital in 1 to 2 days for further follow-up by the local community doctor.

From the total number of victims, 18 patients (17.7%) were children (aged below 16 years old); however, all of them received relatively minor injuries from air gun/rifle due to careless handling by older members of the family.

All the patients presented to the hospital were classified with Injury Severity Score (ISS). The median Injury Severity Score in this study was 15 ranging from 2 to 41. Forty-five percent of the wounded patients had ISS less than 10. Among firearm victims, 24 patients were classified with ISS between 10 and 20 (23.5%) and 28 patients had ISS above 20 (27.5%) respectively. All the patients with ISS less than 20 presented with Glasgow Coma Scale (GCS) of 14–15. Also, the majority of the subgroup of patients with ISS less than 20 did not show any symptoms of hemorrhagic shock. Only 6 patients from the subgroup with ISS less than 20 were established with the first degree of hemorrhagic shock and did not require any blood transfusion. However, 22 patients with ISS more than 20 presented with second and third degrees of hemorrhagic chock and received from 1 to 4 units of blood transfusion according to their arterial blood gas (ABG) and hemoglobin reading. Also, this subgroup presented with GCS varying between 13 and 10. Thus, positive correlation was found between patients with ISS less 20 and ISS more than 20, which reflected a higher chance of low GCS and hemorrhagic shock development ($p < 0.03$).

None of the patients in this study required immediate intubation due to GSC < 9, and also, there was no necessity for an introduction of massive transfusion protocol.

The character of the sustained injuries was related to firearms used, range of shooting, and the characteristics of the projectiles, whether it was high-energy bullets or low-energy pellets. Injuries to the anatomical structures are shown in Table 3.

However, 36 patients (35.3%) had to be readmitted to the hospital within the first week after discharge due to poorly controlled pain or minor complications such as superficial wound infection and further assessment of disabilities. Thirty-seven (36.3%) patients developed long-term disability.

In total, 514 hospital days the patients from this study spent in the hospital. The mean length of stay was 5 days and ranging from 1 to 19 days, depending on the severity of injury, anatomical area, and estimated blood loss. These included 8 patients, who were admitted to the intensive care unit with mean 2 days ranging from 1 to 3 days. The positive correlation was identified between ISS and the length of hospital stay and significantly increased when the patients had ISS more than 20 ($p < 0.04$).

The economy expense estimated in this study was calculated based on the cost of patient occupying surgical bed, which is near 500 Saudi riyals per patient per day for regular hospital bed and about 2000 Saudi riyals for occupying a bed in intensive care unit (ICU) per patient per day. This cost was not including special investigations such as radiological investigations and treatment such as surgical procedures and patient care. Thus, the total government expense managing all firearm and air gun injuries in this study was estimated as near as 285,000 Saudi riyals without cost of treatment.

**Table 3** Affected anatomical structures by firearm injuries ($n$ = 84)

| Patients ($n$) | Percentage | |
|---|---|---|
| Major peripheral artery | 6 | 5.9 |
| Small peripheral vessels | 26 | 25.5 |
| Major peripheral nerves in the arm | 8 | 7.8 |
| Long bones | 8 | 7.8 |
| Ribs | 6 | 5.9 |
| Small bones | 10 | 9.8 |
| Tendon injury | 6 | 5.9 |
| Bowel injury | 12 | 11.8 |
| Head injury non penetrating | 2 | 1.9 |
| Total injuries causing disability | 84 | 82.3 |

## Discussion

### Epidemiology of firearm injuries in Saudi Arabia

A population in different countries, regardless of their continental location, have various availability to acquire firearms, which reflect the number of firearm-related deaths and disabling injuries.

According to the University of Sydney international research on Gun Policy, the annual rate of all gun-related deaths in Saudi Arabia is 0.35 per 100,000 of population. This is a relatively small number, compare to the USA (11.96), South Africa (9.39), Argentina (6.73), Austria (2.9), France (2.65), Turkey (2.63), Egypt (1.61), Sweden (1.6), and Australia (1.04). However, it is exceeding the numbers in such countries as Malaysia (0.3), UK (0.17), Japan (0.02), and Morocco (0.01), where access to the firearm is very limited (www.GunPolicy.org, The University of Sydney international research on Gun Policy Facts). Availability of small firearms has been compared to a cancer spreading across the developed countries. Although firearm injuries periodically have been reported from Saudi Arabia, these injuries are mostly accidental and mortality and morbidity are low compare to many developed countries.

The incidence of firearm injuries in the Al Kharj region was estimated as 3.13 per 100,000 of the population. This is approximately 2.5 times lower compare to the results demonstrated by a study performed in the Abha region of Saudi Arabia, which can be explained by differences in demographic proportions on nationalities living in these regions (Softah et al. 2002).

Unfortunately, there was no data available to compare the incidence of firearm injuries with largely populated urban places such as Riyadh or Jeddah. According to the Menoufiya University Hospital study, firearm injuries were found more common in rural regions (72.41%) compare to urban areas (27.59%). This could be explained by the facts that rural population has easier access to small firearms to protect their livestock and less gun regulations than urban areas (Badawy et al. 2009).

For the period of this study from 2013 to 2017 inclusive, there were 102 firearm and air gun offenses recorded by submission to the major local public hospital. Based on the data collected by the Trauma Audit, this represents 23.4% of all trauma cases recorded over this period, which included road traffic accidents, burns, industrial and domestic injuries, and stabbing.

The evaluation of these injuries requires specialized training and expertise.

The human factor remains to be the major, if not the only, when the trauma injury is related to firearms. A study conducted in 2015 showed that firearms were the leading cause of trauma deaths and long-term disabling injuries in the Abha region of Saudi Arabia (Softah et al. 2002). The highest numbers of firearm victims were in the 20–30-year-old age group. This study also concluded that the head and torso were the most vulnerable areas due to organ destruction and hemorrhage.

In this study, 18 patients (17.7%) were identified as children (age below 16 years old). All episodes of injured children were related to unintentional fire due to careless handling of firearms or air guns.

The majority of Saudi population would consider an air gun as a toy rather than a dangerous weapon. This attitude of population more likely is due to the lack of education about air guns as weapons, which can cause severe injuries although rarely fatal.

### Initial assessment of presented injuries

According to the Trauma Assessment rules and algorithms, doctors in the emergency department were inquiring about the type of weapon used if the victim or witnesses are able to answer.

It was mandatory to examine the entry wound and the exit wound where applicable.

All patients underwent full blood examination and X-ray or CT scan investigations depending on GCS score on presentation for bullet/pellet localization and ultrasound study in search of hematoma and estimation of the volume of blood loss, and the degree of hemorrhagic shock.

All patients were checked for tetanus up-to-date cover and received primary vaccination or buster injection.

### Management

All patients with gunshot injuries had cross matching of 1 to 4 units of blood and two large-bore IV cannulae for fluid replacement. Systolic blood pressure maintenance was aimed as 100 mmHg to avoid exacerbation of blood loss. X-rays (AP and lateral) of affected body region above and below the entry wound were performed to search for an embedded bullet or pellet. The vital signs, arterial blood gases, and ECG monitoring were used after the initial primary and secondary assessments, as per universal trauma protocol. The decision to take patient to operating theater immediately, to the intensive care unit, or to a high-dependency unit was made depending on the patient's hemodynamic stability and ISS. In order to reduce the risk of infection, debridement of damaged tissue followed by delayed closure of wounds and use of prolonged broad-spectrum antibiotics were implemented.

### Chest injuries

Although 6 patients sustained rib fractures from the un-established type of weapon or projectile caliber, there were only 2 chest-penetrating injuries, which required insertion of the chest drain for moderate pneumothorax.

### Abdominal injuries

Twelve of abdominal injuries were associated with bowel injuries of various localizations and required emergency laparotomies for damage control and bowel repair or partial bowel resection with primary anastomosis. Superficial non-penetrating wounds of the abdomen required bullet/pellet extraction, wound wash out, and further close observation in high-dependency unit for occult bleeding. In case of doubts in patients who were hemodynamically stable, diagnostic laparoscopies were performed to exclude hollow organ injuries and internal bleeding. Early administration of broad-spectrum antibiotics took place with any abdominal injury.

### Limb injuries

Large vessels, peripheral nerves, and tendons were endangered in 46 cases, including 6 injuries of femoral arteries, causing significant blood loss and requiring urgent revision of the arteries with primary repair, which was followed by a close monitoring of the limb circulation. Injuries to the peripheral nerves and tendon injuries (14 out of 102, %) were referred after patient stabilization to the appropriate specialized center for further management.

### Wound closure

Where soft tissue damage occurred with low-velocity bullets, gunshot wounds were managed by bullet/pellet extraction from the soft tissue followed by wound care and further outpatient review. Wide excision or fasciotomy was required to clean from foreign material (normally clothing) and dead tissue. In these cases, the primary wound closure was delayed for 3–7 days.

### Forensic aspects in gunshot reporting

The Saudi Arabian law implements guidance concerning the reporting of all firearm-related injuries. The local police authorities were quickly informed upon gunshot injuries presented to the hospital. This information is important statistical crime/event investigation information and gun injury statistics. The disclosure of personal information of the injured person by medical personnel to the public without consent from the patients or their family was avoided.

### Forensic evidences

Healthcare professionals preserved the potential forensic evidences, as a rule. These included the patient's belongings and bullet/pellet fragments extracted from the body. The recovered forensic evidences were labeled and kept in a secure place until transferred to the police.

### The cost of hospitalization due to firearm injuries

Researchers from Boston University School of Medicine through the analysis of more than 17,000 men and 2200 women admitted after a firearm injury demonstrated that the cost of acute and longer term medical care and recovery in this category of patients has increased greatly during the last decade. They concluded that many, almost certainly, face a long, painful recovery reflected in high medical bills (DiGravio 2018). This study was supported by multiple centers, such as Stanford University School of Medicine and Iowa University School of Medicine, which estimated the initial hospitalization cost of firearm injuries ranging from US$622 million to US$735 million per year (Peek-Asa et al. 2017).

Our findings, in agreement with the US studies, demonstrate the high healthcare cost burden of firearm injuries, in proportion to much larger scale of research. It is also showing high impact on young population by firearms.

## Conclusion and recommendations

This research in one of the heavily populated Saudi Arabian regions concluded that the firearm injuries have significant effects on the morbidity and mortality in the society. So it is recommended to enforce the current tight gun law regulations in Saudi Arabia and to encourage better education in Saudi Arabian communities in relation to firearms and their use in order to reduce the number of firearm accidents and related injuries.

In addition, this study proposes further research on population awareness of firearm-related injuries and their effect on the community.

#### Abbreviations

ABG: Arterial blood gases; ECG: Electrocardiogram; GCS: Glasgow Coma Scale; ICU: Intensive care unit; ISS: Injury Severity Score; KSA: Kingdom of Saudi Arabia; MVA: Motor vehicle accidents; SPSS: Statistical Package for the Social Sciences

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#### Availability of data and materials

The dataset remains as property of the King Khaled Hospital, al Kharj, KSA, and can be provided upon request by the corresponding author.

#### Authors' contributions

AM, main writer, contributed to the conception and design. NAAlA, critical reviewer, contributed to the conception and design. NAAlO, co-author and writer, contributed to the acquisition of the data. SAA, co-author, reviewed the literature. AFA, co-author, contributed to the analysis and interpretation of the data. HMA, SOAA, and MAMA, co-authors, contributed to the acquisition of the data. All authors read and approved the final manuscript.

**Ethics approval and consent to participate**
This research has been approved by the Scientific Research Committee of the Prince Sattam bin Abdulaziz University, Al Kharj, KSA (Approval # PSAU/COM/RC/IRB/A/2).
Permission for data collection from the Medical Records from King Khaled Hospital was obtained.

**Consent for publication**
Research approval from the Scientific Research Committee is automatically include consent to publish research material.
No individual consent required in retrospective medical record base study.

**Competing interests**
The authors declare that they have no competing interests.

## Publisher's Note



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