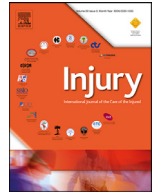




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Review

The nature and consequences of camel-related injuries: A scoping review with special reference to Arab Middle Eastern countries

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ABSTRACT

Animal-related injuries are a substantial but under-reported, emerging public health problem contributing considerably to worldwide morbidity and death. Understanding the behavior of big animals may help in injury prevention. Camels are large long-neck ungulates of the genus *Camelus* that have been domesticated for millennia as a mode of transportation, race, and food source. Camel-related injuries are not well studied when compared with other animals' injuries. Camels can occasionally be very hostile to humans, inflicting serious injuries. These injuries can be caused by camel bites, falls from their backs, kicks, or collisions with motor vehicles. The relative magnitude of each mechanism has never been extensively studied in the literature. Furthermore, the incidence of camel-related injuries is not well reported worldwide. Camels remain a potential cause of serious injuries and a public health problem for some countries in the Middle East. There are gaps in the incidence, risk factors and mechanism, distribution of camel-related injuries. We aimed to summarize the data and draw conclusions pertaining not just to the most common mechanism of injury but to demographics, incidence, severity, and appropriate methods of prevention of camel-related injuries. This scoping review findings will help for better understanding of the nature and consequences of camel-related injuries, and to improve the existing preventive and management strategies.

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Introduction

Humans contact and interact with a wide variety of animals in several different environmental settings. Human-animal interactions can occur in urban and rural settings, and these differences might lead to differences in the injury spectrum and management priorities. Animal-related injuries are serious and under-reported, developing public health issues contributing significantly to global morbidity and mortality [1–4]. Human injuries caused by domestic and wild animals are becoming more common worldwide, depending on the animals' distribution, anatomy, behavior, ecosystems, and relations with humans [5–9]. The dromedary camel (*Camelus dromedarius*), often known as the one-humped camel or (Arabian camel), is a valuable natural resource throughout arid regions of Africa, the Middle East, and Western Asia with a bit of introduction into Australia [10]. Camel population worldwide is estimated to be approximately 28.4 million [10]. The United Arab Emirates

(UAE), Yemen, Saudi Arabia, and Oman have the most significant camel populations in the Middle East, followed by Iran and Egypt. The Arabian world, where the camel is renowned as the "ship of the desert," has a significant economic and social significance [11]. Camels have social significance, and depending on the country, they are mainly employed for sports and recreation, milk, meat, fiber production, as 'pack' animals and camel trade. Unfortunately, they are also a substantial contributor to major trauma and injury to the human population in the Middle Eastern region.

Out of a global population of roughly 14 million camels, approximately 500,000 are reported to be free-roaming in Saudi Arabia. They form densely populated groups as high as six camels per ten square kilometers in specific locations and 12 camels per kilometers stretch of the highway [12,13]. Because of the high population density, camel vehicle collisions (CVCs) are practically unavoidable. Over four decades, the population of camels in the UAE had skyrocketed and increased by 150 percent. Like many other rural enterprises, camel numbers began to rise in the UAE in the late 1970s. Camel's population in the UAE have increased from an estimated 100,000 to a current population of 250,000. The UAE currently boasts one of the greatest camel populations globally, second only to Qatar and 20 times higher than Saudi Arabia.

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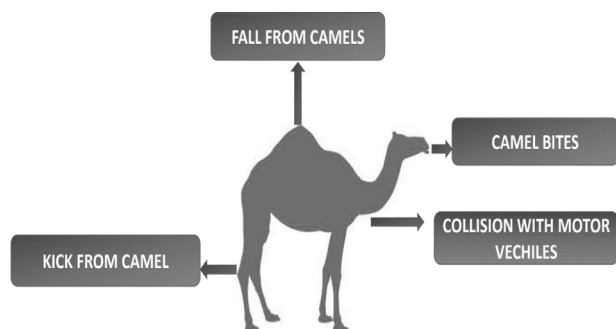


Fig. 1. mechanism of injury in the camel-related trauma.

Camels can sometimes be aggressive towards humans, causing serious and even fatal injuries [14–16]. Bites, fall from backs, kicks, and collisions with motor vehicles are examples of camel-related injuries [6,16,17]. Camel remains the most traumatizing animal, accounting for 83% of the animal-related trauma in the UAE, 80% in the Saudi Arabia and 25% in Nigeria [19–21]. However, the global prevalence and scale of camel-related injuries remain largely unknown in the contemporary literature. Unpublished data from the Hamad Trauma center in Qatar, the only tertiary trauma center in the country, showed that there were 145 cases hospitalized with camel-related injuries over the last 10 years (around 1% of the total trauma hospitalizations).

In this paper, we reviewed publications of the most reported patterns of camel-related trauma. There are critical knowledge gaps about the incidence, risk factors and mechanism, distribution of camel related injuries. Fig. 1 summarizes the mechanism of injury in camel-related trauma. Realizing the need for a thorough review of the literature to identify the risks, factors and patterns related to camel related injury to humans was the impetus for this review. This quick scoping review's findings will help better understand the nature and consequences of camel-related injuries, improve the existing management and strategies, and inform better injury prevention initiatives.

Methods

Search strategy: Using PubMed, MEDLINE, and Google search engines, a scoping review was conducted. We used the keywords "Camel-related injuries", "Camel injuries," "Trauma," "epidemiology," "Middle East", "Arab", "Middle Eastern countries "between December 1974 and July 2021. Due to the paucity of information regarding this topic, all articles were considered for analysis. Medical subject headings (MeSH) terms used were "Camelus" OR "Camel" (MeSH terms) OR "Injuries" (all fields) AND "Accidents" (all fields). These were limited by the terms ("Arabs" [MeSH Terms] OR "Arabs" [all fields] OR "Arab" [all fields]) AND ("Middle East" [MeSH Terms] OR ("Middle" [all fields] AND "East" [all fields] OR "middle east" [all fields])). These articles were then screened for review. The criteria for the inclusion of articles were based on the literature available on the incidence and epidemiology of camel-related injury in the Arab Middle Eastern region between January 1974 to July 2021. This review also considered articles published in English that were available on electronic databases and specialized university websites. We focused on data from Arab Middle Eastern nations such as the UAE, Oman, Qatar, Saudi Arabia, Iraq, Palestine, Jordan, Kuwait, Bahrain, Lebanon, Syria, Tunisia, Yemen, and Egypt. The publications identified through the search were independently vetted for inclusion by two authors, resulting in 21 papers being chosen for the current review. The bibliographies of the retrieved references were also used to identify related articles for cross-referencing. The search produced a total of 137 articles re-

lated to "Camel Related Injuries", and adding "Middle East" to the search narrowed down the articles to 55, and subsequent use of "Arab" yielded only 5 more articles.

Results

Out of 137 articles based on the camel-related injuries in the Middle East, 77 were found to be irrelevant to the purpose of this review and were excluded because the majority ($n = 62$) were not related to camel-inflicted human injuries, 09 were from non-Arab countries, 3 were published in a language other than English, and 3 had no abstracts available. Finally, a total of 21 articles were included in this review (Fig. 2). Cross-referencing of the retrieved references enables us to include a total of 73 references, including published articles and references of data sources on specific websites. One recent relevant preprint article has been briefly included in the discussion.

Discussion

This is a unique quick scoping review on the nature and consequences of camel-related injuries with a special reference to the Arab Middle East region. The review extensively addressed the gaps in the contemporary literature.

Injuries related to camel bites

- **Epidemiology:** Animal bite is a worldwide issue that has eluded reliable statistics [17]. Camel bite injuries account for a small proportion of all documented mammalian animal bite injuries, with the majority reported from Middle Eastern countries [18]. There is relatively scant attention in the literature about camel-bite injuries in western countries [19,20]. Studies reporting camel bites are mainly case reports or retrospective in nature. The estimated incidence of camel bite injuries necessitating hospitalization in one of the UAE's cities is 1.5 per 100,000 residents per year [15], suggesting that these injuries are under-reported due to lack of necessary training in research, reporting, and data publication. Camels may appear docile and inoffensive, but they can occasionally be violent and potentially dangerous if wrongly dealt with. Camels have a nasty habit of attacking their caretakers [21]. Camels are seasonal breeders, and their breeding season is limited to the coolest months of the year [22]. Most camel bites occur in the Middle East during the rutting or breeding season, which runs from November to March (the latter half of winter) when camels are more aggressive and agitated [20–24].

Furthermore, the caregiver's brusque behavior may make the camel even more combative. This occurs only in the one-humped camel. Under such circumstances, when they bite, the outcome can be severe and fatal [16]. A sexually active camel's mouth has an air-filled, inflatable, pink diverticulum called the "dulla," which can be up to 25 cm long, and rutting camels can be identified by this pink "dulla" that protrudes from their mouths [25–27]. This "dulla" indicates that the camel can be potentially dangerous and should be avoided [25].

- **Injury Pattern and Mechanism:** Camel bite wounds are extremely varied and include penetrating and crushing injuries by the camel jaw and blunt injuries when victims are picked up, lifted, and thrown by the camel, resulting in fractures and severe lacerations of skin muscle, tendons and nerves. A mature camel has 34 sharp teeth and a powerful jaw that can expand wide and exert high pressure [26,27] and its canine teeth can grow up to four centimeters, resembling a dagger. These teeth can cause fatal wounds [17], illustrating those deep structures might be seriously injured, whereas modest superficial structures may be impacted. It also has a long neck, enabling it to get around and

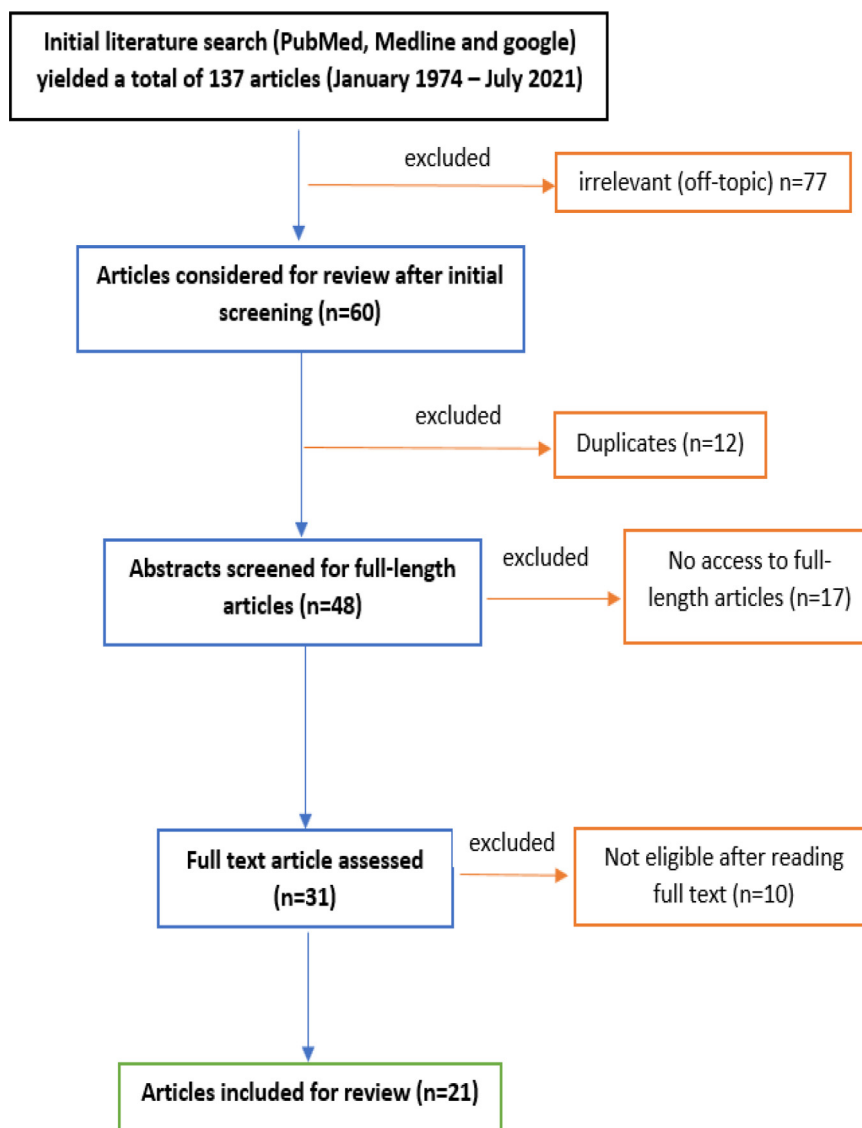


Fig. 2. Flow Diagram of the review design.

reach with its mouth from multiple angles and positions [28]. Most bite-related injuries generally occur when camel handlers try to make the camels stoop down to allow for mounting by pulling the reins on the camels' heads. Camel bites involve complex mechanisms that are not solely due to the bite's consequence. Camel bites have been reported in which the teeth lift the victim, agitated with jerky movements, and thrown down [14,24,29]. After the first injury, the camel's hooves or body may crush the sufferer. The jerky movement of the camel head could aggravate the damage [24]. Although the wound may appear to be a simple puncture, it may affect deeper structures. As a result, repeated penetrating injuries mixed with physical trauma are relatively uncommon. Upper limb injuries caused by camel bites have been demonstrated to involve 64–94 percent of recorded cases [15,17], with fractures occurring in 15–31 percent of bites and traumatic amputation occurring in 3.3 percent of bites [4]. Camel bites have been described to cause injuries, including scalp avulsion, skull fractures, brain trauma, traumatic tracheostomy, common carotid artery injury, and fracture ramus [30,31]. There has also been reported incidence of orbital fracture-dislocation of the temporomandibular joint and fractures with or without neurovascular involvement [32].

Injuries to the abdomen caused by camel bites have also been reported in the literature. [15] The camel bites thin regions of the body, such as the upper limbs and neck, and the neck is involved in roughly 8% of cases. [16]. The puncture wounds of these bites, despite their small size, penetrate deeply, inflicting significant injury to deeper structures. Also, all recorded wounds are on the left side of the neck, maybe due to the behavior of camels [31].

– Camel bite-related major vascular injuries:

Vascular injuries have been described in a scatter matter including case reports and small studies [33]. A recent preprint article from the UAE described 7 cases with camel-related major vascular injuries during the rutting season of camels (4 carotid artery, 1 Aorta, 1 femoral artery and 1 common iliac vein) [34]. Although these injuries were very rare and collected from a 20-year database, the outcome was poor. Six out of the 7 cases were due to camel bite. Authors described that each bite causes four small elliptical wounds of the canine teeth which resembles two stab wounds of 8 cm long that cause penetrating trauma.

– Infection risk, treatment, and prevention modalities from Camel bites:

Camel bites are susceptible to infection, just like any other animal bite. Furthermore, camel bite infections can be caused by a

variety of bacteria including *Staphylococcus aureus*, *Streptococcus pyogenes*, *Pseudomonas aeruginosa*, and *Bacteroides* and *Fusobacterium*. Some of the most prevalent pathogens include *Aeromonas*, *Pasteurella aerogenes*, and *Actinobacillus*. It has been reported that the infection rates from camel bites might reach 86 percent [35]. The bacterial content of the saliva may spread quickly after camel bites causing necrotizing fasciitis if not adequately and timely debrided [36]. Moreover, few cases were reported to have severe osteolysis resulting from camel bite [37]. Patients who suffered camel bites are in danger of contracting tetanus and rabies if both the camel and the handler have not received the appropriate vaccinations.

A patient who sustained a camel bite should be carefully stabilized and thoroughly checked at the time of presentation. Once the patient's hemodynamic has stabilized, the wound should be explored to determine if deeper structures were involved. A radiographic examination of the afflicted area should be undertaken to check for underlying fractures or dislocations. To decrease infection risk, camel bites should be thoroughly irrigated and debrided [32,38]. Sometimes a surgical debridement is required in the operating room. Antibiotics have been used prophylactically in many case reports [8,20] despite lack of evidence. It is recommended that tetanus prophylaxis be given as needed [38]. Because camels can spread rabies, this must constantly be taken into consideration, especially if the camel cannot be monitored directly.

Injuries due to camel vehicle collisions (CVCs)

Traffic accidents caused by vehicle collisions with wildlife occur all over the world. Camels are commonly involved in these crashes throughout the Middle East. As camels are huge animals, collisions frequently result in high morbidity and mortality rates. Camel-vehicle collisions in the Middle East, particularly Saudi Arabia, have reached such alarming proportions that immediate action is required to stem this tide.

Over four decades, the number of camels in the UAE has increased by 150 percent. When combined with rising urbanization and the construction of rural roads and highways in desert areas, this increase in camel population creates a unique case of habitat fragmentation and a major cause of motor vehicle accidents on the rapidly expanding network of highway roads in the Middle East. Furthermore, collisions involving camels are unique in several ways, such as the severity of related injuries (mortality and morbidity), spatial distribution, and the socio-cultural importance of domesticated camels—as essential parts of society. The death of a camel in vehicle collisions is a loss to wildlife and the utility value linked to these pack animals.

Epidemiology, mechanisms and patterns of camel and vehicle related injuries

According to a study by Saudi Arabia's National Committee on Transport Safety, a total of 341 CVCs were observed in 1997, resulting in 16 human fatalities and 215 injuries. This equates to seven out of every 10 CVCs causing human death and morbidity. According to another research, the yearly occurrence of CVCs in Saudi Arabia is over 600, with a mortality rate of one out of every four CVCs, a rate that is six times higher than all other forms of road traffic incidents. A study conducted at Riyadh Armed Forces Hospital in Saudi Arabia (1998) reported that most patients with low cervical spine injuries were due to motor vehicle accidents, and camel collisions were shown to be a primary contributor to traffic accidents [39]. Camel accidents are prevalent in the evenings, when camels that stay in the desert, generally unattended, roam around in herds of four to six, often unexpectedly crossing roadways [39]. There are no specified camel crossing routes, and camel

owners frequently break the fence constructed in various locations to allow the camels to cross. As a herd on the road, they come unexpectedly in front of the motor vehicle. There is no room or opportunity for the driver to maneuver or swerve to avoid colliding.

Camel being a tall, long-limbed mammal standing above 2 m (6 ft 7 in) at the shoulders, often appear on the highways without any warnings [40]. Most automobile hoods are considerably below 1.2 m, which is the height of the camel hump above the ground. When these automobiles collide with camels, the delicate limbs are initially struck, propelling the animal's tremendous weight into the roof and windshield, often causing serious injuries to the front seat occupants. This might result in neck flexion injuries, cervical compression injuries and long-term neurological damage in the passengers [40]. The occupants of the afflicted cars frequently exhibit an avoidance reflex movement pattern, which in many incidents can be counterproductive because such behaviors are likely to enhance the likelihood and severity of injuries [39]. Factors such as whether a seat belt restrained the driver and passengers may affect the pattern of injury sustained. A seat belt reduces the probability and degree of avoidance movement significantly. Individuals are more prone to develop compression fractures on the spine, head, and chest due to the camel's body directly impacting the upper portion of the occupant's body.

The pattern of injuries may also be classified into two categories: The first being injuries received directly from the original accident and injuries sustained due to subsequent occurrences. The first impact of the animal's massive weight on the vehicle and all following events causes severe damage to humans and animals alike. There is a risk that the animal's crushing weight may fall axially on the front seat passenger's heads, necks, and chests [39,41,42].

In the second scenario, the driver and passengers may make a last-ditch effort to avoid colliding with the animal. This could lead to crashing into surrounding buildings such as trees because of avoidance. There have been reports of drivers and passengers (typically without seatbelts) bending and extending the head and neck protectively or laterally stretching the spine. This can lead to fracturing of the spine in the process of lacerations from shattered glasses, spinal disk compression fractures, multiple rib fractures, and dislocations leading to total paraplegia have also been documented [39,42,43]. However, both injury mechanisms are not mutually exclusive, and they have been observed to coexist. For instance, Both direct collision with the camel and protective flexion affecting the neck apparently led to an unusual case of carotid artery damage resulting in the "traction and total blockage of the left internal carotid artery" in a case reported at the Riyadh Armed Forces Hospital involving a 34-year-old guy [41]. Such kind of injuries is often documented in high-intensity sports like jockeying [44].

Specific characteristics and behavioral habits of camels may impact the pattern of CVCs incidence on highways and rural roads. In Saudi Arabia, camel owners often choose to settle and keep their animals near highways to make transportation facilities easier, increasing the possibility of these animals wandering onto highways [13]. Camels frequently travel in groups across highways and country roads to look for water and food during the mating season [12]. Camels are hard to detect by car drivers, especially at night, and can cause serious accidents if they collide. One study has concluded that camels are commonly implicated in CVCs, accounting for 97 percent of all recorded CVCs. Over 90% of these collisions occur at night, between sunset and morning [45]. These accidents cause substantial damage to the environment, economy, and social life, such as significant economic loss (Cost of treatment and rehabilitation of sustained injuries) and associated human fatalities; loss of utility value attached to killed and debilitated camels;

loss of valuable wildlife, and damage to properties (cost of vehicle damage) [46,47].

Prevention modalities for vehicle collisions involving camels

The alarming incidence of CVCs occurring in the Arabian landscape has necessitated the implementation of specific preventive measures to moderate the trend and lower the accompanying cost, both in socioeconomic terms and in the loss of valuable animal life [48,49]. Understanding these extra consequences may offer a framework for improving methods to manage animal behavior through education and legislation to guarantee that camel owners accept responsibility for keeping their animals from roaming unattended.

Reduced visibility owing to poor road lighting, heavy traffic, particularly in rural regions with a high population density of domesticated camels, and flat terrain, which encourages vehicles to over-speed, have all been cited as factors increasing the probability of CVCs [12,48]. Improved visibility on highways and country roads is strongly advised since it has been claimed that more than 90% of collisions occur between nightfall and morning when camels are difficult to see until it is too late [47]. A recent review focused mainly on the CVCs and recommended the use of wildlife over- and under-passes in conjunction with the erection of highway fencing, especially in areas vulnerable to high rates of CVCs [48]. However, building such structures is very capital expensive, and a substantial deal of maintenance is necessary to maintain their stability. Especially because camel owners have been reported breaking fences to allow camel access, it is also recommended that reflecting warning signs be used [48,50]. When warning signs are coupled with speed bumps put in susceptible parts of the road, their effectiveness is likely improved. Attention to fundamental safety precautions on the part of road users can substantially minimize the probability of injuries in an accident [51,52]. Public awareness should be raised via the use of social media and electronic platforms to educate and sensitize the public to the hazards of dangerous driving habits and inadequate supervision of camels near highways. On rural roads/highways and in camel-populated regions, a low-speed limit should be established.

Injuries sustained due to falls from camels (Camel racing)

Camel racing is a deeply ingrained traditional sport in the Arabian Peninsula, North Africa, and the Middle East. Camel racing has quickly grown in popularity as a spectator activity in the Gulf nations during the last two decades [53]. Although there have been instances of motor vehicle accidents involving camels, direct camel-related injuries are uncommon and rare, and little is known about them. Camel Racing has long been a popular sport in the Gulf countries, especially the UAE and Qatar [54]. It's a popular tourist attraction sport that holds cultural, heritage, and socioeconomic importance in Middle Eastern countries [53,55]. Camel racing circuits may be found in most of the Gulf's major cities. Around 16,000 camels raced in the UAE, a camel racing hotbed in 2005 [56]. A standard riding camel jogs at 8 to 10 km/h for 50 km per day, whereas a racing camel runs at 30 to 40 km/h for 50 km per day [9]. Camel racing riders, often called Jockeys, mainly consists of children in the Gulf region. Given that a camel may stand up to 2 m high at the shoulders, this may be a considerable height and result in severe head injuries [57]. In the past, camel jockeys as young as three were trained since they were lightweight and did not interfere with the camel's breathing or pace [9,54]. Camel Jockeys had to work long hours in high temperatures, and food intake was restricted to make them underweight so that camels could run faster [58]. The majority of camel riders in the Middle East have been claimed to originate from the Indian subcontinent (from

Bangladesh, Pakistan, and East Africa), belonging to the poor social and financial background. Two Decades ago, it was estimated that more than 40,000 child camel jockeys were present in the Middle East [59].

In the literature, there are just a handful of published clinical investigations on camel jockeys [9,19,54,60]. All of them were children from the Gulf nations. Most of the injuries have been attributed to falls from the camel [25,61]. Camel racing has the greatest fatality rate of any sport in the region and is potentially riskier than motorbike or automobile racing [25,54,57,58,61]. Sankaran-Kutty and Abu Baker [9] documented the characteristic camel racing injury of isolated tibial fractures in an observational study from the UAE in 1992. Prior data from Qatar and UAE reported the anatomical distribution of child camel jockey injuries in 2005, revealing a significant prevalence of intracranial and spinal injuries [19,54]. There were 275 child camel jockeys aged between 5 and 15 years in Qatar. Sixty percent of these patients needed hospitalization. He found that the upper limb (23.2%), lower limb (21.1%), head (20.7%), chest (8.4%), abdomen (7.2%), and neck (6.6%) were the most common locations for injuries in children, followed by other types of injuries.

Moreover, a study published in 2003, reported that 2.6% of all children were injured in Qatar because of camel races [62]. In UAE, Nawaz et al. [19], in a ten-year study, reported 75 hospitalized children camel jockeys' injuries ranging between 4 and 15 years. Ninety-five percent were child jockeys who had fallen while racing. The most frequent injury was a head injury (more than 55%), and broken tibia (18%), with an accompanying fracture of the fibula in 4%. This form of tibial fracture was regarded as distinctive among camel jockeys and is a common injury [9]. Also, Camel falls can occasionally result in intra-abdominal injuries though they are extremely rare [63].

Camels, particularly camel jockeys, are a possible source of serious injuries and a huge health issue for children, and every effort should be taken to avoid them. Limiting camel racing to adults and prohibiting minors under the age of 18 years from participating in the activity would be an effective preventative strategy. In this regard, a response committee [64] was formed in response to growing and persistent criticism from human rights organizations about using children as young as 5–6 years old as camel jockeys. Qatar was the first country to enact legislation to address this issue effectively [60]. Soon UAE followed the suit, and the Emirates Camel Racing Federation adopted a regulation on July 22, 2002 and followed it up by strictly enforcing the law on July 5, 2005, prohibiting those younger than 18 years from participating in camel racing [65]. Furthermore, camel jockeys were replaced at that time by robotic camel riders [66,67]. This explains the progressive decline of pediatric injuries from 2002 to 2005 in the UAE and their complete disappearance after 2005 [60]. The number of kid camel race-related injuries in Qatar declined after 2003, as well [54]. This can be ascribed to commendable developments in Qatar and simultaneously as those in the UAE. Kuwait soon followed the suit, and a ministerial directive was issued on June 5, 2005, instructing camel racing clubs not to hire camel jockeys under the age of 18 or weighing less than 45 kg [68].

Incidence, mechanism, and anatomical distribution of injuries due to camel kicks

Camel kicks are the most common cause of camel-related human injuries [16]. Fig. 3 summarizes the incidence of camel kick-related injuries in 2 studies from the UAE, in relation to the other camel-related injuries [15,57]. Camels were responsible for more than 80% of animal-related injuries in the UAE, with kicks being the most prevalent method of damage [69]. The study described camel kick as the most common mechanism of camel-related hu-

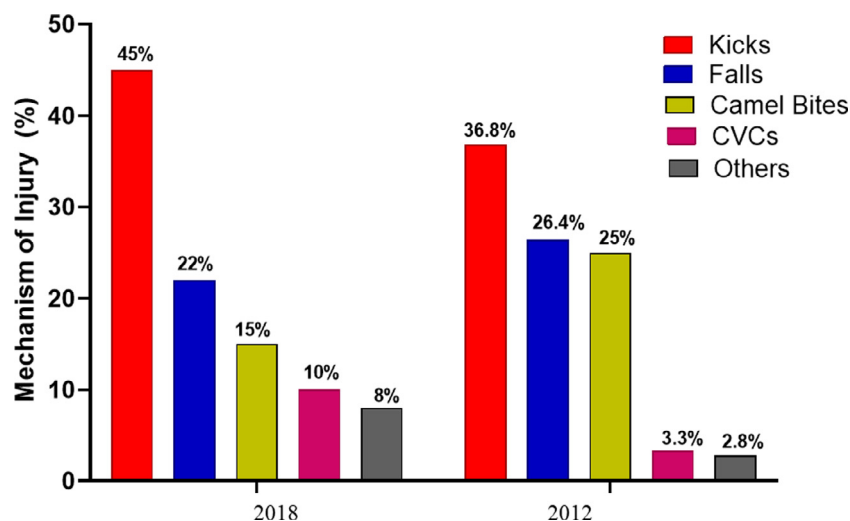


Fig. 3. Mechanisms of camel-related injuries available from two studies in a Middle East country, the United Arab Emirates [ref 15,57].

man head, face, neck injuries. Camel's kicks were shown to have a considerably greater rate of facial bone fractures than other mechanisms [7,8,13]. The mid-facial bones (49%) were the most often fractured, including the zygomatic bone. Bilateral mandibular fractures were frequent, accounting for 44% of all mandibular fractures. These injuries can be caused by the high surface area of camel hooves. Another prospective investigation of mechanisms in more than 200 people wounded by camels in Saudi Arabia discovered that kicks were the most prevalent (36.8%), followed by falls (26.4%) and bites (2.4%) [16]. This mechanism of camel related injury has most commonly been noticed in camel handlers or caregivers.

Attacks involving kicks are more common in the breeding season when male camels become more aggressive [58] and violent; female camels may also attack the handlers [70]. The camel may kick with the front knee when the caregiver bends to tie the camel's front knee to prevent it from standing up. Furthermore, the standing camel's rear hoof may kick at high speed by the back hoof, which may reach up to the level of the victim's head and chest [16]. This explains the high percentage of head, chest and abdominal injuries caused by camel kicks. A prior UAE study [16] reported that 72% of head and facial injuries caused by camel kicks resulted in fractures, much more common than other mechanisms of injury.

Apart from the head, kicking usually involves the chest and may cause fractures of the midfacial bones and ribs with the bony destruction exacerbated by the large surface area of camel hooves [57]. A camel may also kick with its front knees when kneeling [16,57,63,70]. Abdominal injuries occur in 20% of those kicked and may include trauma to the duodenum and pancreas with subsequent traumatic pancreatitis [63]. The initial trauma may be exacerbated if the attacking animal then stands on the victim. In addition to kicking, camels may also walk on, trample, or squat on people, resulting in numerous fractures and significant organ and soft tissue damage, as described in previous studies [25,71]. Camels, like caged elephants, may sit on humans, resulting in death from a combination of crushing injuries and crush asphyxia [72–74]. It is worth noting that dromedaries may weigh up to 750 kg; thus, the deadly effects of such behavior are expected. [70] These secondary processes of camel-related injuries were reported in 13% of the cases [16]. Given that camel kicks have been found to be the most common mechanism of injuries to humans, it becomes imperative to understand the biomechanisms and correlate them

with the behavior of the camel to the prevention of camel-related injuries.

Limitations

This review was confined to peer-reviewed publications published in English, which may have resulted in missing some data related to camel injuries, especially from countries like Oman, Iraq, Palestine, Jordan, Kuwait, Bahrain, Lebanon, Syria, Yemen, and Egypt. Arabic is the first language spoken in Middle Eastern countries, while English is the second language spoken and the formal language used in the medical sector, encompassing academic and scientific professional research. There are just a few databases that include Arabic-language articles. However, they generally contain just a small number of articles from a wide variety of topics such as art and engineering, rather than primarily on animals or animals and human injuries in specific. As a result, choosing English was the best option for finding more studies. While a thorough search was carried out, it is conceivable that relevant papers were missed since the authors may have used only scientific databases (Table 1 and 2 summarize the available literatures in English regarding different camel-related injuries studies) [9,14,19,27,30–32,39–42,54,61,75–78]. Although efforts have made to enquiry all the available relevant articles, the quick scoping review may do not formally evaluate the quality of evidence and often gather information from a wide range of study designs and methods and selection bias cannot be ignored [79].

Conclusions and perspectives

We have demonstrated several diverse ways and mechanisms in which camels may negatively impact human health. This review focused only on the Arab Middle Eastern countries' publications, with many case studies and retrospective studies including data from the past three decades. The literature during this timeframe is quite sparse. Direct injuries and trauma from attacking animals may involve kicking and biting. In addition, these agitated and aggressive animals may also inflict injuries by kneeling or sitting on a victim or picking them up or shaking and throwing them. Moreover, fatal injuries and death may follow, particularly during racing, or after camel-vehicle collisions. We expect our data presented in the current review to raise awareness of the frequency and severity of camel-related trauma in the Gulf Region. The majority of

Table 1
Summary of Case Reports available in the literature on injuries caused by Camel Bites.

Authors	Year	Age	Sex	Country	Mechanism of Injury	Clinical Presentation	Injuries
Janjua et al. [27]	1993	52	M	Saudi Arabia	Bitten by a camel, lifted- up and thrown aside	Swollen left shoulder, absent left radial pulse	Bite mark on the left shoulder without penetration, Left subclavian artery occlusion, fractured clavicle
Ogunbodede et al.[32]	1997	16	M	Nigeria	Camel Bite	Patient was stable, normal vital signs conscious, alert and calm.	Multiple facial lacerations, contusions and bilateral edema of the lower half of the face. Intraoral bleeding, lower left incisors, canine and premolars were avulsed. Deranged occlusion with floating right mid-mandibular segment.
Nawaz et al. [19]	2005	11	M	UAE	Camel bite	Neck wound, Four puncture wounds on left side of the neck, ear and cheek	Intimal tear of the left internal carotid artery without occlusion, fractured mandible
Abu-Zidan et al. [14]	2007	45	M	UAE	Bitten by a camel, lifted up and thrown to the ground	Unconscious, dyspnea, shock, right hemiparesis	Left carotid artery injury without occlusion, massive left-brain infarction, fractured cervical spine, massive left hemothorax, fractured clavicle and ribs
Khatana et al. [30]	2013	32	M	India	Bitten by a camel, lifted up by the jaw and thrown aside	Conscious, alert, and oriented, with no difficulty in respiration or deglutition.	Multiple laceration and puncture wounds on the bilateral cheek region and the neck. Occlusion was deranged, and the right mandibular canine was avulsed. Radiographic examination showed displaced horizontal mandibular ramal fracture with right compound displaced mandibular body fracture and an avulsed right mandibular canine
Abu-Zidan et al. [31]	2014	23	M	UAE	Camel bite	Neck wound, inability to abduct the left arm	Puncture wounds on left side of the neck, Intimal tear of the left common carotid artery, left brachial plexus injury
Sanadi et al.[75]	2016	29	M	Saudi Arabia	Camel Bite	Patient presented with wound at the right side of the face, vitals stable, conscious, bleeding profusely.	Five cm lacerated wound on the right side of the face, bleeding from right ear with 03 separate wounds in the scalp of the right side. CT scan revealed a fracture of the right sub- condyle.
Balac et al. [76]	2019	25	M	UAE	Camel Bite. Bitten several times in face and neck, lifted up and thrown to the ground	Patient fully conscious, but in severe distress	Globe rupture. Multiple puncture, laceration wounds on the left side of face and neck. Maxillofacial CT showed a comminuted fracture of the left nasal bone, medial orbital wall, medial rectus muscle hematoma, fracture of lacrimal bone, left preseptal hematoma, complete opacification of left intraocular content.
Al-Umran et al.[77]	2020	40	M	Saudi Arabia	Camel Bite	Vitally stable and afebrile, little disoriented but no lateralizing neurologic deficits observed.	Camel bite associated with depressed skull fracture with rapidly spreading subgaleal cellulitis. Scalp inspection showed 2 small cut wounds on the left side and 3 on the right side both just above the pinna of the ear. Abrasion above the left supraorbital region. CT scan showed depressed skull fracture on the left temporal region associated with pneumocephalus.
Albazei et al. [78]	2021	48	M	Saudi Arabia	Camel Bite	Conscious, oriented, distressed and vitally stable Multiple lacerations on the left side of face and multiple fractures in the left forearm.	Ophthalmic examination revealed a superior scleral wound about 6 mm from the limbus extending to the equator with prolapse of uveal and vitreous tissues, an opaque cornea, total hypphema, diffuse subconjunctival hemorrhage, and a lower lid laceration involving the lid margin and the nasolacrimal duct.

Table 2
Summary of the studies and case reports related to Injuries caused by Camel-Vehicle Collisions and Falls (Camel Racing).

Study	Year	Country	Patients N	Mean Age	Clinical presentation and Injury characteristics
Camel -Vehicle Collisions related injuries					
Sebai et al. [40]	1997	Saudi Arabia	16	27.2	Cervical spinal cord injury and associated Flexion and extension injuries
Ansari et al. [39]	1998	Saudi Arabia	39	32	Lower cervical spinal cord injury, Flexion injury, followed by vertical compression, hyper-extension, lateral flexion, and Flexion rotational injuries
Ansari et al. [41]	1998	Saudi Arabia	1 (Case report)	34	CT scan showed a large left temporo-parietal area infarct with petechial hemorrhage in the region. occlusion of the left internal carotid artery
Ansari et al. [42]	2001	Saudi Arabia	3 (Case report)	50	1. Multiple rib fractures along with burst fractures of D3 and D4 resulting in complete paraplegia below D4
				24	2. Fracture dislocation of D6 and D7, resulting in complete paraplegia below D6, along with fractures of the 5th, 6th, and 7th ribs on the right side
				40	3. fracture dislocation of D7 and D8. Patient Paralyzed.
Injuries related to falls from camel					
Bener et al. [54]	2005	Qatar	275	8.1	165 boys (60%) were hospitalized. 110 boys (40%) had only superficial injuries. 82 patients (50%) saw improvement through physiotherapy; 17 patients (10%) were disabled due to a fractured femur, fractured pelvis, fractured spine, and intracranial hemorrhage; and 66 (40%) did not require any physiotherapy
Nawaz et al.[19]	2005	UAE	78	8.6	In 75, the cause of injury was a fall from a racing camel. 56.4% had head and 6 had associated skull fractures, whereas 3 had intracranial hematomas. Twenty-five (32.1%) had fractures of various bones, and 14 of them had fracture of the tibia. Two sustained thoracic injuries, whereas 9 had intraabdominal injuries, including liver injury (3), splenic injury (1), renal injury (3), and (1) bowel injury.
Sankaran-Kutty [9]	1994	UAE	42	10–11	Tibial Fracture without the involvement of fibula. The fracture of the tibia was typically spiral in configuration and situated at about the junction of the middle and lower thirds of the shaft. Forty of these patients showed no displacement.
Wong et al. [61]	2002	Australia	1	52	skull fracture and a life-threatening extradural haematoma. CT of the head showed a large right-sided parietotemporal extradural haematoma with overlying fractures which extended from 6 cm above the right petrous bone which itself was fractured transversely and extended into the right temporal fossa

camel-related injuries appeared to be linked to legality, education, and a lack of compliance with basic safety precautions and other safety equipment. The information provided in this updated review will help us to better understand the nature and consequences of camel-related injuries, improving our existing management and strategies and informing new injury prevention initiatives.

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Declaration of Competing Interest

The authors declare no conflict of interest.

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