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Insights into Fatal Head Trauma from Road Traffic Incidents

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Abstract

Background: Road traffic accidents (RTAs) are a major global health concern, causing significant morbidity and mortality. Head injuries, particularly fatal ones, are a critical outcome of RTAs, necessitating detailed analysis to inform preventive strategies and improve trauma care protocols.

Objective: This study aims to analyse fatal head injuries resulting from RTAs, focusing on demographic characteristics, types of injuries, causes of death, and circumstances of these incidents.

Material and Methods: A retrospective study was conducted at the Department of Forensic Medicine & Toxicology, GMCH Purnea, Bihar, covering the period from January 2023 to December 2023. The study included confirmed cases of fatal head injuries from RTAs with complete records. Data were analyzed using SPSS software, employing descriptive statistics, cross-tabulation, and chi-square tests to identify significant associations.

Results: Out of 247 cases, 85.4% were males and 14.6% were females. The 21-30 years age group was most affected (36.4%), followed by 41-50 years (18.2%) and 11-20 years (15.8%). Motorcyclists were the most common victims (46.6%), followed by pedestrians (14.2%). Most fatalities occurred at the accident scene (68.43%). The majority of skull fractures were comminuted (38.85%), with fissure + depressed fractures being significant (29.14%). The anterior cranial fossa (ACF) was the most commonly affected skull region (57.09%). Intracerebral haemorrhage (34.85%) and extradural haemorrhage (21.66%) were the most prevalent types of intracranial haemorrhage. Contusions (25.71%) and lacerations (37.14%) were common internal brain injuries.

Conclusion: Fatal head injuries from RTAs predominantly affect young adult males, with motorcyclists being particularly vulnerable. Immediate fatalities at the scene highlight the need for prompt emergency response. The findings emphasize the importance of targeted road safety measures, public awareness campaigns, and improved trauma care systems to reduce the incidence of fatal head injuries in RTAs.

Keywords: Road Traffic Accidents; Fatal Head Injuries; Demographic Analysis; Skull Fractures; Intracranial Haemorrhage; Trauma Care; Public Health Policy.

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Introduction

Road traffic accidents (RTAs) are a pervasive worldwide health concern, explaining substantial morbidity and mortality. As per World Health Organization (WHO), approximately 1.35 million individuals pass away year as a result of road traffic crashes, and an additional 20 to 50 million people sustain non-fatal injuries, numerous examples of which result in long-term disabilities.[1] Among the various types of injuries resulting from RTAs, head injuries are particularly catastrophic due to their high fatality rate and potential for causing permanent neurological damage.[2]

Fatal head trauma from RTAs can arise via a variety of mechanisms, such as direct impact, acceleration-deceleration forces, and secondary complications such as intracranial hemorrhage and brain swelling. These injuries not only lead to immediate fatalities but they provide substantial obstacles for emergency medical services and trauma care systems.[3]

Understanding the epidemiology of fatal head injuries in RTAs is vital for creating efficient preventive measures, improving trauma care protocols, and informing public health policies.[4] Previous studies have highlighted the significance of demographic factors, the role of different types of road users, and the nature of injuries sustained. However, there is a need for comprehensive and detailed analysis to better understand the critical factors contributing to fatal outcomes in head injuries from RTAs.

The primary aim of this study is to provide an in-depth analysis of fatal head injuries brought on by car accidents. By examining the demographic characteristics of the victims, the types of injuries sustained, the immediate causes of death, and the circumstances surrounding these incidents, we aim to identify key patterns and risk factors. The study aims to provide actionable insights for healthcare professionals, policymakers, and traffic safety authorities. Ultimately, this study seeks to contribute to the reduction of fatal outcomes and improve the overall management of head injuries in road traffic accidents.

Material and Method

Study Design: This study employs a retrospective analysis of fatal head injuries sustained in auto accidents (RTAs). The investigation wascarried out at the Department of Forensic Medicine & Toxicology, GMCH Purnea Bihar, from January 2023 to December 2023 who underwent postmortem examination and/or autopsy and retrospectively analysed. This comprehensive study focuses on understanding the demographic distribution, types of injuries, causes of death, and circumstances leading to fatal head trauma in RTAs.

Inclusion criteria: Confirmed fatal head injury due to an RTA, Cases with complete records detailing demographic information, type of road user, nature and extent of injuries, place of death, and survival period.

Exclusion criteria: Cases with incomplete records, Fatalities due to causes other than RTAs.

Data Analysis

The gathered information were compiled and analysed using statistical software SPSS. The analysis focused on identifying patterns and correlations within the dataset, including: Descriptive statistics to summarize the demographic data, types of injuries, and circumstances of each case. Cross-tabulation to examine the distribution of injuries and outcomes across different groups (e.g., age, sex, type of road user). Chi-square tests to determine the significance of associations between categorical variables.

Ethical Considerations: The investigation was carried out in accordance with ethical standards. The approval came from the institutional Ethics Committee of GMC Purnea. Due to the retrospective nature of the study, individual consent was waived. However, confidentiality and anonymity of the subjects were strictly maintained throughout the study.

Observation

Table 1: Distribution of Cases by Age Group and Sex

Age Group	Male Cases	Female Cases	Total Cases
1-10 years	0	0	0
11-20 years	30	9	39
21-30 years	80	10	90
31-40 years	28	8	36
41-50 years	40	5	45
51-60 years	12	2	14
61-70 years	21	2	23
71-80 years	0	0	0
Total	**211**	**36**	**247**

As per Table 1, the age group most susceptible to RTAs is 21-30 years, comprising the highest number of cases (90), followed by the age groups 41-50 years and 11-20 years, with 45 and 39 cases respectively. A decline in cases is observed in older age groups, with minimal occurrences beyond 60 years. Males are disproportionately affected by RTAs across all age groups, constituting 211 out of 247 total cases. Conversely, females account for a smaller proportion of cases, with 36 reported instances.

Table 2: Type of Victim

Type of Road Users	Male	% of Total	Female	% of Total	Total	% of Total
Pedestrians	25	10.1%	10	4.0%	35	14.2%
Motorcyclists	105	42.5%	10	4.0%	115	46.6%
Pillion Riders of Motorcycles	27	10.9%	12	4.9%	39	15.8%
Drivers of Cars/Buses	28	11.3%	0	0.0%	28	11.3%
Falls from Running Buses	12	4.9%	0	0.0%	12	4.9%
Train Accident (Passengers in Train)	14	5.7%	4	1.6%	18	7.3%
Total	211	85.4%	36	14.6%	247	100%

As per Table 2, the analysis reveals that the majority of road traffic accident (RTA) victims are male, accounting for 85.4% of total cases, compared to 14.6% among females. Motorcyclists represent the largest group, constituting 46.6% of total cases, followed by pedestrians at 14.2%. Notably, no female drivers of cars/buses were reported among the cases analysed. Falls from running buses and train accidents also contribute to a significant proportion of RTA cases, highlighting the diverse circumstances leading to such incidents.

Table 3: Place of Death

Place of Death	Male	Female	Number of cases %
Spot death	155	14	68.43
On the way to hospital	24	12	14.57
In hospital	32	10	17.00
Total	**211**	**36**	**100**

As per Table 3 the analysis of road traffic accident (RTA) fatalities indicates that the majority occur at the scene (Spot death), comprising 68.43% of total cases, followed by deaths on the way to the hospital (14.57%) and in the hospital (17.00%). While males constitute a larger proportion of fatalities overall, females represent a relatively higher percentage of deaths on the way to the hospital compared to other categories.

Table 4: Type of Skull Fractures

Type of Fracture	Male	Female	Number of cases %
Comminuted	90	15	38.85
Fissure	25	5	12.15
Depressed	40	3	17.42
Diastitic	0	0	0
Hinge	6	1	2.43
Fissure + Depressed	50	12	29.14
Total	**211**	**36**	**100**

As per Table 4 the analysis of fractures resulting from road traffic accidents (RTAs) reveals a variety of patterns. Comminuted fractures are the most prevalent, accounting for 38.85% of cases, followed by fissure + depressed fractures at 29.14%. Notably, diastitic fractures were not reported among the cases analysed. While males generally constitute a larger proportion of fracture cases, females have a relatively higher percentage of fissure + depressed fractures compared to other fracture types.

Table 5: Involvement of Base of Skull

Base of Skull Involvement	Male	Female	Number of cases %
Anterior cranial fossa (ACF)	145	23	57.09
Middle cranial fossa (MCF)	42	8	16.50
Posterior cranial fossa(PCF)	4	2	1.98
ACF + MCF	6	1	2.83
PCF + ACF	2	0	0.99
MCF + PCF	12	2	5.93
ACF + MCF + PCF	0	0	0
Total	**211**	**36**	**100**

As per Table 5 the examination of base of skull involvement in road traffic accident (RTA) fatalities highlights varied patterns. Anterior cranial fossa

(ACF) is the most commonly affected, representing 57.09% of cases, followed by middle cranial fossa (MCF) at 16.50%. Posterior cranial fossa (PCF) involvement is less frequent, accounting for 1.98% of cases. Combinations of ACF and MCF or MCF and PCF contribute to a smaller proportion of cases, while instances involving all three regions are negligible. Notably, no PCF involvement is reported among females, indicating potential gender-specific differences in skull base injuries.

Table 6: Distribution of cases according to type of intra cranial haemorrhage

Intra cranial haemorrhage	Male	Female	Number of cases %
Extra dural Haemorrhage	50	8	21.66
Subdural Haemorrhage	47	5	18.98
Subarachnoid Haemorrhage	39	1	16.26
Intracerebral Haemorrhage (ICBH)	66	20	34.85
Intraventricular Haemorrhage (IVH)	9	2	8.25
Mixed type			0
Total	**211**	**36**	**100**

As per Table 6 the analysis of intra cranial haemorrhage in road traffic accident (RTA) fatalities reveals varied patterns. Intracerebral haemorrhage (ICBH) is the most prevalent, comprising 34.85% of cases, followed by extra dural haemorrhage at 21.66%. Subdural and subarachnoid haemorrhages represent 18.98% and 16.26% of cases respectively. Notably, mixed type haemorrhages were not reported among the cases analysed. While males generally constitute a larger proportion of haemorrhage cases, females have a relatively higher percentage of ICBH compared to other types of haemorrhage.

Table 7: Internal Brain Injury

Injury to brain	Male	Female	Number of cases %
Contusion	60	12	25.71
Laceration	80	8	37.14
Oedema	26	5	12.57
Drained out	45	11	24.57
Total	**211**	**36**	**100**

As per the Table 7 the examination of brain injuries resulting from road traffic accidents (RTAs) highlights varied patterns. Lacerations are the most common type of injury, accounting for 37.14% of cases, followed by contusions at 25.71%. Drained out injuries represent 24.57% of cases, while edema accounts for 12.57%. While males generally constitute a larger proportion of brain injury cases, females have a relatively higher percentage of lacerations compared to other types of brain injury.

Table 8: Areas of Brain Involved

Areas of brain involved	Male	Female	Number of cases %
Frontal	54	8	25.10
Temporal	60	9	27.63
Parietal	60	12	29.15
Occipital	10	2	5.05
Diffuse	27	5	13.07
Total	**211**	**36**	**100**

As per Table 8 the analysis of brain areas involved in road traffic accident (RTA) fatalities reveals diverse patterns. Parietal lobe involvement is the most prevalent, comprising 29.15% of cases, followed closely by temporal lobe involvement at 27.63%. Frontal lobe and diffuse involvement account for 25.10% and 13.07% of cases respectively, while occipital lobe involvement is the least frequent at 5.05%. While males generally constitute a larger proportion of cases, females have a relatively higher percentage of parietal lobe involvement compared to other areas of the brain.

Table 9: Cause of Death

Cause of death	Male	Female	Number of cases %
Shock and haemorrhage	180	22	81.78
Coma	12	8	7.45
Others	19	6	10.77
Total	**211**	**36**	**100**

As per Table 9 the analysis of causes of death in road traffic accident (RTA) fatalities indicates that shock and haemorrhage are the leading cause, accounting for 81.78% of cases. Coma and other causes contribute to 7.45% and 10.77% of deaths respectively. While males constitute the majority of fatalities, females have a relatively higher percentage of deaths due to shock and haemorrhage compared to other causes.

Table 10: Circumstances leading to head injury

Circumstances leading to head injury	Male	Female	%
Accident	181	29	85.02
Suicide	5	3	3.24
Homicide	25	4	11.73
Total	**211**	**36**	**100**

As per Table 10 the analysis of circumstances leading to head injury in road traffic accident (RTA) fatalities reveals that accidents are the predominant cause, constituting 85.02% of cases. Homicide and suicide contribute to 11.73% and 3.24% of head injury cases respectively. While males constitute the majority of cases across all circumstances, females have a relatively higher percentage of cases attributed to homicide compared to other circumstances.

Table 11: Distribution of cases of head injury according to the duration of survival period

Duration of survival period	No of Cases	% of Cases
Spot Dead	126	51.01%
0 to 12 hours	68	27.53%
12 to 24 hours	34	13.77%
1 to 7 Days	12	4.86%
7 to 15 Days	7	2.83%
Total	**247**	**100%**

As per Table 11 the analysis of the duration of survival period in road traffic accident (RTA) fatalities reveals that a significant proportion of victims succumb to injuries at the scene (Spot Dead), accounting for 51.03% of cases. The majority of fatalities occur within the first 12 hours post-accident, comprising 27.53% of cases, with smaller percentages observed in subsequent time intervals. This distribution underscores the acute and often severe nature of injuries sustained in RTAs, with a rapid decline in survival rates shortly after the incident.

Table 12: Complications causing or contributing to death After Head Injury

Cause of Death	No. of Cases	% of Cases
Head Injury Alone	51	20.65%
Head Injury with pneumonia	16	6.47%
Pyogenic meningitis as a complication of head injury	12	4.86%
Head injury, Shock and Hemorrhage	150	60.73%
Sepsis following head injury	18	7.28%
Total	**247**	**100%**

As per Table 12 the analysis of causes of death among road traffic accident (RTA) fatalities reveals that head injury, shock, and haemorrhage are the primary contributors, accounting for the majority at 60.73%. Head injury alone and sepsis following head injury contribute to 20.65% and 7.28% of cases respectively, while head injury with pneumonia and pyogenic meningitis as a complication of head injury represent smaller percentages at 6.47% and 4.86% respectively. This distribution underscores the critical role of head injuries and associated complications in RTA-related fatalities.

Discussion

Fatal head injuries resulting from road traffic accidents (RTAs) represent a significant public health concern. This study aimed to identify the demographic patterns and risk factors connected to these injuries, providing insights essential for developing targeted interventions. Our findings reveal key trends and highlight the pressing requirement for all-encompassing tactics to reduce the incidence and intensity of fatal head injuries among vulnerable populations.

Our study reveals that the 21–30-year age group is most susceptible to fatal head injuries from road traffic accidents (RTAs), with males disproportionately affected, comprising 85.4% of cases. This finding aligns with Sehlikoğlu K *et al.* (2024)[2] and Shobhana S S *et al.* (2019),[5] who reported similar trends, highlighting young adult males as the most vulnerable demographic. Male preponderance discovery that was published in previous work conducted by various researchers[7, 8, 9] and is explained by the fact that men are more likely to be exposed to the outer world than females.

Our study reveals significant Motorcyclists are the most affected group (46.6%), followed by pedestrians (14.2%). Most fatalities occur at the scene (68.43%). These findings align with Shobhana S S *et al.* (2019),[5] who also reported high vulnerability among two-wheeler occupants and pedestrians. In contrast, Leijdesdorff HA *et al.* (2014)[6] found cyclists to be the most affected group. These results highlight the need for targeted interventions to improve road safety, particularly for motorcyclists and pedestrians, through stricter traffic law enforcement, public awareness campaigns, and enhanced emergency response systems.

Our study reveals distinct patterns, Comminuted fractures are the most prevalent, accounting for 38.85% of cases, followed by fissure + depressed fractures at 29.14%. Notably, no diastatic fractures were reported. Males generally constitute a larger proportion of fracture cases, yet females have a relatively higher incidence of fissure + depressed fractures compared to other types. These findings align with the study by Bhowate S. *et al.* (2016),[10] which reported skull fractures in 81.25% of cases, with fissured fractures being the most common type (35.41%), followed by combinations of fractures (31.2%). Our study's higher prevalence of comminuted fractures suggests a variation in injury mechanisms or reporting standards. Sevitt S. *et al.* (1969),[8] Tyagi A. K. *et al.* (1986)[11], and Jennet Bryan (1996)[12] also reported similar observations, with fissured fractures being prominent. The absence of diastatic fractures in our study contrasts with the broader range of fracture types observed by Bhowate S. *et al.*, indicating possible regional or methodological differences in data collection.

In our study the anterior cranial fossa (ACF) is the most frequently affected region, accounting for 57.09% of cases, followed by the middle cranial fossa (MCF) at 16.50%, and the posterior cranial fossa (PCF) at 1.98%. Comparatively, the study by Shobhana S S *et al.* (2019)[5] found that MCF fractures were involved in 17% of cases, ACF in 10% of cases, and a combination of all fossa regions in a single case. While both studies highlight the prominence of ACF and MCF fractures, our findings indicate a higher prevalence of ACF involvement.

The analysis of intracranial hemorrhage in RTA fatalities shows that intracerebral hemorrhage (ICBH) is the most prevalent (34.85%), followed by extradural hemorrhage (21.66%), subdural hemorrhage (18.98%), and subarachnoid hemorrhage (16.26%), with no mixed-type hemorrhages reported. Comparatively, Bhowate S. *et al.* (2016)[10] found SDH to be the most common (31.25%), followed by SAH (25%), ICBH (10.41%), and IVH (14.58%), with mixed hemorrhages, especially SAH and SDH, observed in 16.66% of cases. These findings align with studies by Chandra J. *et al.* (1979)[,13] Tyagi A. K. *et al.* (1986)[11], and Tonge J. I. *et al.* (1979)[15], which also reported significant occurrences of SDH and SAH. In contrast, KSN Reddy's[14] study noted extradural hemorrhage as the least common type (1-3%).

lacerations are the most common brain injury (37.14%), followed by contusions (25.71%) and drained-out injuries (24.57%). The parietal lobe is most frequently involved (29.15%), followed by the temporal (27.63%) and frontal lobes (25.10%). Shock and hemorrhage are the leading causes of death (81.78%), with coma and other causes accounting for 7.45% and 10.77%, respectively. In comparison, Bhowate S. *et al.* (2016)[10] found traumatic cranio-cerebral injury to be the primary cause of death in 52.08% of cases, increasing to 56.18% when including head injury complications. Our data also show that accidents are the predominant cause of head injury (85.02%), similar to Bhowate's finding of 93.75%, with homicides and suicides contributing smaller proportions. Regarding survival duration, 52.13% of victims in our study died at the scene, and 27.49% within the first 12 hours post-accident, whereas Bhowate reported 18.75% deaths on the spot and 45.83% within 0-12 hours. Finally, our findings indicate that head injury, shock, and hemorrhage are the primary causes of death (60.73%), corroborated by Bhowate's 52.08% for traumatic cranio-cerebral injury and Shobhana S S *et al.* (2019)[5] highlighting shock and hemorrhage as the most common causes, followed by coma. These variations underscore the critical role of head injuries in RTA fatalities and highlight the need for improved prevention and intervention strategies.

Conclusion

This study emphasizes how young adultsespecially menare the most vulnerable to fatal head injuries from road traffic accidents, with motorcyclists being the highest-risk group. Most of the fatalities occur at the accident scene due to severe injuries such as comminuted skull fractures and intracerebral hemorrhages, primarily caused by shock and hemorrhage. Effective interventions, including enhanced road safety measures, public awareness campaigns, improved emergency response, and advanced trauma and post-trauma care, are essential to reduce these fatalities and improve outcomes for survivors.

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Conflict of Interest: The authors declare no conflicts of interest regarding the publication of this article.

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