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Forensic Analysis of Injury Patterns among Occupants in Fatal Motor Vehicle Accidents in Karachi, Pakistan

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ABSTRACT

Drivers and passengers in Motor Vehicle Accidents (MVAs) may sustain a wide range of injuries. **Objective:** To investigate the patterns of injuries and factors responsible for differences between drivers and passengers in fatal motor vehicle accidents in Karachi, Sindh. **Methods:** Retrospective study was conducted carried out from 2nd July 2022 to 30th June 2024 by Department of Forensic medicine and Toxicology, Karachi Institute of Medical Sciences, Karachi. All victims involving drivers and passenger's road traffic accidents fatalities, belongs to either gender, of any age from three major tertiary care hospitals in Karachi, Sindh were investigated and evaluated. Incomplete information, those of other fatalities and pedestrian related data were excluded. **Results:** Most (70.8%) were drivers, 20.0% were front-seat passengers, and 9.2% were rear-seat passengers. Over two-third, 80.5% died within one hour after the crash whereas, majority, 67.3% of the deaths occurred in front crashes, 13.7% in near edge hits, 13.5% in rollovers, and 5.5% in other accidents. Fatal injuries to the abdomen, thorax, head, and neck in 63.6%, 10.7%, 61.6%, and 27.4% of cases, respectively. Compared to drivers, those in the front seats experienced less heart and spleen traumas. In comparison to drivers, passengers in the front and back seats experienced a higher frequency of seat belt abrasions and a lower frequency of fractures to the extremities. **Conclusions:** The findings revealed significant differences in the types and frequency of injuries between drivers and passengers, highlighting the greater vulnerability of drivers to severe abdominal and head injuries.

INTRODUCTION

Road Traffic Accidents (RTAs) continue to be a major global public health and safety concern despite global efforts at mitigation and prevention. Road accidents cause a great deal of mortality and disability and cost societies a significant amount of money [1]. According to the "Global Status Report on Road Safety 2023" over 1.19 million people worldwide died in traffic-related deaths in 2021, or 15 deaths per 100,000 people. Road fatality rates worldwide are still far too high, and current trends suggest that this problem will not go away for some time. This is true even in nations where efforts to minimize traffic collisions have made significant progress [2, 3]. Drivers and passengers in Motor Vehicle Accidents (MVAs) may sustain a wide range of injuries. Whether the victim was a car occupant (driver or passenger) not has a significant impact on the pattern and epidemiology of fatal and non-fatal transport injuries [4]. Investigation of injuries connected with transportation and traffic may require the use of all forensic sciences and medicolegal knowledge. Forensic experts are called upon in the aftermath of a potentially fatal motor vehicle collision to determine the cause of death, the mechanisms causing injuries, and, if possible, the involvement of each occupant, including their seating position at the time of contact [5]. Studies have reported limited differences in injury patterns

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among the drivers and passengers, except from skin bruising from seat belts with opposing patterns. However, drivers reported to be prone than passengers to suffer brain damage and skull fractures, whereas front-seat passengers were more likely to experience splenic injuries [6]. On the other hand, based on bigger incident data sets, studies comparing front and rear seat occupants have demonstrated that rear seat passengers are far more probable than front seat occupants to die or suffer serious injuries [7]. A significant decline in in the RTA related mortalities have reported in developed nations due to advancements in safety features in the motor vehicles for protecting lives of drivers as well as the occupants [8]. On the other side, the developing countries (low- and middle-income countries) like Pakistan ranks among the top 50 countries in Asia for road traffic accident-related fatalities. The World Health Organization estimates that the country loses over 30,000 lives to traffic accidents each year, resulting in a mortality rate of 20 deaths per 100,000 people annually due to such incidents [9]. The country is still facing a serious challenge of RTA specially injuries sustained by the drivers and the occupants. Among these countries' improper road conditions, behavior of population towards the road traffic safety measures, lack of knowledge related to rules of road safety as well as substandard quality of vehicle manufacturing etc. are reported as important factors. Furthermore, accident-related events, such as drinking alcohol or using other psychoactive substances, are frequently documented for driver fatalities but have received far less attention when it comes to passenger fatalities among countries like Pakistan [10, 11]. All these factors reported to be responsible for the fatal injuries and higher mortalities among these countries. Comprehending these injuries is crucial in order to optimize road safety regulations, interventions, and safety measures. A better understanding of passenger fatalities may provide crucial insights about the mechanisms underlying injuries and help identify populations at greatest risk [11]. Limited studies and a lack of data regarding the patterns of injuries and factors affecting drivers and passengers in fatal motor vehicle accidents in Karachi have been noted. In light of these gaps, the present study aims to investigate various aspects related to vehicle information, injury locations, safety equipment, conditions, and toxicology that contributed to the fatalities of drivers and occupants in Karachi over a two-year period.

The objective of the study was to investigate the pattern of injuries and responsible factors for between drivers and passengers in fatal motor vehicle accidents in Karachi, Sindh.

METHODS

Retrospective study was conducted carried out from 2nd July 2022 to 30th June 2024 by Department of Forensic medicine, Karachi Institute of Medical Sciences (KIMS) in collaboration with Shaheed Mohtarma Benazir Bhutto Medical College (SMBBMC), Lyari and Liaquat National Hospital and Medical College (LNHMC), Karachi. Public hospitals were selected using a non-random purposive sampling technique, targeting main hospitals across various localities in Karachi that were authorized to perform autopsies. A total sample size of 401 was determined using the OpenEpi online calculator, based on a prevalence rate of 64% for Road Traffic Accidents (RTAs) among car occupants [13]. The calculation was conducted with a confidence level of 95% and a margin of error of 5%. This approach ensures that the selected hospitals were representative of the population of interest while adhering to the criteria necessary for conducting autopsies within the region. All victims involving drivers and passenger's road traffic accidents fatalities, belongs to either gender, of any age from three major tertiary care hospitals in Karachi, Sindh were investigated and evaluated for all sudden, unexpected, violent or suspicious deaths within their jurisdictions. Incomplete information, those of other fatalities and pedestrian related data were excluded. Data from all the hospitals were also collected (LGHK (Est.) 4151/52). All applicable ethical guidelines for performing forensic assessment of victims were followed. The permission mentioned refers to consent from the victim's immediate family members for conducting the autopsy assessment. This is distinct from institutional or hospital administration approval, which is typically obtained by the researcher to conduct the study. In this case, family consent ensures ethical compliance for performing the autopsy. The full autopsy findings of all victims were recorded with the help of medico-legal officers on duty. A written structured questionnaire was used for recording details including information of the vehicle occupants, vehicle seating arrangements, safety equipment's, age and sex of deceased, the distribution of injuries, post-injury survival time, as well as toxicology results. Moreover, data related to features associated with collisions include kind of collision, direction of contact, types of vehicles involved, years of vehicle model etc. were also collected [10]. The driver, front seating passenger, and back seating passenger were all considered occupant in the current study, regardless of where they were in the car. Three distinct groups were used to classify the placement of the occupants: driver, forward seating passenger, and the backward seating passenger. Drivers and forward seating passengers were grouped together as forward seating row occupants and contrasted with backward seating

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passengers in a subgroup evaluation. For statistical analysis, all of the passengers in the different back seating positions were combined into a single group due to the limited number of passengers in each position. The data was analyzed in SPSS version 28.0. The data was presented as frequency and proportions. The chi-square test for binomial categorical variables were used for bivariate analysis of data while multivariate logistic regression analysis was performed. P value < 0.05 was taken as significant.

RESULTS

The study included 401 fatalities from motor vehicle collisions that were forensically examined. Of the total victims, a significant majority of the cases involved drivers followed by front-seat passengers and rear-seat passengers. Overall, there were not many kid fatalities 11 (2.7%), and forward seat passengers had a significant percentage 91 (22.7%) of elderly people. Majority of the victims were drivers, followed by forward seat passengers, and back seat passengers. Between drivers and passengers, there were notable differences in the distributions of age and gender. The driving group was clearly predominately male (Table 1).

Table 1: Demographic Characteristics of Occupants in RTA Fatalities(n=401)

Variables	N (%)
Gender	
Male	296 (73.8%)
Female	105 (26.2%)
Age	
<25 Years	106 (26.4%)
25-34 Years	87 (21.6%)
35-44 Years	84 (21.0%)
45-54 Years	74 (18.4%)
55 and above	50 (12.6%)
Seat Occupancy	
Driver	284 (70.8%)
Front-seat	80 (20.0%)
Rear-seat	37 (9.2%)
Types of Accident	
Front Crashes	270 (67.3%)
Near Edge Hits	55 (13.7%)
Rollovers	54 (13.5%)
Other Accidents	22 (5.5%)
Fatal Injuries by Body Region	
Head	247 (61.6%)
Neck	152 (38.0%)
Thorax	97 (24.2%)
Abdomen	201 (50.2%)
Reported Time of Death	
Within 1 Hour	323 (80.5%)
More than 1 Hour	78 (19.5%)

Table 2 presented the incidence of various fatal injuries among different occupant types. Similar rates of fatal injuries to the abdominal region were seen in drivers and front-seat passengers, however, the rate was lower in rear-seat passengers. In comparison, fatal thoracic injuries were more common among rear-seat passengers. A high rates of head injuries were observed across all groups, with drivers having the highest percentage. A notable difference in seat belt abrasions, with front-seat passengers and rear seat passengers experiencing more abrasions while a higher frequency of extremity fractures observed in rear-seat passengers (Table 2).

Table 2: Proportional Distribution of Injury Patterns According to Seat Occupancy

Injury Pattern	Seat Occupancy N (%)		
	Driver's	Front	Rear
Seatbelt Abrasions	10.0%	35.0%	30.0%
Extremity Fractures	20.0%	12.5%	14.0%
Fatal Injuries to Head	61.6%	58.8%	51.4%
Fatal Injuries to Neck	27.4%	30.0%	21.6%
Fatal Injuries to Thorax	10.7%	7.5%	13.5%
Fatal Injuries to Abdomen	63.6%	65.0%	51.4%

The results of bivariate analysis comparing injury patterns between drivers and passengers were presented in table 3. A statistically significant ($p<0.01$) strong association between occupant type and abdominal injuries and seat belt abrasions were observed (Table 3).

Table 3: Bivariate Analysis of Injury Patterns by Seat Position

Injury Pattern	Occupant Type	p-Value
Seat Belt Abrasions	Drivers versus Passengers	<0.001*
Extremity Fractures	Drivers versus Passengers	0.09
Fatal Injuries to Head	Drivers versus Passengers	0.06
Fatal Injuries to Abdomen	Drivers versus Passengers	<0.01*

*Statistically significant (Chi-square)

Table 4 was assessing the impact of various factors on the likelihood of sustaining fatal injuries employing multivariate analysis. The odds ratio of 0.30 with a p-value of <0.001 indicates a strong protective effect of seat belt use, significantly reducing the likelihood of fatal injuries, while the odds ratio of 2.05 suggested that individuals involved in front-impact collisions were more than twice as likely to sustain fatal injuries (Table 4).

Table 4: Multivariate Analysis of Injury Patterns

Variables	Odds Ratio (OR)	95% C.I	p-Value
Occupant type (Driver)	1.00 (Reference)	-	-
Seat Belt Use (Yes)	0.30	0.15 - 0.60	<0.001*
Crash Type (Front Impact)	2.05	1.30 - 3.25	<0.01*
Front Seat Passenger	0.75	0.52 - 1.08	0.12
Rear Seat Passenger	0.50	0.25 - 1.01	0.05

* Statistically significant f (Multivariate Analysis)

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DISCUSSION

The present study presents the investigation into mobile vehicle collision occupant fatalities reveals critical insights into the demographics and injury patterns of drivers and passengers. The data demonstrated that a significant majority of fatalities involve drivers (70.8%), with front-seat passengers accounting for 20% and rear-seat passengers for only 9.2%. This distribution highlights the heightened risk faced by drivers and front-seat occupants, consistent with findings from recent studies which also emphasize the vulnerability of these individuals in fatal accidents. The predominance of male drivers aligns with trends observed in other studies. For instance, a study by Mohamed J *et al.*, reported that male drivers were involved in a disproportionately high number of fatal accidents, likely due to riskier driving behaviors [12]. This investigation further reveals notable differences in gender distributions between drivers and passengers. Similar findings reported by different researchers from Somalia, Australia and Pakistani studies who highlighted the increased risk of injury among male passengers compared to their counterparts. Older passengers in frontal collisions [12, 13, 14]. Young age people were more likely to have more aggressive behaviors as compared to older drivers. This study observed that majority of population of victims were of younger age up to 35 years of age (48.1%) were involved in more severe injuries compared to the older age group victims. Whereas, amongst the victims, 26.4% were under 25 years and 21.6% were 25-34 years old. This finding offers supportive evidence of the demographic factors influencing the high burden of traumatic injury in Pakistan. Study by Gorge J *et al.*, reported around 71% of the accident victims in their study belong to age up to 35 years [15]. Whereas, in their study majority (46.7%) were under 25 years old. Another study by Farid R *et al.*, along with Rahman MA *et al.*, also reported consistent findings of involvement of age groups under 35 years [16, 17]. The analysis of fatal injuries reveals significant insights into the types of injuries sustained by different occupant types. Notably, abdominal injuries were prevalent among both drivers (63.6%) and front-seat passengers (65.0%), echoing findings from recent literature that underscore the critical nature of abdominal protection in vehicle design [10, 17]. Conversely, rear-seat passengers exhibited a lower incidence of abdominal injuries (51.4%), which may reflect differences in restraint systems, seating positions, and the angles of impact during collisions. Specifically, frontal impacts, typically occurring at angles close to 0 degrees, often result in severe abdominal injuries, while side impacts at angles ranging from 30 to 60 degrees can exacerbate such injuries in rear-seat occupants due to their proximity to the vehicle's side structure. Interestingly, the higher incidence of thoracic injuries in rear-seat passengers (13.5%) compared to drivers (10.7%) suggests that this group may be more susceptible to such injuries due to less effective restraint systems or vehicle design. The biomechanics involved, such as the angle of impact particularly in oblique collisions at angles of approximately 45 degrees can lead to increased forces on the thorax of rear-seat passengers [18, 19]. This finding supports the need for enhanced safety measures, particularly for rear-seat occupants, whose protection has historically been overlooked in vehicle safety standards. The significant difference in seat belt abrasions between drivers (10.0%) and passengers (front: 35.0%, rear: 30.0%) raises important considerations regarding seat belt compliance and effectiveness. These results were consistent with findings from a study by O'Donovan S *et al.*, and Wasif M *et al.*, which emphasized the role of passive restraint systems in reducing injury severity [4, 10]. The disparity in seat belt use suggests that promoting proper seat belt usage, particularly among drivers, could be a key intervention to improve safety outcomes. The multivariate analysis indicates that seat belt use significantly reduces the odds of injury (OR = 0.30, $p < 0.001$), reinforcing the critical importance of seat belts in occupant safety. This finding was supported by a meta-analysis conducted by Masumitsu A *et al.*, and Diego Febres J *et al.*, which concluded that consistent seat belt use was associated with a substantial reduction in fatal outcomes [5, 20]. Additionally, the odds of severe injury were higher for front impact crashes (OR = 2.05, $p < 0.01$), highlighting the need for ongoing improvements in vehicle crashworthiness, particularly for frontal collisions. While this study provides valuable insights, it was essential to acknowledge its limitations. The analysis was based on autopsy data, which may not capture all aspects of occupants' behavior or vehicle dynamics like driving speed, alcohol consumption, or other risk-taking behaviors during collisions. Future studies should consider incorporating real-world crash data to provide a more comprehensive understanding of the factors influencing occupant injuries.

CONCLUSIONS

The study findings reveal significant differences in injury types and frequencies between drivers and occupants, highlighting the greater vulnerability of drivers to severe abdominal and head injuries. Conversely, front and rear-seat passengers exhibited higher rates of seat belt abrasions and fewer extremity fractures, suggesting varying injury profiles based on seating position and restraint use. Stricter enforcement of seat belt laws, improved vehicle safety standards, and educational programs to raise awareness about the risks associated with motor vehicle accidents were strongly recommended.

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Conceptualization: AW
Methodology: AW, HR, SAQ, FAK, IAK
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All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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