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Forensic Evaluation of Injury Pattern in Pedestrian Road Traffic Accidents in Karachi

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ABSTRACT

Pedestrian-related injuries are among the top of all road traffic-related injuries in Pakistan. **Objectives:** To determine the pattern of injuries and responsible factors for pedestrian fatality due to road traffic accidents in Karachi. **Methods:** This retrospective study was carried out at the Department of Forensic Medicine, Karachi Institute of Medical Sciences. Victims involved in pedestrian road traffic accident fatalities, belonging to either gender of any age from three major hospitals in Karachi, were evaluated. Information was recorded in a semi-structured written questionnaire. The multivariate logistic regression analysis was performed for multiple variables simultaneously and reports adjusted odds ratios to determine the independent contribution of each factor to pedestrian mortality. A p-value less than 0.05 was considered statistically significant. **Results:** A total of 681 deceased pedestrians were examined and evaluated for the patterns and factors. The majority of the deceased were male (81.0%) with a mean age of 34.7 ± 2.9 years. The highest proportion (39.2%) of fatalities due to RTA was reported in the 18-30 years' age group. Over two-thirds (74.6%) of accidents took place on the main roads of the city. Common injuries that resulted in death included fatal injuries to the brain and associated vessels (64.4%) and thoracic injuries (14.7%). **Conclusion:** The findings highlight a significant prevalence of male victims, particularly in the 18-30 age group, with brain injuries being the leading cause of death. The analysis also emphasizes the critical role of accident timing, with peak fatalities occurring between 12:00 pm and 4:00 pm, and on main roads.

INTRODUCTION

The spatial mobility provided by automobiles on the local, regional, and global scale has an enormous effect on everyday travel and the flow of commodities globally [1]. Among all types of transport-related mishaps, road traffic accidents (RTAs) have arisen as an essential counter-product of increased motorization and a fast-paced lifestyle, and RTAs are regarded as a modern-day plague [2]. Pedestrian road traffic injuries pose a major global public health challenge, accounting for an estimated 270,000 fatalities annually according to the World Health Organization (WHO) [3]. Pedestrians face disproportionately higher risks of death and serious injury compared to occupants of motor vehicles, with fatality rates per distance travelled being over four times greater. This vulnerability is attributed to their unprotected state upon collision impact and the biomechanical forces involved, which are influenced by factors such as vehicle type, speed, and impact zone [4]. Road fatalities are predicted to rise in the next two decades in most developing countries, like Pakistan, if appropriate strategies and planning are not taken [3, 5]. The high burden of road traffic injuries in most of these developing

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countries is due to the growing number of motor vehicles, disregard for traffic regulations, defective roads, poor health infrastructure, and meager ambulance service [5]. The W.H.O. has estimated that in Pakistan, over 30,000 people die due to traffic accidents per year. While over 75% of road crash fatalities and injuries involved the age groups (15 - 64 years). Moreover, the male-to-female fatality ratio with the 15-49-year age group, who are most vulnerable to fatalities in Pakistan [6, 7]. Forensic pathologists play an important role in investigating pedestrian road traffic fatalities through post-mortem examination and determination of cause and manner of death [8]. Autopsy findings provide objective evidence to characterize injury patterns sustained, which can provide insights into crash dynamics and impact mechanisms. Detailed documentation of trauma patterns, including location, severity and associations between injuries, aids reconstruction of the collision event. Such data assists law enforcement investigations and helps establish whether impairment, reckless or dangerous driving may have contributed to the incident [7, 9]. Some studies have examined injury patterns in a specific group of road users involved in fatal RTCs, but comparisons between different road user groups are limited. Head injuries appear to be more prevalent among pedestrians and cyclists compared to motor vehicle occupants [10]. The severity and type of pedestrian injuries are influenced by multiple factors, including the height of the pedestrian, the design of the striking vehicle, and road conditions at the time of the accident [11]. Forensic studies have also highlighted the importance of toxicological analysis in pedestrian RTAs. Alcohol and drug consumption among pedestrians has been identified as a contributing factor in a significant number of fatal accidents [12]. Blood alcohol concentration (BAC) levels and toxicology screenings are routinely performed in forensic evaluations to determine impairment, which can influence legal responsibility in traffic accidents. Additionally, forensic entomology and post-mortem interval (PMI) assessments can be useful in cases where there is a delay in discovering the victim, aiding in estimating the time of death and accident occurrence [13]. From a road safety perspective, analysis of pedestrian fatality autopsy results can help identify high-risk scenarios and vulnerable groups. Injury profiles correlated with variables such as age, gender, road environment and vehicle types involved may guide the targeting of effective countermeasures [14, 15]. Comparison of findings across jurisdictions enhances understanding of international trends and evaluation of existing intervention strategies. However, standardized protocols for thorough documentation of autopsy results are needed to optimize such analyses [16]. Pedestrian road traffic accidents (RTAs) are a significant public health and forensic concern, particularly in densely populated urban centers like Karachi, where high traffic volume, inadequate pedestrian infrastructure, and non-compliance with traffic laws contribute to fatal injuries. Understanding the injury patterns in these accidents is crucial for improving forensic investigations, guiding clinical management, and informing policy decisions aimed at enhancing pedestrian safety. However, existing literature lacks region-specific data correlating injury severity with demographic, environmental, and toxicological factors, limiting its applicability to Karachi's unique traffic and urban landscape.

This study aims to analyze and classify injury patterns in pedestrian RTAs, correlate autopsy findings with clinical records, toxicology results, and environmental factors, and compare the findings with global and historical data to identify previously unreported trends.

METHODS

This Retrospective study was carried out from 1st February 2024 to 31st January 2025 by the Department of Forensic Medicine, Karachi Institute of Medical Sciences (KIMS), Karachi, in collaboration with Forensic experts of Shaheed Mohtarma Benazir Bhutto Medical College (SMBBMC), Lyari and Liaquat National Hospital and Medical College (LNHMC), Karachi. The data were collected from the medico-legal examiner's office of three different mortuaries of public hospitals, including Lyari General Hospital, Civil Hospital Karachi and Abbas Hospital, which are responsible for investigating all sudden, unexpected, violent or suspicious deaths within their jurisdictions. Furthermore, these hospitals also encompass the urban, suburban and rural road networks of Karachi. Ethical approval was received by the Institutional Review board of KIMS as an exempt retrospective study using de-identified data (Reference No.14(a)/24/IRB/KIMS). While permission to collect data from all the hospitals was also collected. All applicable ethical guidelines for using the data records were followed. Cases were included based on the cause of death that was attributable to injuries sustained from a motor vehicle collision while the decedent was a pedestrian. Deceased cases with other causes of death and those who were riders or occupants, alcohol or drug users were excluded. A semi-structured data collection form was used to collect information about the deceased victims. Questionnaire including the demographic details (age, sex, and residential area), Collision details (location, date/time, vehicle types involved, etc.), Injury characteristics (descriptions, locations, severity, cause and manner of death were evaluated. The Abbreviated Injury Scale (AIS) is commonly used to classify the severity of injuries. This system categorizes injuries based on their severity in various body regions (e.g., brain, chest, abdomen), helping to assess the impact of each injury on

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the victim's survival and treatment needs [17]. To ensure accuracy, a second data collector was involved who independently extracted data from 10% of reports, with discrepancies resolved by consensus. Data privacy was ensured as only the investigator has the access to the collected information. Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 25.0. The descriptive statistics characterized demographic profiles and frequencies of variables were presented as frequencies and percentages in tables and figures. The dependent variable is pedestrian mortality, and the independent variables include gender, age group, accident time, and accident location, as these factors were evaluated for their association with pedestrian fatalities and injuries. The multivariate logistic regression analysis was performed for multiple variables simultaneously and reports adjusted odds ratios (ORs) to determine the independent contribution of each factor to pedestrian mortality. A p-value less than 0.05 was considered statistically significant.

RESULTS

A total of 681 deceased pedestrians were examined and evaluated for patterns and factors during the study duration. The demographic details, accident timings, time of injury to death and number of cases are presented. The study findings revealed that the majority of pedestrians were male compared to their counterparts, with the male: female autopsy ratio being 5.8:1. The Highest number of fatalities due to RTA were reported in the 18-30 years' age group while the age group of >60 years reported the lowest number of deaths. The most common time of accidents was 12:00 am – 4:00 pm. Over half of the victims died within seconds to minutes of arrival at the facility. Moreover, the maximum number of incidents was reported in the year 2023(Table 1).

Table 1: Demographic Characteristics of Pedestrian RTA Fatalities(n=681)

Study variables	n(%)
Sex	
Male	552(81.0%)
Female	129(19.0%)
Age	
<18 years	96(14.1%)
18-30 years	267(39.2%)
31-45 years	195(28.6%)
46-60 years	85(12.5%)
>60 years	38(5.6%)
Reported Time of Collision	
6:00 am-11:59 am	265(39.0%)
12:00 pm-4:00 pm	301(44.2%)
6:00 pm-11:59 pm	97(14.2%)
12:00 am-5:59 am	18(2.6%)
Reported Time of Death on Arrival at Facility	
Within seconds to minutes	398(58.4%)
1-3 hours	226(33.2%)
Within 24 hours	37(5.4%)
>24 hours	20(3.0%)
Year Wise Deaths	
2019	126(18.6%)
2020	105(15.4%)
2021	143(21.0%)
2022	148(21.7%)
2023	159(23.3%)

A significant number, 269 (39.5%) of RTAs involved four-wheelers (cars), followed by trucks/loaders 199 (29.2%), buses/pickups 153 (22.5%) and motorbikes/ rickshaw 60 (8.8%). Among the victims, the majority, 390 (57.3%) were had one site of injury, followed by 171(25.1%) of the victims had more than 2 sites, and 120 (17.6%) had more than two sites of injury. Whereas, among the pedestrian victim injuries, 488 had head and neck injuries, 165 had abdominal and pelvic region injuries, 145 reported with thoracic region injuries, while 103 suffered from injuries to their lower extremities, and 58 had upper extremities injuries. Among the type of injuries, majority 520 (76.5%), of victims were with lacerations, 406 (59.6%), 307 (45.1%) were with contusions whereas, and 161 (23.6%) had fractures. Whereas, on assessing the site of fractures, it was observed that the skull was the most common site for the fracture, 87 (54.1%), followed by fractures to ribs and sternal bone, 29 (18.0%). The fractures to the upper extremity, lower limb, pelvis and neck were observed in 17 (10.6%), 14 (8.7%), 10 (6.2%) and 04 (2.4%) of the cases, respectively. The graphical presentation of month-wise fatalities due to RTA. The highest number of fatalities was reported in January, November, and December. When the yearly distribution of the cases was studied, a significant rise in several RTA-related fatalities was observed from 2019 to 2023. The number of deaths recorded between March and July 2020 compared to the rest of the studied years. This sharp decline was presumably a result of the implementation of stringent measures and lockdowns to contain the COVID-19 pandemic at that time(Figure 1).

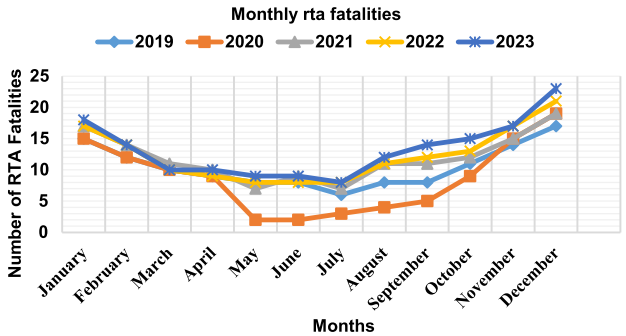

Figure 1: Month-Wise Fatalities Due to RTA in the Last 5 Years (n=681)

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The study demonstrated that most 508 (74.6%) accidents took place on the main roads of the city, followed by link roads 106 (15.6%), around about 59 (8.6%) and house streets 8 (1.2%). The victims were examined for the cause of death, it was observed that most of the deaths resulted from fatal injuries to the brain and associated vessels of the victims (Table 2).

Table 2: Distribution of Cause of Death According to the Site of Injury (n=681)

Cause of Deaths	n (%)
Brain And Associated Vessels Injuries	438 (64.4%)
Thoracic /Abdominal Aorta or Both Injury	59 (8.7%)
Thoracic Visceral Injury	41 (6.0%)
Abdominal Visceral Injury	15 (2.2%)
Femoral Vessels Injury	76 (11.1%)
Brachial / Radial Vessel Injury	19 (2.8%)
Pelvic Region Injury	33 (4.8%)

Results show the higher relative risks for pedestrian mortality in different groups. Men were more than five times more likely than women to die from RTAs ($p<0.05$), underscoring their high susceptibility to accidents. The risk of brain injury death was 1.5 times higher in the 18–30 age group, indicating that this population needs priority interventions. Enforcing traffic laws during peak hours may help prevent brain injuries, as accidents that occur in the afternoon have a 1.7-fold increased risk of brain damage. The multivariate analysis of independent risk factors of pedestrian mortality after adjusting the confounders demonstrated that, compared to the remaining age groups, pedestrian victims aged 18-30 years had 2.1 times higher adjusted risks of mortality due to RTA whereas, comparing females, males have a 3.4 times higher probability of dying in pedestrian RTAs. Moreover, there was 1.9 times higher probability of (adjusted mortality risk) associated with afternoon time RTAs (12-4 pm) considered as a high-risk period, and main highways were found to be associated with 1.6 times higher odds of pedestrian mortality (Table 3).

Table 3: Risk Assessment and Multivariate Logistic Regression Analysis of Different Factors for Pedestrian Mortality

Risk Assessment			
Outcome	**Exposure**	**RR (95% CI)**	**p-Value**
Death	Males	5.8 (4.8-7.0)	0.000*
Brain Injury Death	Age Group (18-30 Years)	1.5 (1.2-1.9)	0.037*
Brain Injuries	Accident Time (12-4 pm)	1.7 (1.4-2.1)	0.001*
Head Injuries	Main Roads	2.3 (1.8-2.9)	0.000*
Multivariate Logistic Regression Analysis			
Study Variables	**Adjusted OR**	**95% CI**	**P-Value**
Male Gender	3.4	2.5-4.6	0.000*
Age Group (18-30 Years)	2.1	1.5-3.0	0.000*
Accident Time (12-4 pm)	1.9	1.3-2.7	0.001*
Main Road (Location)	1.6	1.2-2.1	0.034*

*Statistically significant $p<0.05$

DISCUSSION

Pedestrians are among the most vulnerable road users, with fatality risks disproportionately higher compared to motor vehicle occupants. Determining causes and manners of pedestrian RTA deaths through post-mortem examination is very important in forensic investigations [18]. The findings of medico-legal autopsies are legitimate proof in a court of law and are carried out by the laws of all countries. An extensive epidemiological profile can be created based on autopsy findings that could assist in the future implementation of suitable preventive measures [19, 20]. The present study was designed to determine the pattern of injuries and responsible factors for pedestrian fatality due to road traffic accidents in Karachi, Sindh. This study demonstrated the different injury patterns, site of injuries, timings and months of fatalities in pedestrian victims of different age groups through a prospective analysis of data. Based on the findings, a high proportion (39.2%) of fatalities were observed in the age group between 18-30 years. Our findings are consistent with those reported by Uddin *et al.*, Khurshid *et al.*, and Chaturvedi *et al.*, [21-23]. Whereas, Hb *et al.*, reported that RTA fatalities were common among those aged 40 years and above, which is higher than our findings [24]. Concerning gender, the findings of our study revealed that there were over two-thirds of the victims were males (81.0%) compared to female (19.0%). Hb *et al.*, Yadav *et al.*, and Talpur *et al.*, also reported identical findings like the present study, with a higher proportion of male victims compared to their counterparts [24-26]. This may be due to the societal expectations and a greater inclination towards outdoor activities, as men are more vulnerable to RTAs than women. Moreover, in comparison to adolescents and elderly people, young people are presumably more engaged, and their activities presumably require them to travel more frequently. The study's findings about the involvement of the younger age group in RTAs may be explained by the fact that this is not only the generation with the greatest potential for society, but also the most energetic period of life in terms of both physical and social activity. Therefore, it may be considered a significant loss when such economically productive people pass away. A significant number (39.6%) of RTAs involved four-wheelers (cars), followed by trucks/loaders (29.4%), buses/pickups (22.2%) and motorbikes/ rickshaw (9.8%). Our findings are in line with research by Talpur *et al.*, [26]. With the greater increase in number of vehicles The cars on crowded and open city roads, whereas trucks and loaders on main highways, district highways, or even city roads are typically involved in accidents because of careless over-speeding, driving while intoxicated, frequent lane changes without

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signaling, and poorer vehicle stability as well as decline in following road traffic regulations resulting in increasing number of accidents. The majority of accidents in this study (44.2%) occurred between the hours of 12:00 pm and 4:00 pm, with early morning hours (6:00 am to 11:59 am) accounting for 39.0% of all accidents. These findings are in line with Talpur *et al.*, however, some national and international studies reported that the majority of accidents occurred during night timings [26]. Since automobiles travel at a faster speed on main roads, RTIs primarily happen on these routes, followed by residential streets and connection roads. This aligns with the findings of research conducted in Pakistan and India [22, 27]. The findings of the present study also showed that RTIs were common on the main roads of the city. Over two-thirds of victims suffered fatal head and neck region injuries, followed by injuries to the abdomen, pelvis and thoracic region. Among the type of injuries, majority 520 (76.5%) of victims were with lacerations, 406 (59.6%), 307 (45.1%) were with contusions whereas, and 161 (23.6%) had fractures of which skull was the most common site for the fracture 87(54.1%), followed by fracture to ribs and sternal bone 29 (18.0%). Fatal brain injuries and associated vessels of victims in the present study we found at peak, as most (64.4%) of the deaths resulted from these injuries. Our study findings are consistent with the findings reported by different national and international studies found that the leading cause of fatalities or deaths in their studies was acute head trauma, which resulted in the ultimate cause of death, cardio-respiratory failure [26, 28]. The alarming findings of our study are that over 5 years, the majority of RTA victims (58.4%) died within seconds to minutes before they arrived at the emergency unit; they may have died at the scene of the accident or while being transported. Other studies from LMICs also reported this observation [25, 29]. This raises serious concerns over the absence of pre-hospital management services, a referral mechanism, and delayed emergency services. Other potential causes could be the absence of an adequate emergency management service in the nearby the site of accidents. Moreover, the increasing number of mortalities among younger people in the last five-year period is raising a serious concern.

CONCLUSIONS

The findings highlight a significant prevalence of male victims, particularly in the 18-30 age group, with brain injuries being the leading cause of death. The analysis also emphasizes the critical role of accident timing, with peak fatalities occurring between 12:00 pm and 4:00 pm, and on main roads. These findings underscore the need for targeted interventions, such as improved road safety measures, enforcement of traffic laws during peak hours, and public education to reduce pedestrian fatalities.

Authors Contribution

Conceptualization: AW
Methodology: AW, SAQ, HR, MN
Formal analysis: AW, IAK, SAQ
Writing review and editing: AW, IAK, FAK, SAQ

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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