

Causes and Patterns of Traumatic Mandibular and Maxillofacial Fractures in Saudi Arabia: Systematic Review and Meta-Analysis

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ABSTRACT

Aims: to assess the demographic distribution, causes and types of mandibular-maxillofacial (MM) traumatic fractures in the Kingdom of Saudi Arabia (KSA).

Methods: Several databases were searched for reports on MM fractures in the KSA. Variables collected from articles that met inclusion criteria were: age, gender, city in KSA, cause and site of facial trauma.

Results: 19 of 41 articles were eligible for data collection. Most subjects were male, 6,416 (23.5%) and >18 years old, 4,067 (56.8%). Of 8,981 fractures, there were 504 (5.6%) dentoalveolar, 1,867 (20.8%) zygomatico-maxillary complex, and 4,314 (48.0%) mandibular- with condylar fracture being the most frequent mandibular fracture, 969 (10.8%). Motor-vehicle accident (MVA) was the leading cause of MM fracture in KSA with pooled prevalence of 55.5% (39.0%-71.3%, I²=99.4%).

Mandibular fracture was the most common site of fracture with pooled prevalence of 45.2% (35.5%-55.1%, I²=98.5%).
Conclusion: Fracture of the mandible is the most common type of fracture and MVA remains the main cause of MM trauma. Young male adults comprise the majority of demographics. Medical studies on this topic lag behind recently published non-medical reports that take into account the implementation of stringent seatbelt and speed laws, and recently-allowed female driving in KSA.

Key words: Prevalence, Fractures, Facial bones, Mandible, Meta-analysis

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INTRODUCTION

The Kingdom of Saudi Arabia (KSA) has one of the highest rates of road-traffic deaths in the world, with an increase from 17.4 to 27.4% people dying for every 100,000 since the last decade [1]. Motor vehicle accidents (MVA) are the main cause of trauma in KSA and worldwide. In the KSA, around four people are injured per hour and 81% of total fatalities in hospitals are due to MVA, with majority of victims being young adults causing devastating social, economic, and health consequences [2].

Other causes of trauma are due to fall, physical or firearm assault, sports, work-related, animal attacks, and others. The etiology of fractures has shifted throughout the past three decades due to changes in culture, economics, and traffic regulations [3]. Mandibular-maxillofacial (MM) trauma may present as a single or multiple fracture(s) and

may cause pain, masticatory dysfunction, speech impairment, facial disfigurement, emotional distress, and reduced quality of life.

The incidence and patterns of MM trauma in KSA have been recently reported in a systematic review, however the authors recorded the fracture site as maxilla and mandible only, and failed to record causes other than MVA for 5 out of 13 articles included.[4] Studies that reported the frequencies of facial trauma and/or causes in KSA show large variability in the study design, cohort age, single city or medical centre from which the data was collected [4].

This study aims to determine, via systematic review and meta-analysis, the proportion of MM fractures resulting from different traumatic etiologies among adults and children in KSA.

MATERIALS AND METHODS

Article screening and evaluation

The search was completed following the PRISMA guidelines in three phases:

Phase I: Identification and screening

An electronic search strategy was developed for PubMed (Table 1) and adapted for each of the following bibliographic databases and grey literature: PubMed, Scopus, Web of Science, and Google scholar. The search

started June/2019 and concluded at the end of March/2020.

Inclusion criteria: Human studies, reporting trauma in the maxillofacial and/or mandibular structures, in KSA.

Exclusions: Editorials/letter to the editor and studies reporting dental fractures only. The titles and abstracts of the articles were reviewed for inclusion to the next phase.

Table 1: Keyword search strategy.

Search	Query	#of article hits
#1	"maxilla" OR "maxillary" OR "maxillofacial" OR "facial" OR "mandible" OR "mandibular" OR "jaw" OR "jaws"	
#2	"trauma" OR "fracture" OR "injury" OR "injuries"	
#3	"Saudi Arabia" OR "Kingdom of Saudi Arabia" OR "KSA" OR "Saudi"	
#4	#1 AND #2 AND #3	Pubmed 12 Scopus 33 Web of Science 19

Phase II: Eligibility

Full article review was completed, and inclusion/exclusion criteria applied. Using the references of the included articles, manual search was completed to search for relevant articles possibly missed from the electronic search.

Phase III: Included studies

The Newcastle-Ottawa scale [5] was used for methodological quality and risk of bias assessment. Demographic data (age and gender), site of fracture, cause of trauma, and city in KSA were collected for each study.

Two reviewers (RB and MQ) individually conducted the review. Any uncertainty or disagreement about an article was resolved by discussion and consensus among the reviewers and the supervisor (NA).

Statistical analysis

Eligible studies were included for meta-analysis to calculate the overall rate of common trauma sites and causes by pooling with a random effects model. To visualize rates and corresponding 95% CIs within and across the common sites and causes of trauma, forest plots were generated. The I2 statistics were calculated to assess for heterogeneity and Egger's regression to assess publication bias. The analyses were performed using MedCalc Statistical Software V. 19.2.6 (MedCalc Software Ltd, Ostend, Belgium). For all statistical tests, p<0.05 was considered statistically significant.

RESULTS

A total of 81 articles were screened for inclusion criteria. Of these, 19 articles were eligible for systematic review. The meta-analysis for trauma cause was completed for 14 articles, and 15 articles for the trauma site, Figure 1. Of the articles included, 8 were of high quality, the remaining 11 articles were of moderate quality.

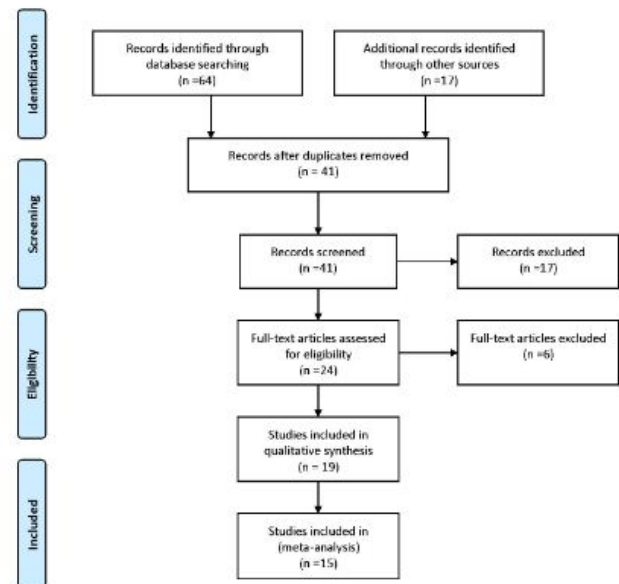


Figure 1: PRISMA Flow diagram of the screened articles.

Of the 8,233 subjects with MM fracture, 6413 (77.9%) were males and 4305 (52.3%) were adults. One study[6] from AlQurayyat city reported the highest number of subjects (n=2160) followed by eight studies [3,7-13] from Riyadh (n=1442), one study [14] from Makkah

(n=1130), and three studies[15-17] from Madinah (n=1465). Other single studies from other cities are: Jeddah [18], Aseer region [19], AlBaha [20], Hofuf [21], Khamis Mushait [22], and Tabuk [23].

The most common cause of traumatic MM fractures in Saudi Arabia was MVA, 3074 (45.4%). The frequency of other trauma causes is presented in Figure 2. The most common fracture site was the zygomaticomaxillary complex (ZMC), n=1867 (20.7%), followed by the mandible n=4,314 (48.0%); of which n=969 (10.7%) were in the condylar head, then the dentoalveolar area n=504 (5.6%). Frequency of other sites is presented in Figure 3. Detailed descriptive data of each study are summarized in a Table 2.

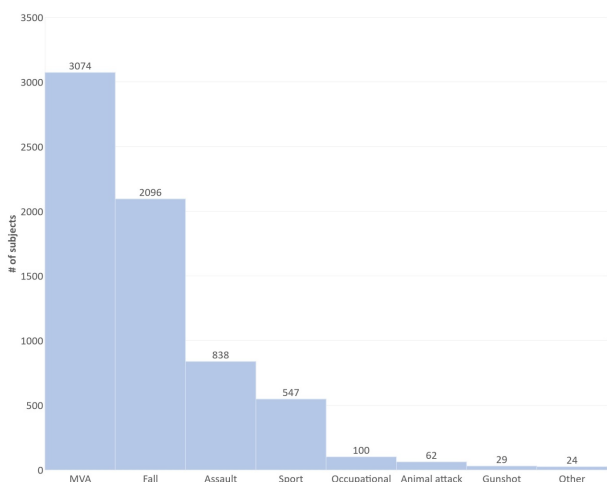


Figure 2: Histogram of descriptive frequencies of cause of maxillofacial-mandibular trauma.

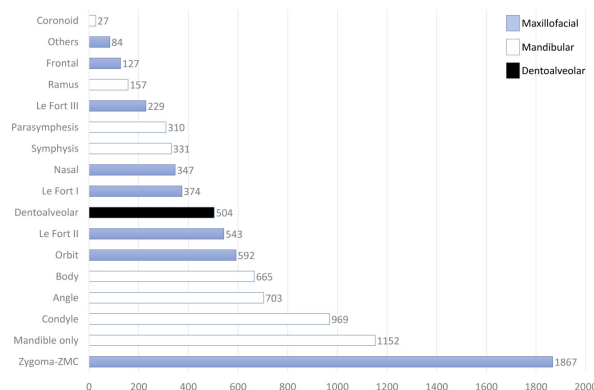


Figure 3: Histogram of descriptive frequencies of maxillofacial-mandibular fracture site.

Table 2: Descriptive data for the included articles.

Study (Sample size) [Bias/quality score]	Age (years)	Gender		City	Reason for trauma					Type of fracture		Total fracture	
		Male	Female		Fall	Sport	MVA	Assault	Other				
Al Arfaj et al [10] (n= 102) [Moderate]	<18	41	16	Riyadh	30	14	7	6			Nasal 45		45
Abdullah et al [3] (n= 97) [Moderate]	<18	69	13		19	7	49	6	NR	1	Condyle 42	DenAlv 24	303
											Coronoid 3	ZMOC 73	
											Ramus 2	Nasal 6	
											Angle 33	Lefort I 14	
											Body 30	Lefort II 6	
											Parasym 56	Lefort III 2	
	>18	103	15		21	4	73	17	NR	3	Sym 12		
Almasri et al [19] (n= 95) [Moderate]	NR	92	3	Aseer	-	3	90	8			Condyle 31	DenAlv 6	134
											Coronoid 2	ZMOC 27	
											Ramus 1	Frontal 21	
											Angle 18		
											Body 8		
											Parasym 29		
Samman et al [16] (n= 197) [Moderate]	<16(44)	34	10	Madinah	12	2	178	5			Condyle 103	DenAlv 22	260
											Coronoid 7		
											Ramus 5		

	>16(153)	131	22							Angle 51		
										Body 23		
										Parasym 45		
										Sym 4		
Alsuliman et al [11] (n= 306) [Moderate]	<20 (96)	271	35	Riyadh	4	4	66	21	Camel attack 4	ZMC 283		303
										Zyg arch 20		
	>20 (210)				13	6	155	33				
Bokhamseen et al [21] (n= 270) [High]	<18 (78)	68	10	Hofuf	43	22	171	18	Gunshot 2	Condyle 56	ZMOC 86	476
									Occ. 8	Angle 51	Nasal 11	
										Body 58	Orbital 57	
										Ramus 4	Zyg arch 19	
									Animal attack 6	Coronoid 3	Lefort I 20	
										Parasym 64	Lefort II 18	
	>18 (192)	173	19							Sym 24	LEfort III 5	
Aldwsari et al [9] (n= 237) [High]	<20 (46)	231	6	Riyadh	-	-	237	-		Condyle 4	Max sinus 29	222
										MANDIBLE 18	Orbit 22	
										Parasym 4 Temporal 33 Parietal 44	Occipital 4	
										Zyg arch 15		
										Frontal 29		
										Nasal 17		
	>20 (191)									Sphenoid 3		
Rabi et al [17] (n= 403) [Moderate]	<20 (134)	337	66	Madinah	66	13	225	27	Occ. 14	Condyle 83	DenAlv 31	585
										Angle 46	Zygoma 117	
	>20 (266)									Body 96	Nasal 42	
										Sym 38	Orbital 35	
										Parasym 41	Lefort I 7	
											Lefort II 39	
											Lefort III 10	
Alqahtani2 2018 (n= 205) [Moderate]	<25	114	0	Khamis Mushait	-	-	-	215	-	DenAlv 105		191
	>25	91								Mandible 58		
										Maxilla 17		
										Zygoma 11		
Shalhoub et al [8] (n= 2) [Moderate]	>20	2	0	Riyadh	-	-	-	-	Occ. 2	Mand body 2		4
										Sym 1		
										Max sinus 1		
Lawoyin et al [20] (n= 473) [Moderate]	<15	332	141	Albaha	-	-	90	84	Gunshot 4	Mandible 41		89
									NR 9	Nose 39		
										Maxilla 9		
Brown et al. [12] (n= 268) [Moderate]	27.1 (age range 2-78)	214	54	Riyadh	40	15	200	0	5 Gunshot	Condyle 134	Lefort I 94	552
									8 Occ.	Ramus 11	Lefort II 153	

										Angle 72	Lefort III 21	
										Body 59		
										Symp 8		
Lawoyin et al [23] (n=140) [High]	<20 [57] >20 [83]	135	5	Tabuk	13	21	85	10	11 others	Condyle 7 Ramus 8 Angle 1 Body 25	DenAlv 8 Nasal 52 Zygoma 17 Orbit 12	143
										Lefort I 6 Lefort II 5 Frontal 2		
Alhammad et al [7] (n= 372) [High]	<15 (n=9) >15 (363)	325	47	Riyadh	40	16	295	12	9	Condyle 30 Coronoid 3 Ramus 4 Angle 21 Body 21 Sym 14 Parasym 10	DenAlv 30 Nasal 38 Zygoma 119 Orbit 109 Lefort I 23 Lefort II 34 Le fort III 8	531
Albeshir et al [15] (n= 865) [High]	<12	531	334	Madinah	776	4	71	12	Gunshot 1 Animal 1	Mandible 60 Maxilla 4 Orbital 10 Zygoma 6 Frontal 3 Nasal 2		85
Almasri et al [14] (n= 1130) [Moderate]	<16 (n=135) >16 (n=995)	904	226	Makkah	NR					Mandible 523 Orbital floor 25 ZMC 399 NOE/ frontal 18		
Ahmed Jan et al [18] (n= 853) [High]	<20 (n=109) >20 (n=744)	728	125	Jeddah	77	60	570	17	Occ. 68 Animal 51 Gunshot 8	Body 264 Angle 247 Ramus 122 Sym 176 Condyle 390	DenAlv 183 Le Fort I 32 Le Fort II 74 Le Fort III 28 Zygoma 116 Fronto-NE 18	1650
Alanazi et al [6] (n= 2160) [High]	<12 (n=1417) >12 (n=743)	1490	670	Qurayyat	942	356	512	350		DenAlv 308 Mandible 452 Zygoma 157 Maxilla 143 NOE 95 Frontal 36		1191
Nwoku et al [13] (n= 986) [High]	<20 (n=140) >20 (n=846)	828	158	Riyadh	-	48	1050	-	Other 63 Gunshot 9 Occ. 36	Condyle 89 Coronoid 9 Angle 163	ZMC 193 Orbital 316	1522

Angle 163	Orbital 316
Body 79	Lefort I 178
Parasym 61	Lefort II 214
Sym 65	Lefort III 155

Sym: symphysis, Parasym: parasymphysis, DenAlv: Dento-alveolar, ZMC: Zygomatico-maxillary complex, NOE: Naso-Orbital-ethmoidal complex, Occ.: Occupational

Meta-analysis for trauma causes excluded: Aldwsari et al [9] (for exclusively reporting MVA cases), Alqahtani [22] (for exclusively reporting assault cases), Almasri et al [14] and Nwoko et al [13] (did not report the cause), and Shalhoub et al [8] (n=2 work-related injuries in the mandible). The four most common causes of trauma were taken into consideration for the meta-analysis i.e., MVA, fall, sports, and assault. Metanalysis for trauma sites excluded: AlArfaj et al [10] (exclusively reported nasal bone fracture), Samman et al [16] (exclusively reported mandibular bone fracture), Alsuliman et al [11] (exclusively reported zygomatic bone fracture), and Shalhoub et al [8] (n=2 work-related injuries in the mandible). Since dentoalveolar site was not consistently reported nor specifically excluded in the studies, meta-analysis of this site was not carried-out. For the metanalysis, the trauma sites were classified to four large categories: Mandibular, zygomatico-maxillary-orbital complex (ZMOC), nasal, and Lefort.

The data was heterogeneous, accordingly random effects model was chosen. The pooled prevalence of MVAs in KSA was 55.5% (95% CI 39-71.3%), 17.2% (95% CI 5.3-34.1%) for falls, 6.8% (95% CI 3.5-11.3%) for assaults, and 5.5% (95% CI 2.5-9.7%) for sports. The prevalence and 95% CI for each etiology are presented in Figure 4.

The pooled prevalence of mandibular fracture in KSA was 45.2% (95% CI 35.5-55.1%), 21.9% (95% CI 14.0-31.1%) for ZMOC, 4.3 % (95% CI 1.8-8.0%) for nasal bone, and 5.5% (95% CI 1.1-13.0%) for Lefort fractures. The prevalence and 95% CI for each site are presented in Figure 5.

Publication bias was analyzed by Egger's regression which was found non-significant for all etiology and site outcomes, $p > 0.05$, except for sports ($p < 0.001$).

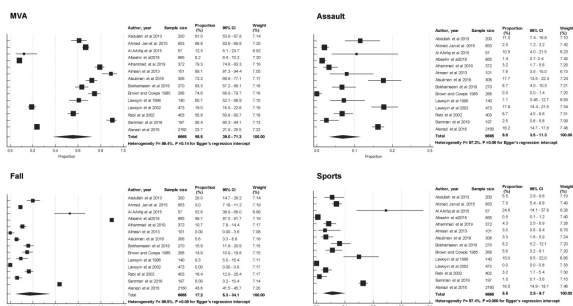


Figure 4: Meta-analysis of common causes of maxillofacial-mandibular trauma.

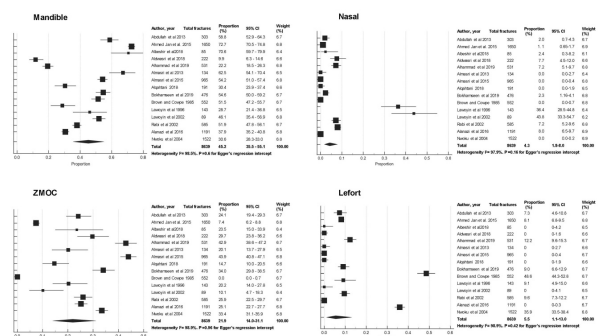


Figure 5: Meta-analysis of common fracture sites in maxillofacial-mandibular trauma.

DISCUSSION

The Kingdom of Saudi Arabia consists of 13 regions with 46 main cities, yet only 10 cities were covered by this systematic review. The most frequent reports were from the capital city of Riyadh and the second largest metropolitan city of Jeddah. Frequent studies emerged from the two holy cities of Makkah and Madinah that house two Holy Mosques to which millions of Muslim pilgrims visit every year. This added traffic is likely associated with higher road traffic accidents. The lack of reports from other cities in KSA should not be misinterpreted as low levels of trauma; rather it means a lack of research either due to small university, hospital, or medical centres.

The demographic analysis in this systematic review revealed that most MM trauma was sustained by males (77.9%) and adults (52.3%), which is in line with previous studies across the globe [24-28]. The age and gender distribution will be affected by the cause of trauma and demographic of the studied society. For example, the Saudi cohort was younger than the Australian, median age 36 vs. 50 years, in a study of MM of injuries caused by MVA [29]. Abdullah et al [3] showed how MM trauma in KSA differs in adult vs. pediatric MVA (37% vs. 25%) and assault (8.6% vs. 3%). Conceptually, sustaining trauma to the MM structures due to MVAs, sports, occupational, physical and armed assaults are likely to occur in the adult and male cohort. In the KSA, the employment rate of women between the age of 25 to 34 years old has risen to 53.3% and the ban of women driving has been lifted since 2018. The studies included in this review did not compare the frequency of MM trauma between male and female across the years. Even

if they did, it is possible that not enough years have passed to detect such a change.

MVA was the leading cause of fracture in this review, pooled prevalence 55.5%, similar to reports from China, Iran, Greece, and Brazil (range 45- 72%)[26-28, 30, 31]. North America, Europe, and Australia showed a decrease in MVA (8.4- 19.2%); attributed to increased road safety laws[24, 32-34]. In a five-region hospital study in KSA, the prevalence of non-use of a car seat or seatbelt was 44.0- 56.1%, 24.4% of children were seated in the front seat, 20% of 14 -16-year-olds were drivers, and 21.7% of <4-year-olds were sitting on the passengers' lap[35]. Moreover, it was only in 2010 and 2018 that the KSA launched one of the largest automated speed enforcement cameras in the world "Saher", and applied electronic surveillance of seatbelts and cell phone use while driving [36]. In the recent Saudi Vision 2030 progress report, the number of traffic accident fatalities per 100,000 population showed a 53% decrease from 2010 to 2020, and head injuries from 16.4% to 3.6% [37,38]. Future studies reporting MM trauma due to MVA sustained after 2018 could analyze the possible effect of the newly implemented road surveillance system.

The next leading etiologies of MM fractures in KSA were fall (pooled prevalence 17.2%), assault (pooled prevalence 6.8%), then sports (pooled prevalence 5.5%), figure 4. Occupational, animal related, and gunshot injuries were minimally reported, figure 2. The prevalence of MM trauma due to fall is bimodal; high in children and old subjects, and that of sports is usually higher in active youth populations. The studies by Alarfaj and Albeshir [10, 15] (exclusively reported MM trauma in children) showed higher frequencies of fall and sport injuries over MVAs with visible asymmetries in the forest plots (figure 4), as well as publication bias in the 5.5% pooled prevalence of sports. In a recent study in Najran, KSA, falls accounted for most of the etiology in the 1-5-year group whereas in the 16-20-year group, MVA was the main reason [39].

Fall was the leading cause of MM trauma in USA, China, and Europe (30.9-46%)[24, 26, 40]. Assaults, interpersonal violence, or gunshot injuries were the leading cause in USA, Brazil, Europe, Australia (26-60.5%) [24,25,28,41]. Generally, alcohol consumption was a significant contributor to the increased incidence and severity of MM trauma in MVA, fall, and assault [25,33,40]. Unlike the USA, the possession of firearm in KSA is permitted only with reason (sport shooting license or proving danger to life). Furthermore, the possession and consumption of alcohol are not permitted in KSA due to religious rules. Collectively, this may explain the lower provenances of trauma due to assault. MM trauma due to sports is generally low throughout the world except for Europe; explaining 10% of MM fractures [40].

Reporting the site of trauma was not consistent throughout the studies. For example, fractures of the mandible were detailed by sub segment and in others were reported as "Mandible" only. Of the 8,981 fractures,

the most common site was in the mandible at pooled prevalence of 45.2%, figure 5. The ZMOC was the next common site of fracture at pooled prevalence of 21.9%. Lefort fractures and fractures of the nasal bone were not frequently counted in the included articles. The pooled prevalence was 4.3% for nasal bone fracture and 5.5% for Lefort fractures. Both rates are possibly inflated due to two studies by Lawoyin et al [20] for nasal fracture, and Brown and Cowpe [12] for Lefort fractures; one a tertiary trauma centre and the other a military hospital.

Studies in China, Greece, Brazil, and Romania were similar to the KSA in having mandibular fracture as the most common type of fracture (40.0-67.1%)[26, 30, 31, 34]. Studies in USA, Australia, and Iran reported fractures of the ZMC as the leading site and at a much higher proportion than the KSA (50.2-68.4%)[24, 27, 32].

The magnitude and direction of force are important factors in determining the site of fracture. Fracture of the mid-face, Lefort-types and Comminuted fractures are expected in high velocity impacts such as MVA and gunshot wounds compared to falls and assaults[25, 41]. Almasri et al[19] recorded a high frequency of MVA, 89.1%, relative to other causes within their study, figure 4, yet did not record any Lefort fractures, figure 5. It is accepted that high forces of MVA would result in de-buckling of the facial buttresses seen in Lefort fractures, so the lack of such fractures was likely due to the authors' decision not to include such fractures. Brazil and China report similar frequencies of Lefort fractures (6-8%), Romania and USA reported lower numbers (1.7-2%), and Greece reported 13.6%[24, 26, 30, 31, 34]. Nasal bone fractures reported in USA, Greece, and Romania are similar to the KSA (1-6.9%) whereas Australia, Brazil, and Iran showed higher numbers (16.2-43.9%)[24, 27, 30-32, 34].

The results may vary depending on the geographic area, population density, socioeconomic status, specific period, governmental laws of the region, and the source i.e. the hospital or centre [4,33].

None of the studies in this review attempted to relate the fracture site to the etiology of trauma.

In the KSA, and across the globe, there is variability in sample sizes, inconsistency in reporting certain MM fracture etiologies or sites, and substantial heterogeneity is often observed across studies resulting in large confidence intervals.

To remedy this, data collection for MM trauma studies should be collected from a nation-wide registry. The Saudi Trauma Registry (STAR) was established in 2017 and fully operational by 2018[42]. STAR offers large sample sizes, covers major parts of the KSA, and consistent reporting of variables (demographics, cause and site of trauma, treatment offered, days in hospital etc.). Interested researchers are encouraged to utilize this nationwide database and avoid cross-sectional or retrospective analyses of single centres. Applying this in the KSA, and in other countries, will allow robust global studies on MM trauma.

CONCLUSIONS

The majority of the subjects sustaining MM fractures in KSA were young adult males. The leading etiology of trauma was MVAs and the most common fracture site was in the mandible. KSA is showing a great shift in its motor-vehicle safety regulations and social structure however medical studies lag behind recently published non-medical reports on the same topic. Future studies using nationwide registry would enable rigorous reporting of the outcomes and detection of any changes in epidemiological trends of MM trauma in the KSA and globally.

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