



National Road Traffic Injury Trends in Saudi Arabia (2018-2020): A Retrospective Secondary Analysis with Orthopaedic and Rehabilitation Implications

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Abstract Background: Road Traffic Injuries (RTIs) are a source of many preventable deaths and fatalities. National-level statistics allow us to examine changes over short periods of time, affected groups and the severity of injuries. They also give us hints about disability, functioning and the use of mobility aids, which help us plan orthopedic trauma care and rehabilitation for the future. **Methods:** We conducted a retrospective secondary analysis using the Saudi Arabian national road traffic injury and death data from 2018 to 2020. We calculated the yearly totals and changes in the number and percentage from year to year. We analyzed the injuries and deaths in five age groups (<18, 19-30, 31-40, 41-50 and ≥51 years) over three years, with the proportion of each group and the death-to-injury ratio (case-fatality ratio, CFR: deaths per 1,000 injuries). We calculated the age-specific injury and death rates per 100,000 population using the mid-year population estimates. We also analyzed the differences in injuries and deaths by sex, with male-to-female ratios and sex-specific CFRs. **Results:** For 2018 to 2020, there were 89,050 injuries and 16,159 deaths. Injuries increased from 30,579 in 2018 to 32,910 in 2019, then decreased to 25,561 in 2020. Deaths increased from 5,787 to 5,754, then to 4,618. The marked 2020 decline likely reflects reduced exposure during the COVID-19 pandemic and associated movement restrictions rather than a routine secular trend. The CFRs remained relatively stable (189.25, 174.84 and 180.67 deaths per 1,000 injuries for 2018-2020), with little change in the fatality rate despite large variations in the number of injuries and deaths. The three largest three-year injury proportions were for the 19-30 (26,465; 29.72%) and 31-40 (23,424; 26.30%) age groups. The ≥51 group accounted for 11,148 injuries (12.52%) but 2,326 deaths (14.39%) and had the highest three-year CFR (208.65 per 1,000). In 2019-2020, the highest injury rates per 100,000 population were for the 19-30 group (140.0 in 2019; 105.8 in 2020) and this group also had the highest death rates (24.8 in 2019; 20.4 in 2020). **Conclusion:** National data from 2018-2020 show that road injuries were concentrated in young adults, whereas older adults had higher fatality ratios. Injuries and deaths declined substantially in 2020, likely in relation to pandemic-related mobility changes, while the deaths-per-injury pattern remained relatively stable. These findings primarily describe national RTI trends and suggest likely orthopaedic and rehabilitation implications, rather than directly measuring orthopedic clinical workload.

Key Words Road-Traffic Injuries, Trauma Epidemiology, Orthopaedic Trauma, Mortality, Case-Fatality Ratio, Age-Specific Rates, Sex Differences, Disability, Rehabilitation, Saudi Arabia

INTRODUCTION

Road Traffic Injury (RTI) is a large and preventable source of early death and chronic disability [1]. RTIs occur mainly in teens and working-age individuals and result in huge economic and health system costs. While deaths are valuable for surveillance, most nonfatal RTIs result in traumatic musculoskeletal injuries such as fractures, dislocations, ligament injuries and multiple injuries, which often require surgery, prolonged hospital stays and rehabilitation [2-3]. Some individuals suffer from permanent functional

impairment. Thus, deaths alone cannot capture the broader service implications of RTIs. Although the present study does not include direct orthopedic diagnosis or procedure data, the number of injured persons, their age and sex distribution, case-fatality ratios and contextual disability indicators can still help frame the likely orthopedic and rehabilitation relevance of the national RTI burden [4].

In Saudi Arabia, increased motorization, expanded road infrastructure and changes in modes of transport have

maintained high crash rates, making RTIs a significant public health and health system issue [5]. There are national initiatives to prevent crashes and enhance enforcement but annual monitoring is still required because trends over time reflect not only more or fewer crashes but also changes in exposure, reporting and access to care [6]. One of the major challenges in RTI research is that information is collected from three different sources: police records, hospital data and civil registration, each using different definitions and approaches, which may yield different numbers of injuries and deaths. National health statistics offer a convenient and consistent way to compare years, particularly when data are stratified by age and sex for both injuries and deaths [7-8]. However, these official tabulations are usually presented as annual summary tables and are not always interpreted in an integrated epidemiologic framework. Secondary analysis is therefore useful to derive year-to-year changes, age- and sex-specific contrasts and deaths-per-injury indicators that can better support national injury surveillance and service planning.

Secondary analysis of national tables can yield policy-relevant descriptive data with minimal measurement bias, illustrating how things change over time, how estimates differ by age and sex and how injury severity correlates with planning for trauma systems [9]. When these estimates are considered in the context of other national disability data, such as mobility problems, use of assistive devices and frequency of traffic accidents blamed on others, they can be seen to help frame injury numbers in the context of a larger orthopaedic and rehab burden problem [10-12]. The years 2018-2020 are helpful in this regard because they offer a pre-pandemic baseline and early pandemic years when travel and healthcare use patterns likely changed and could have influenced the frequency of injuries as well as the distribution of cases. This study therefore conducts a retrospective secondary analysis of Saudi national Ministry of Health road-traffic injury and death data for 2018-2020 to describe yearly changes, age-specific patterns, sex-specific patterns and case-fatality ratios at the national level. A secondary aim is to interpret these national RTI patterns in relation to likely orthopaedic and rehabilitation planning needs, without claiming direct measurement of orthopedic case-level burden.

METHODS

Study Design and Reporting Framework

We retrospectively examined the Saudi national data tables for road traffic injuries and deaths from 2018 to 2020. We employed a simple descriptive method to illustrate what happened over time, by age group and sex when available and supplemented these with population data and national disability statistics.

Data Sources and Study Setting

We extracted the national data for road traffic injuries and deaths from the Saudi Ministry of Health (MOH) tables for 2018-2020. These tabulations were treated as official national summary sources for the purposes of this study. However, because the analysis relied on already-published

aggregate tables, we could not independently verify the extent to which they captured all sectors of care, such as private, military or university hospitals, nor could we quantify any residual under-reporting. When available, we employed rate indicators from the MOH Yearbook for the same years (injury rate per 100,000 and death rate per 100,000) to compare by population. Mid-year population data for age-specific analysis was obtained from the General Authority for Statistics (GASat), by age group and sex. To provide a better insight into the overall outcomes, we summarized GASat census-linked disability data and national Disability Survey data (including causes from traffic accidents and use of mobility aids). The Saudi Trauma Registry (STAR) provided insight into how the national trauma registry is constructed but it was not used as a data source for this analysis.

Study Population and Unit of Analysis

We analyzed annual national totals for 2018-2020 and totals by age group and sex as presented in the MOH tables. No individual data were analyzed. All analyses were conducted using population-level data from publicly available national sources.

Variables, Definitions and Stratification

The key burden results were (i) Total road-traffic injuries per year and (ii) Total road-traffic deaths per year. The stratified results used MOH age categories (<18, 19-30, 31-40, 41-50 and ≥51 years) and sex (male, female) for 2019-2020, when sex-stratified results were available. In the context of this study, “orthopaedic burden” refers to the likely service and rehabilitation implications of RTI-related musculoskeletal trauma at the population level, inferred indirectly from national RTI counts, stratified distributions, case-fatality ratios and contextual disability indicators. It does not represent direct measurement of fracture types, surgical workload or orthopedic diagnoses.

Outcomes and Derived Measures

Absolute differences (Δ) and annual percentage differences in injuries and deaths between years were calculated. Case-fatality ratios (CFRs) were deaths per 1,000 injuries for each year and for each age or sex group when data were available. The proportion of injuries and deaths by age group was the three-year total for that group divided by the three-year total for all ages, expressed as percentages. Sex ratios (male-to-female) were calculated as the number of males divided by females for each year when sex data were available.

Population Denominators and Rate Estimation

Age-specific injury and death rates for 2018 and 2020 were estimated using GASat mid-year population data that correspond to the MOH age groups. Rates per 100,000 were calculated as $(\text{count}/\text{population}) \times 100,000$ for each age group and year. For national rates, MOH Yearbook rates were pooled with MOH counts to provide both absolute numbers and population-adjusted burden for 2018-2020.

Statistical Analysis

The analysis was descriptive and used counts, proportions, rates per 100,000 population, sex ratios, annual percentage changes and deaths per 1,000 injuries. No hypothesis testing or model-based inference was performed because the objective was to summarize national aggregate patterns rather than formally test statistical significance or interaction effects across year, age and sex.

Ethics and Governance

As this research utilized publicly available aggregate national data and did not involve individuals or any identifiable information, it did not require ethical review or informed consent. The research only utilized secondary de-identified data. Care was taken to preserve source definitions, distinguish direct findings from contextual interpretation and report the public-data sources transparently. All data used in this study were derived from publicly available national sources cited in the reference list, including Saudi Ministry of Health, MOH Yearbook and GStat publications. The analytical tables generated from these public data are available from the corresponding author upon reasonable request.

RESULTS

A brief three-year national trend is shown in Table 1 and Figure 1. In 2018, there were 30,579 reported road traffic injuries, which increased to 32,910 in 2019, then decreased to 25,561 in 2020. Deaths increased from 5,787 in 2018 to 5,754 in 2019, then decreased to 4,618 in 2020. Thus, injuries increased in 2019 by 7.62% and deaths remained nearly unchanged by -0.57%, then both injuries by -22.33% and deaths by -19.74% decreased substantially in 2020. Despite these large changes, the case fatality ratio remained relatively stable: 189.25, 174.84 and 180.67 deaths per 1,000 injuries in 2018-2020, respectively. This is depicted in Table 1 and Figure 3, which suggest that the deaths-per-injury relationship remained relatively stable despite the marked reduction in total injuries and deaths in 2020. Meanwhile, population-standardized measures (Table 1 and Figure 2) revealed injury rates of 100.07 and 109.47 per 100,000 in 2018 and 2019, respectively, which decreased to 81.01 per 100,000 in 2020, while death rates per 100,000 remained almost unchanged in 2018-2019 (19.16 vs 19.14) and decreased to 14.64 in 2020. Because 2020 coincided with the COVID-19 pandemic and major mobility restrictions, this year should be interpreted cautiously as an exceptional exposure context rather than a standard trend point.

The age groups in Table 2 and Figure 4 indicate that the 19-30 and 31-40 age groups had the highest injuries from 2018 to 2020, with 26,465 injuries (29.72%) and 23,424 injuries (26.30%), respectively. The <18 age group had 11,981 injuries (13.45%), 41-50 had 16,032 injuries (18.00%) and ≥51 had 11,148 injuries (12.52%). The deaths also followed a similar pattern in Table 2 and Figure 5, where the 19-30 age group had the highest number of deaths over the three-year period (5,069; 31.37%), followed by 31-40 (4,096; 25.35%), 41-50 (2,438; 15.09%), ≥51

Table 1: National Totals and Trend Indicators for Road-Traffic Injuries and Deaths, 2018-2020

Year	Injuries (MOH tabulation)	Deaths (MOH tabulation)	Δ Injuries vs. prev (18-20)	Injuries YoY %	Δ Deaths vs. prev	Deaths YoY %	CFR (deaths per 1,000 injuries)	Injuries Yearbook 2023)	Injury rate per 100k (Yearbook)	Death rate per 100k (Yearbook)
2018	30579	5787	-	-	-	-	189.25	30217	100.07	19.16
2019	32910	5754	2331	7.62	-33	-0.57	174.84	32910	109.47	19.14
2020	25561	4618	-7349	-22.33	-1136	-19.74	180.67	25561	81.01	14.64
2018-2020 total	89050	16159	-	-	-	-	181.46	88688	(see yearly)	(see yearly)

MOH: Ministry of Health, YoY: Year-Over-Year, Δ: Absolute Change Versus Previous Year, CFR: Case-Fatality Ratio, 100 k: Per 100,000 Population)

Table 2: Injuries and Deaths by Age Group, with 3 Year Totals, Shares and Age-Specific Deaths-Per-Injury Ratios

Age group	Inj total (18-20)			Inj share % (18-20)			Deaths 2018-2020			Deaths share % (18-20)			CFR (deaths/1,000 inj, 18-20)	
	Inj 2018	Inj 2019	Inj 2020	Inj total (18-20)	Inj share % (18-20)	Deaths 2018	Deaths 2019	Deaths 2020	Deaths total (18-20)	Deaths share % (18-20)	CFR	CFR		
<18	4230	4549	3202	11981	13.45	816	827	587	2230	13.8	186.13	186.13		
19-30	9028	9841	7596	26465	29.72	1864	1742	1463	5069	31.37	191.54	191.54		
31-40	8204	8693	6527	23424	26.3	1428	1486	1182	4096	25.35	174.86	174.86		
41-50	5493	5816	4723	16032	18	785	913	740	2438	15.09	152.07	152.07		
51+	3624	4011	3513	11148	12.52	894	786	646	2326	14.39	208.65	208.65		
All ages	30579	32910	25561	89050	100	5787	5754	4618	16159	100	181.46	181.46		

Inj: Injuries, CFR: Case-Fatality Ratio, 18-20: Years 2018-2020. %: Percentage

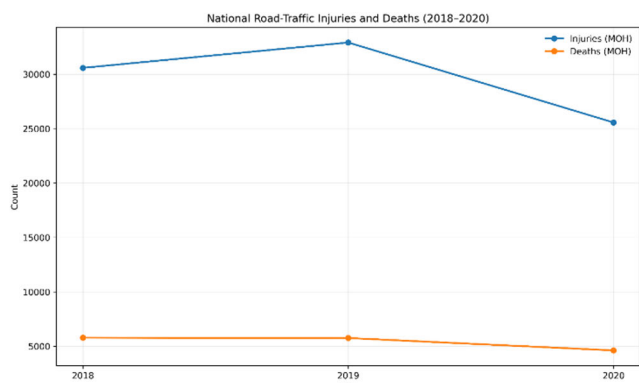


Figure 1: National Road-Traffic Injury and Death Counts in Saudi Arabia, 2018-2020

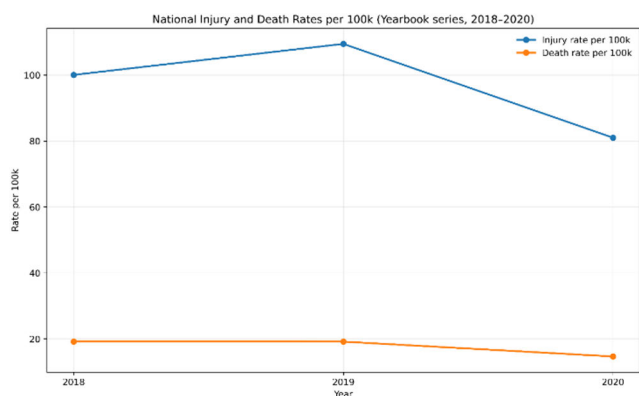


Figure 2: National Road-Traffic Injury and Death Rates per 100,000 Population in Saudi Arabia, 2018-2020

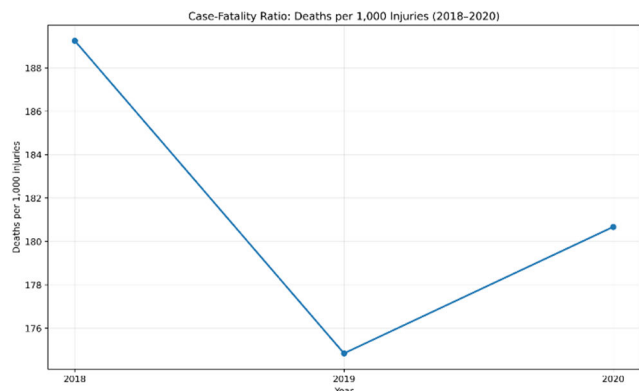


Figure 3: Case-Fatality Ratio for Road-Traffic Injuries in Saudi Arabia, 2018-2020

(2,326; 14.39%) and <18 (2,230; 13.80%). Notably, the deaths per injury were highly variable by age group, even though the injury rates were relatively similar. The highest deaths per injury rate was in the ≥51 age group (208.65 per 1,000 injuries from 2018 to 2020), followed by 19-30 (191.54), <18 (186.13), 31-40 (174.86) and 41-50 (152.07). Table 3 illustrates the differences in rates by age using population-based rates for 2019-2020. In 2019, the rate was highest in the 19-30 age group (140.0 per 100,000), followed

Table 3: Age-Group Injury and Death Rates for 2019-2020 Using Mid-Year Population Denominators, Plus Deaths-Per-Injury Ratios

Year	Age group	Population (est.)	Injuries	Injuries per 100 k	Deaths	Deaths per 100 k	CFR (deaths/1,000 inj)
2019	<18	9805952	4549	46.4	827	8.4	181.8
2019	19-30	7029076	9841	140	1742	24.8	177
2019	31-40	7021232	8693	123.8	1486	21.2	170.9
2019	41-50	5456692	5816	106.6	913	16.7	157
2019	51+	4433220	4011	90.5	786	17.7	196
2020	<18	10000387	3202	32	587	5.9	183.3
2020	19-30	7181688	7596	105.8	1463	20.4	192.6
2020	31-40	7206696	6527	90.6	1182	16.4	181.1
2020	41-50	5604968	4723	84.3	740	13.2	156.7
2020	51+	4538377	3513	77.4	646	14.2	183.9

Est.: Estimated; CFR: Case-Fatality Ratio, 100 k: Per 100,000 Population

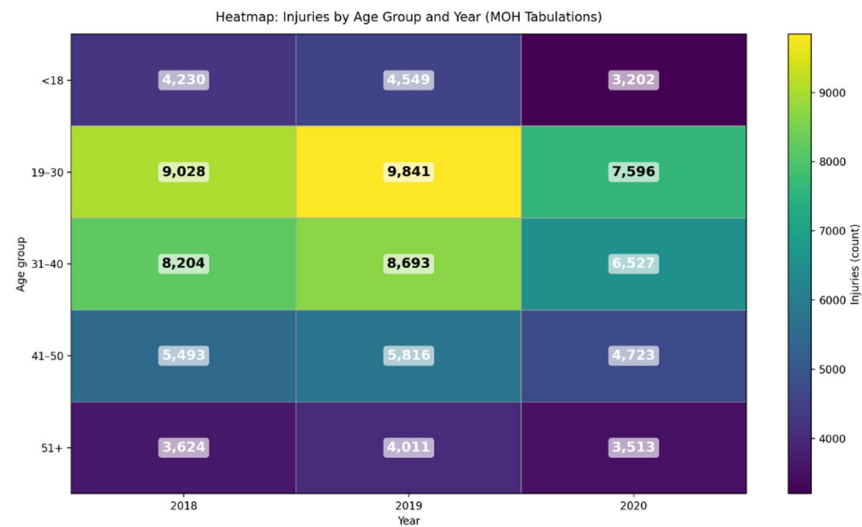


Figure 4: Heatmap of Road-Traffic Injuries by Age Group and Year in Saudi Arabia, 2018-2020

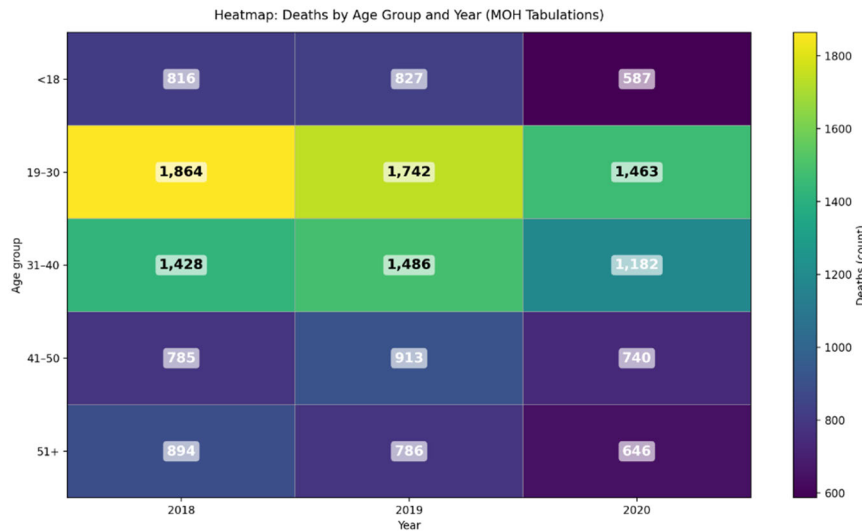


Figure 5: Heatmap of Road-Traffic Deaths by Age Group and Year in Saudi Arabia, 2018-2020

Table 4: Sex Distribution of Injuries and Deaths with Ratios and Sex-Specific Deaths-Per-Injury Rates, 2019-2020

	Injuries (M)	Injuries (F)	Injuries total	Male % of injuries	M:F injury ratio	Deaths (M)	Deaths (F)	Deaths total	Male % of deaths	M:F death ratio	CFR (deaths/1,000 inj) M	CFR (deaths/1,000 inj) F
2019	27281	5629	32910	82.9	4.85	5081	673	5754	88.3	7.55	186.2	119.6
2020	21492	4069	25561	84.08	5.28	4108	510	4618	88.96	8.05	191.1	125.3

M: Male; F: Female; M:F, Male-to-Female Ratio; CFR: Case-Fatality Ratio

by 31-40 (123.8) and 41-50 (106.6) and lower in ≥ 51 (90.5) and <18 (46.4). In 2020, the order was the same but with lower rates (19-30: 105.8; 31-40: 90.6; 41-50: 84.3; ≥ 51 : 77.4; <18 : 32.0 per 100,000), indicating a general fall in rates by age. Rates of death per 100,000 also peaked in the 19-30 age group for both years (24.8 in 2019 and 20.4 in 2020), followed by 31-40 (21.2 and 16.4). The ≥ 51 age group had higher rates of death compared to injury (17.7 and 14.2) and the <18 age group had the lowest rates (8.4 and 5.9). The age-specific case-fatality ratio indicates that in 2019, the ≥ 51 age group had the highest case-fatality ratio (196.0 per

1,000), while in 2020, the 19-30 age group had the highest case-fatality ratio (192.6 per 1,000).

Table 4 examines sex for 2019-2020 and finds a large male preponderance for both injuries and deaths. Males comprised 82.9% of injuries in 2019 and 84.08% in 2020 (injury M:F ratios 4.85 and 5.28) and 88.3% and 88.96% of deaths (death M:F ratios 7.55 and 8.05). The ratio of deaths to injuries by sex remains higher for males than females (2019: 186.2 vs. 119.6; 2020: 191.1 vs. 125.3), indicating that males have more injuries and more deaths per injury.

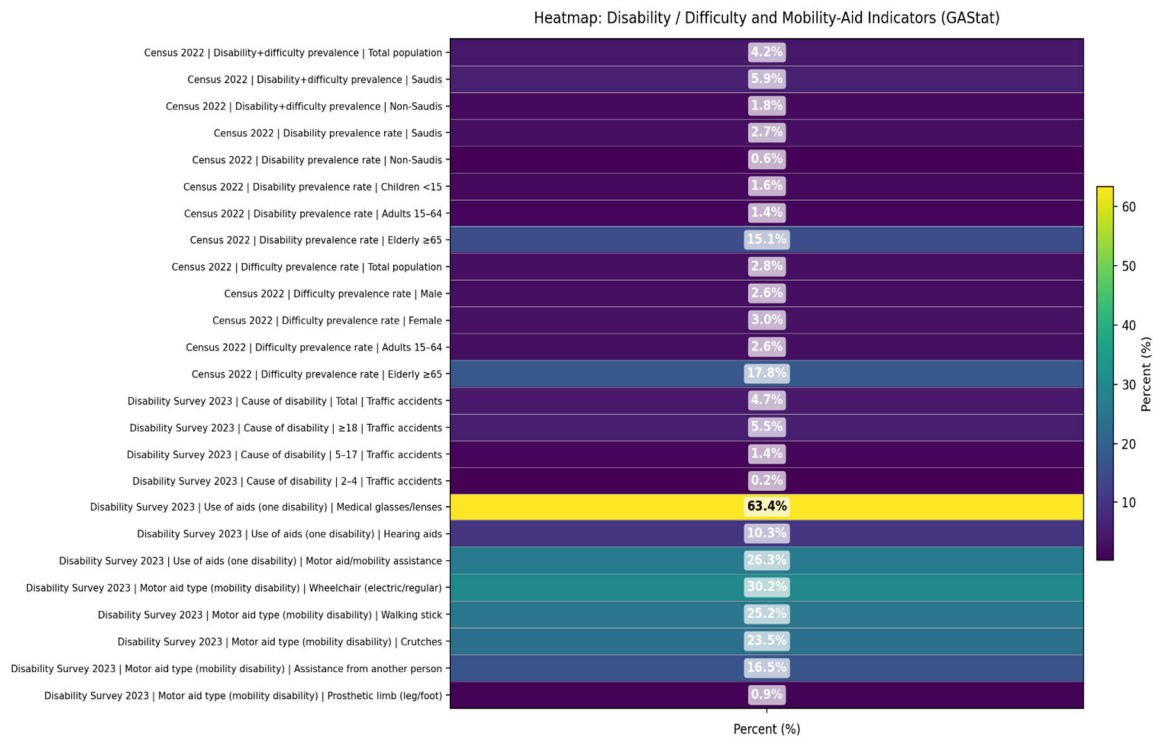


Figure 6: Heatmap Summary of Disability/Difficulty Prevalence and Traffic-Accident-Attributable Indicators in Saudi Arabia

Table 5: Disability and Functional Difficulty Indicators with Traffic-Accident Attributable Shares and Mobility-Aid Statistics

Block/source	Indicator	Group/breakdown	Value
Census 2022	Disability+difficulty prevalence	Total population	4.2%
		Saudis	5.9%
		Non-Saudis	1.8%
	Disability prevalence rate	Saudis	2.7%
		Non-Saudis	0.6%
		Children <15	1.6%
		Adults 15-64	1.4%
		Elderly ≥65	15.1%
	Difficulty prevalence rate	Total population	2.8%
		Saudis	3.8%
		Non-Saudis	1.3%
		Male	2.6%
		Female	3.0%
Children <15		1.6%	
Adults 15-64		2.6%	
Elderly ≥65	17.8%		
Disability Survey 2023	Disability prevalence	Total population	1.8%
	Household sample size	All regions	29,920 households
		Difficulty severity mix	Mild difficulty
	Cause of disability percent	Severe/very severe disability	68.2%
		Total Traffic accidents	4.7%
		≥18 Traffic accidents	5.5%
		5-17 Traffic accidents	1.4%
	Use of aids among people with one disability	2-4 Traffic accidents	0.2%
		Medical glasses or lenses	63.4%
	Motor aid type distribution for mobility disability	Hearing aids	10.3%
		Motor aid or mobility assistance	26.3%
		Wheelchair electric or regular	30.2%
		Walking stick	25.2%
Crutches		23.5%	
Assistance from another person		16.5%	
Prosthetic limb leg or foot	0.9%		

Table 5 and Figure 6 turn to disability and functional difficulties, providing insight into the longer-term impact. Census data reveal a combined prevalence of disability and

difficulty of 4.2% in the total population, higher among Saudis (5.9%) than non-Saudis (1.8%) and a strong age gradient: 1.6% in children under 15, 1.4% in adults 15-64

and 15.1% in those 65 and older. Difficulty also has a similar distribution, 17.8% in those 65+, 2.6% in adults 15-64 and 1.6% in children under 15. Females report a slightly higher prevalence of difficulty (3.0%) than males (2.6%). The Disability Survey 2023 finds that the majority of disability is severe/very severe (68.2% vs 31.8% mild). Traffic accidents are a significant cause of disability (4.7% overall), higher in adults 18+ (5.5%) than children 5-17 (1.4%) and very low for ages 2-4 (0.2%). For those with one disability, 26.3% use motor/mobility aids. For mobility disability, the main aids are wheelchairs (30.2%), walking sticks (25.2%) and crutches (23.5%), with 16.5% assisted by another person and 0.9% using prosthetic limbs.

DISCUSSION

This study provides a strong national picture of the changes in short-term RTI burden and indicated that large decreases in the total number of cases each year did not necessarily reflect large changes in the frequency of deaths per injury. The analysis directly describes national RTI counts, rates, age and sex patterns and case-fatality ratios. Any interpretation regarding orthopedic workload or rehabilitation demand should therefore be understood as an indirect planning implication rather than a direct clinical measurement. This supports the hypothesis that changes in exposure and the frequency of events can result in large fluctuations in numbers, whereas the relative risk of death remained relatively constant. The results also indicated that injuries and deaths were most prevalent in young adults and thus prevention and enforcement strategies that reduced high exposures in this age group would likely provide the largest reduction in overall burden. However, older adults had a higher risk of death from injuries and thus improved post-crash care, rapid transport and trauma care tailored to older patients would be crucial in reducing deaths in a smaller pool of injuries.

When considered alongside disability and assistive-device indicators, the findings suggest a broader context in which RTIs may contribute to longer-term mobility limitations and rehabilitation needs. However, these indicators are contextual and are not directly linked to the same 2018-2020 RTI cases analyzed in this study. This supports future research that integrates trauma registry data with functional outcomes, incorporates standardized injury severity and orthopedic injury patterns into national surveillance and builds models of rehabilitation capacity needs based on both injury rates and disability. The results also emphasize the importance of routine, stratified national reporting that matches injury numbers with population numbers and disability metrics to enable year-to-year comparisons and inform policy aimed at age- and sex-stratified targets.

According to national data, the number of RTIs increased from 2018 to 2019 but then decreased dramatically in 2020 [12-14]. This sharp decline is most plausibly interpreted in the context of the COVID-19 pandemic,

during which curfews, travel restrictions, reduced commuting and altered healthcare-seeking patterns likely changed both exposure to road traffic injury and the frequency of reported cases. Accordingly, 2020 should not be interpreted as a routine continuation of the 2018-2019 pattern. Deaths from RTIs also decreased in 2020 and the rate of death per injury remained the same. This indicates that there were more accidents due to exposure and travel patterns, rather than the fact that RTIs are less lethal [15]. For other emergency situations, the number of RTI cases remains relatively constant while the annual number of cases fluctuates according to the movement of the population.

Although deaths decreased, many injuries are still orthopedic and require rehabilitation. This is consistent with data from the Saudi health system, where patients injured in RTIs utilize rehab services and generate costs, particularly those requiring long-term care [16-19]. The observation that deaths per injury are higher for older adults is consistent with the typical combination of fractures and spinal cord injuries observed in RTI patients and the increased susceptibility of complications among older individuals [20-23]. This observation is biologically valid because reduced bone strength (reduced bone density) is associated with increased fractures and poor outcomes in global research.

Studies in Saudi Arabia on spinal injuries reveal that RTIs are major contributors to spinal injuries, besides other injuries and serious outcomes. This is evidence that some RTIs are complex and may lead to disability, even if the fatality rate remains the same [24]. Other studies in Saudi Arabia on facial fractures and general awareness of neck and spine first aid indicate that the RTI problem is not just about different injuries but also about the prehospital problems that may influence injury and outcome. Evidence from Saudi Arabia suggests that there is a need for long-term rehabilitation following car accidents, which implies that the RTI problem in the country is not just about deaths but also about living with disability [5, 11].

In the region, evidence from the Middle East and North Africa indicates an increasing problem of lower leg fractures, which indicates that fractures due to RTIs are likely to continue contributing to the workload of the orthopedic departments [25]. Saudi studies on fractures also indicate serious fractures that may lead to long-term problems (such as non-union or loss of blood supply to the bone), which implies that the RTI problem in the country is not just about deaths but also about living with disability [26]. Technical reports and case reports do not provide incidence rates but indicate the complexity of surgeries and complications following high-energy trauma, which implies that the downstream problem is significant in some cases [27-28].

CONCLUSIONS

National RTI data from 2018-2020 showed that injuries and deaths were concentrated in younger adults, whereas older adults had higher fatality ratios once injured. Injuries and

deaths declined markedly in 2020, likely reflecting pandemic-related changes in mobility and exposure, while deaths per injury remained relatively stable. When interpreted alongside contextual disability and mobility-aid indicators, these findings suggest likely orthopaedic and rehabilitation relevance at the population level but they do not directly measure orthopedic clinical workload.

Limitations

The analysis only used national aggregate data, so it did not have the ability to examine individual factors, mechanisms of injury, fracture types, locations of injuries on the body, severity of injury or care processes, nor could it assess regional variation within a year or between facilities. Because the study used summaries that were routinely produced, it may be influenced by changes in reporting completeness over time or changes in how cases were defined or identified. The large decrease in 2020 could not be associated with underlying causes using available data. Age-specific rate estimates were restricted to years with available population data and could not account for variation due to population estimation or under-reporting. Indicators of disability and mobility aids were considered contextual variables rather than outcomes and we could not establish a causal relationship between RTIs and disability based on this ecological analysis.

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