International Journal of Forensic Expert Alliance
https://doi.org/10.70818/ijfea.v02i01.026
Vol. 2, No. 1, 2025

ISSN (Print): 3078-6673
ISSN (Online): 3078-6681

ARTICLE | OPEN ACCESS

Pattern and Distribution of Skull Fractures in Fatal Road Traffic Accidents: A Descriptive Study

Sandwip Talukdar[1]*, Krishna Chandra Das[2], Md Kafil Uddin[3], Muhammad Abdullah Kafi[4], Preyanka Chowdhury[5], Shammi Akter[2], Shishir Kumar Talukder[6]

[1] Associate Professor, Department of Forensic Medicine, North Bengal Medical College, Sirajganj, Bangladesh. [2] Assistant Professor, Department of Forensic Medicine, North Bengal Medical College, Sirajganj, Bangladesh. [3] Associate Professor, Department of Forensic Medicine, Rajshahi Medical College, Rajshahi, Bangladesh. [4] Assistant Professor, Department of Forensic Medicine, Shaheed M. Monsur Ali Medical College, Sirajganj, Bangladesh. [5] Medical Officer, Upazila Health Complex, Manda, Naogaon, Bangladesh. [6] Resident, B.Sc in Microbiology IIAST Affiliated RU, Rangpur, Bangladesh.

ABSTRACT: ***Background:*** Road traffic accidents (RTAs) are a primary global health concern, causing about 1.3 million deaths annually, with low- and middle-income countries bearing most of the burden. Head injuries, particularly skull fractures, are a leading cause of death in RTAs, reflecting the force and mechanism of impact. Fracture patterns vary by accident type, victim role, and protective gear use, with the cranial vault, especially the frontal and parietal bones, most frequently affected. Basal fractures, often involving the middle cranial fossa, are linked to high-energy impacts. Understanding fracture distribution through autopsy studies aids forensic analysis, clinical management, and the development of targeted injury prevention strategies. ***Aim of the study:*** The present study aims to analyze the pattern and distribution of skull fractures in fatal road traffic accidents based on medico-legal autopsies. ***Methods:*** This retrospective descriptive study was conducted in the Department of Forensic Medicine, North Bengal Medical College, Sirajganj, Bangladesh, analyzing 115 medico-legal autopsy cases of fatal road traffic accident victims over 12 months. Inclusion criteria comprised all RTA victims who died from head injuries with complete autopsy records, while cases with incomplete records, decomposition, or non-RTA deaths were excluded. Data on demographics, accident details, and skull fracture characteristics, including anatomical site, specific bones, cranial fossae involvement, and fracture type, were extracted from autopsy reports and related documents. Skull examinations followed standard medico-legal protocols. Data were analyzed using SPSS 26.0, with results expressed as frequencies and percentages. ***Results:*** Among 115 fatal RTA cases, most victims were young adults aged 21–30 years (33.91%), predominantly male (86.09%). Two-wheeler accidents were the leading cause (73.91%), with drivers comprising the majority of victims (53.04%). Skull fractures most commonly involved the cranial vault (65.22%), particularly the frontal bone (32.43%), followed by multiple bones (21.62%) and temporal bone fractures (16.22%). Basal skull fractures primarily affected the middle cranial fossa (61.54%). Linear fractures were the most frequent type (61.74%), followed by combination (19.13%) and comminuted fractures (13.91%), highlighting the severity and distribution of cranial injuries in fatal RTAs. ***Conclusion:*** In fatal RTAs, young adult males are most affected, with two-wheeler collisions predominating. The cranial vault, particularly the frontal bone, and the middle cranial fossa in basal fractures are most commonly involved. Linear fractures are predominant, underscoring the need for improved road safety, helmet use, and trauma care.

Keywords: Road Traffic Accidents, Skull Fractures, Cranial Vault, Basal Skull Fractures, Fracture Patterns, Fatal Head Injuries.

***Correspondence:**
Sandwip Talukdar

How to cite this article:
Talukdar S, Das KC, Uddin MK, Kafi MA, Chowdhury P, Akter S, Talukder SK; Pattern and Distribution of Skull Fractures in Fatal Road Traffic Accidents: A Descriptive Study. *Int. J. Forensic Expert Alliance*. 2025; 2 (1): 1-8

Article history:
Received: January 30, 2025
Revised: March 15, 2025
Accepted: April 24, 2025
Published: June 30, 2025

Peer Review Process:
The Journal abides by a double-blind peer review process such that the journal does not disclose the identity of the reviewer(s) to the author(s) and does not disclose the identity of the author(s) to the reviewer(s).

INTRODUCTION

Road traffic accidents (RTAs) remain one of the leading causes of morbidity and mortality worldwide, posing a significant public health challenge. According to the World Health Organization (WHO), approximately 1.3 million

people die annually due to RTAs, and between 20 and 50 million individuals sustain non-fatal injuries, many of which lead to long-term disabilities.[1] Low- and middle-income countries bear a disproportionate share of this burden, accounting for about 93% of global road traffic deaths, despite having only around 60% of the world's vehicles.[2] In countries like Bangladesh and India, rapid urbanization, increased motorization, and inadequate road safety enforcement have significantly contributed to the rising incidence of RTAs and related fatalities.[3, 4] Head injuries are among the most common and severe consequences of RTAs, often leading to instant death or long-term neurological impairment.[5] Within this spectrum, skull fractures serve as both a direct cause of fatality and an indicator of the magnitude of impact sustained during a collision.[6] The skull, comprising the cranial vault, base, and facial bones, offers considerable protection to the brain; however, when the impact force exceeds its structural resistance, fractures occur, compromising intracranial integrity.[7]

The pattern and distribution of these fractures vary depending on factors such as the mechanism of injury, type of vehicle involved, victim's role (driver, rider, or pedestrian), and use of protective devices like helmets.[8] Understanding the pattern of skull fractures is essential for several reasons. From a forensic perspective, detailed fracture analysis helps in reconstructing the sequence of events leading to death, estimating the direction and magnitude of the impact, and differentiating between accidental and non-accidental trauma.[9] In clinical settings, knowledge of common fracture patterns guides imaging strategies, surgical planning, and prognosis assessment.[10] From a public health standpoint, such studies provide evidence-based insights that can inform preventive strategies, such as helmet design improvements, road safety policy reinforcement, and vehicle safety modifications.[11] Previous studies have documented that the cranial vault is more commonly involved in RTA-related skull fractures than the cranial base, likely due to the direct impact sustained during collisions, particularly in two-wheeler accidents.[12] The frontal and parietal bones are frequently reported as the most affected sites, while base of skull fractures especially involving the middle cranial fossa are associated with high-energy impacts and are often fatal.[13] The type of fracture also varies, with linear fractures being the most common, followed by comminuted and depressed fractures. Multiple fractures often indicate severe trauma and are commonly associated with intracranial hemorrhage and brain contusion.[14]

In South Asia, two-wheeler accidents contribute to a disproportionately high percentage of head injury cases, with riders and pillion passengers often neglecting helmet use or using substandard protective gear.[15] Pedestrians are also highly vulnerable due to inadequate pedestrian infrastructure and a lack of enforcement of traffic laws. In fatal accident cases, autopsy-based studies play a vital role in elucidating fracture patterns, which may differ significantly between regions due to variations in traffic conditions, road infrastructure, vehicle types, and cultural factors.[16] Despite the high burden of RTA-related fatalities in Bangladesh and neighboring countries, limited published data is focusing specifically on the anatomical distribution and fracture types of the skull in fatal cases. Most available literature concentrates on head injuries in general, with limited emphasis on fracture site-specific patterns. This gap underscores the need for detailed morpho-anatomical studies based on autopsy findings, which can provide a more precise understanding of the injury dynamics in RTAs. The present study aims to analyze the pattern and distribution of skull fractures in fatal road traffic accidents based on medico-legal autopsies.

METHODOLOGY AND MATERIALS

This was a retrospective descriptive study conducted in the Department of Forensic Medicine, North Bengal Medical College, Sirajganj, Bangladesh. The study analyzed medico-legal autopsy reports of victims of fatal road traffic accidents (RTAs) to determine the pattern and distribution of skull fractures. The study was carried out over January 01 to December 30 of 2024. All 115 cases of fatal RTAs brought to the mortuary of Shaheed M. Monsur Ali Medical College, Sirajganj for medico-legal postmortem examination during the study period were considered.

Inclusion Criteria

Victims of road traffic accidents confirmed to have died due to head injuries. Cases in which complete autopsy records, including skull examination findings, were available. Both male and female victims of all ages.

Exclusion Criteria

Cases with incomplete autopsy records. Decomposed or skeletonized remains where fracture patterns could not be ascertained. Deaths due to causes other than RTAs.

Data Collection

Data were collected from autopsy reports, police inquest forms, and hospital records (if available). The variables extracted included:

Demographic details: Age, gender.
Accident details: Type of vehicle involved, role of the victim (driver, pillion rider, pedestrian, or occupant).
Skull fracture details:

Anatomical site (vault, base, facial bones, or combinations), specific bone(s) involved in vault fractures, cranial fossa involvement in base of skull (BOS) fractures, and type of fracture (linear, depressed, comminuted, etc.).

The anatomical site classification followed standard forensic guidelines:
Vault: Frontal, parietal, temporal, occipital bones.
Base of Skull (BOS): Anterior, middle, and posterior cranial fossae.
Facial Bones: Maxilla, mandible, zygoma, nasal bones.

Autopsy Procedure

Autopsies were performed according to standard medico-legal protocols. Examination of the skull involved reflection of the scalp, removal of the calvarium, and systematic inspection of the vault, base, and facial bones for fractures. Fracture types were classified into linear, depressed, comminuted, elevated, hinge, crush, or combination patterns based on morphology and distribution.

Data Analysis

All collected data were entered into Microsoft Excel and analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were applied to calculate frequencies and percentages for categorical variables. Results were presented in tables for clarity.

RESULTS

The analysis of 115 fatal road traffic accident cases revealed that the majority of victims were aged between 21–30 years (33.91%), followed by 31–40 years (21.74%) and 41–50 years (18.26%), while the lowest incidence was observed in the 71–80 years group (1.74%) (Table 1). Males were predominantly affected (86.09%) compared to females (13.91%) (Figure 1). Two-wheeler-related accidents accounted for the highest proportion (73.91%), followed by pedestrian accidents (15.65%) and three-wheeler accidents (5.22%) (Table 2). Regarding the role of the victim, drivers constituted more than half of the cases (53.04%), followed by pillion riders (25.22%) and pedestrians (15.65%) (Table 3). Skull fracture distribution showed that the vault was the most commonly involved site (65.22%), followed by combined vault and base fractures (13.04%) and isolated base fractures (11.30%) (Table 4). Among vault fractures, the frontal bone was most frequently fractured (32.43%), followed by multiple bone involvement (21.62%) and temporal bone fractures (16.22%) (Table 5). In basal skull fractures, the middle cranial fossa was most affected (61.54%), followed by the anterior cranial fossa (23.08%) (Table 6). Linear fractures were the most common type (61.74%), while combination fractures constituted 19.13% and comminuted fractures 13.91% of cases (Table 7).

Table 1: Age-wise Distribution of Victims in Fatal Road Traffic Accidents

Age (in years)	Frequency (n)	Percentage (%)
0 – 10	3	2.61
11-20	10	8.70
21-30	39	33.91
31-40	25	21.74
41-50	21	18.26
51-60	11	9.57
61-70	4	3.48
71-80	2	1.74
Total	115	100.00

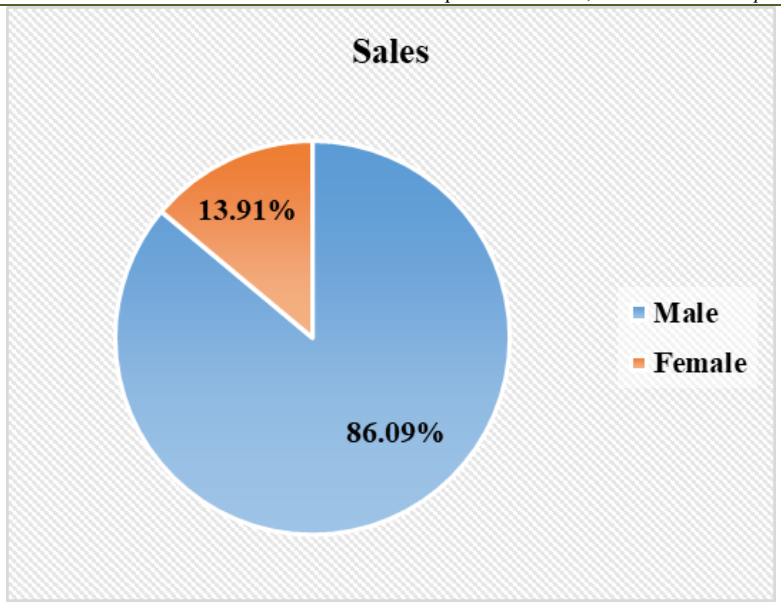

Figure 1: Gender Distribution of Victims in Fatal Road Traffic Accidents

Table 2: Type of Vehicle Involved in Fatal Road Traffic Accidents

Vehicle	Frequency (n)	Percentage (%)
Two-wheeler	85	73.91
Three-wheeler	6	5.22
Four-wheeler	5	4.35
Pedestrian	18	15.65
Bus	1	0.87
Total	115	100.00

Table 3: Role of Victims in Fatal Road Traffic Accidents

Victim	Frequency (n)	Percentage (%)
Driver	61	53.04
Pedestrian	18	15.65
Pillion rider	29	25.22
Occupant	7	6.09
Total	115	100.00

Table 4: Distribution of Skull Fractures by Anatomical Site

Site	Frequency (n)	Percentage (%)
Vault	75	65.22
Base	13	11.30
Facial bones	2	1.74
Vault + base + facial	7	6.09
Vault + facial	3	2.61
Vault + base	15	13.04
Total	115	100.00

Table 5: Distribution of Bone Fractures in the Cranial Vault

Bone fractures in vault	Frequency (n)	Percentage (%)
Frontal	24	32.43
Parietal	10	13.51

Temporal	12	16.22
Occipital	5	6.76
Multiple bones	16	21.62
All cranial vault bones	7	9.46
Total	74	100.00

Table 6: Distribution of Basal Skull Fractures by Cranial Fossa Involvement

BOS fracture	Frequency (n)	Percentage (%)
ACF	3	23.08
MCF	8	61.54
PCF	0	0.00
Multiple	1	7.69
All	1	7.69
Total	13	100.00

Table 7: Distribution of Skull Fractures by Type

Type of fracture	Frequency (n)	Percentage (%)
Linear	71	61.74
Depressed	1	0.87
Comminuted	16	13.91
Elevated	1	0.87
Hinge	1	0.87
Crush	3	2.61
Combination	22	19.13
Total	115	100.00

DISCUSSION

Our investigation of 115 fatal road traffic accident (RTA) cases, centering on the pattern and distribution of skull fractures, revealed several salient insights of forensic and epidemiological importance. Most victims fell within the 21–30-year age group (33.9%), followed by 31–40 (21.7%) and 41–50 (18.3%) (Table 1). This mirrors numerous global findings: Ahmad *et al*., reported that 44 % of skull-fracture victims were aged 21–30 years, with males accounting for 85 % of fatal cases.[17] Similar trends appear across diverse settings, such as in Saudi Arabia and Turkey, where fatal RTA victims predominantly cluster in the younger adult bracket.[18, 19] Gender distribution in our cohort was heavily skewed toward males (86.1%), which echoes reports such as Hashmi *et al*., who found males comprised 84–87 % in skull-fracture cases.[20]

This consistent male predominance may reflect greater exposure due to higher mobility, occupational risks, and risk-taking behaviors. Two-wheeler involvement dominated (73.9%) (Table 3), with drivers (53.0%) and pillion riders (25.2%) most affected (Table 4). This aligns with other studies: in India, fatal RTA cases involving two-wheelers constituted over half of all fatalities, with male victims prevailing.[21] Also, studies emphasize that young male motorcyclists and pillion riders are particularly vulnerable.[22, 23] The cranial vault was most commonly affected (65.2%), significantly higher than base-of-skull (BOS) involvement alone (11.3%) (Table 5). Hashmi *et al*., similarly reported that cranial vault fractures occurred in 71.3% of RTA fatalities, with BOS involvement alone in only 5.9%.[20] Among vault fractures, the frontal bone was most frequently fractured (32.4%), followed by temporal (16.2%) and multiple bones (21.6%) (Table 6). These distributions are consistent with the expected biomechanical dynamics of blunt trauma to the head, where vault bones absorb impact forces. In terms of BOS involvement (Table 7), middle cranial fossa (MCF) accounted for the majority (61.5%), followed by anterior cranial fossa (ACF) (23.1%). Hashmi *et al*., similarly found MCF involvement was most common (23.1%–of BOS fractures), followed by posterior and anterior cranial fossae (15% and 8%, respectively).[20] These findings have medico-legal significance, as BOS fractures, especially those involving MCF, are often associated with rapid fatality due to vital structural involvement. Linear fractures predominated (61.7%),

followed by combination (19.1%) and comminuted (13.9%) types (Table 8). Other autopsy-based research reports similar prevalence of linear fractures: one autopsy series indicated linear skull fractures as most common (43%), followed by comminuted patterns (32%).[24] Linear patterns often arise from lower-energy blunt forces, whereas comminuted and combination fractures may indicate higher-energy impacts, consistent with motorcycle and vehicular collisions.

The observed demographic profile underscores that young to middle-aged males particularly two-wheeler drivers and passengers are disproportionately impacted by fatal skull fractures. This points to the urgent need for targeted interventions: improved helmet use, rider education, and enforcement of traffic laws. The predominance of cranial vault fractures suggests that protective gear and vehicle design should account for blunt impact distribution. Vault fractures, especially involving the frontal and temporal bones, may correspond with coup-contrecoup injuries, increasing the risk of fatal intracranial hemorrhage even when BOS is not involved. Moreover, the high frequency of MCF involvement among BOS fractures aligns with evidence that such injuries can rapidly compromise brainstem structures, increasing mortality risk. The predominance of linear fractures suggests many victims may have been subject to single-impact forces sufficient to fracture the bone but not necessarily to cause fracturing patterns indicating multiple blows or high-velocity impacts. In broader trauma research, head and neck injuries commonly follow extremity injuries in prevalence. One multicountry trauma series found head/neck injuries in 53%, compared with extremities in 46%, including 3–3.5% incidence of skull fractures among RTA casualties.[25] Our incidence of skull fractures within vault and BOS appears notably higher, perhaps due to sample selection (fatal cases only) and autopsy methods, underscoring the severity of head trauma in these fatalities. Two-wheeler accidents globally often yield worse head trauma outcomes due to lack of protection; indeed, bicycle and motorcycle collisions consistently yield high rates of skull and facial trauma. Helmet effectiveness is well-documented: they reduce head injury risk by about 69% and mortality by ~42%.[26] However, helmet usage remains suboptimal, particularly in low- and middle-income countries, reinforcing recommendations for stricter enforcement and awareness campaigns.

Limitations of The Study

This study's retrospective design and limited sample size (115 cases) may restrict generalizability. Autopsy-based studies may over-represent more severe injuries. Data on helmet use, collision dynamics, or pre-hospital time were unavailable factors that could further explain fracture patterns and outcomes.

CONCLUSION AND RECOMMENDATIONS

This study highlights that in fatal road traffic accidents, young adults particularly males are the most affected, with two-wheeler-related collisions predominating. The cranial vault, especially the frontal bone, emerged as the most frequent site of fracture, while the middle cranial fossa was most commonly involved in basal fractures. Linear fractures were the predominant type, followed by combination and comminuted patterns. These findings emphasize the high vulnerability of riders and the severe cranial injuries sustained in high-impact crashes. Strengthening road safety measures, enforcing helmet use, and improving trauma care can significantly reduce the incidence and severity of such fatal head injuries.

Funding: No funding sources.
Conflict of Interest: None declared.

REFERENCES

1. World Health Organization. Global status report on road safety 2018. World Health Organization; 2019 Jan 10.
2. Peden MM. World report on road traffic injury prevention. World Health Organization; 2004 Mar 23.
3. Sultana F, Ahmad M, Islam MS, Hossain MA, Nurunnabi M. Epidemiological Evaluation of Suicidal Deaths due to Hanging: A Retrospective Medicolegal Study in Sylhet. IAHS Medical Journal. 2024 Nov 13;7(1):13-6.
4. Mashreky SR, Rahman A, Khan TF, Faruque M, Svanström L, Rahman F. Hospital burden of road traffic injury: major concern in primary and secondary level hospitals in Bangladesh. Public health. 2010 Apr 1;124(4):185-9.

5. Jha N, Srinivasa DK, Roy G, Jagdish S. Injury pattern among road traffic accident cases: A study from South India. Indian Journal of Community Medicine. 2003 Apr 1;28(2):85.
6. Latha GH, Babu MR, Sugnan B, Lakshmi K, Varma ND. Retrospective Study of Pattern of Skull Fractures in Different Medicolegal Autopsies. Indian Journal of Forensic Medicine & Toxicology. 2023 Apr 1;17(2).
7. Rupani R, Verma A, Rathore S. Pattern of skull fractures in cases of head injury by blunt force. Journal of Indian Academy of Forensic Medicine. 2013 Dec;35(4):336-8.
8. Bharathi MO, Rajesh DR, Abhishek Singh SP. Study of skull fractures in fatal road traffic accident cases from rural Haryana. Asian Pac. J. Health Sci. 2017;4(3):288-91.
9. Karmakar RN. Forensic medicine and toxicology. Academic publishers; 2007.
10. Tunik MG, Powell EC, Mahajan P, Schunk JE, Jacobs E, Miskin M, Zuspan SJ, Wootton-Gorges S, Atabaki SM, Hoyle Jr JD, Holmes Jr JF. Clinical presentations and outcomes of children with basilar skull fractures after blunt head trauma. Annals of emergency medicine. 2016 Oct 1;68(4):431-40.
11. Patil SS, Kakade RV, Durgawale PM, Kakade SV. Pattern of road traffic injuries: A study from western Maharashtra. Indian Journal of Community Medicine. 2008 Jan 1;33(1):56-7.
12. Popa Ș, Ciongradi CI, Sârbu I, Bîcă O, Popa IP, Bulgaru-Iliescu D. Traffic accidents in children and adolescents: a complex orthopedic and medico-legal approach. Children. 2023 Aug 24;10(9):1446.
13. Priyatharsini PP, Balasubramanian S. Estimation of Pattern of Skull Fractures in Homicidal Deaths: An Autopsy Based Cross Sectional Study Conducted in a Tertiary Care Hospital. Prof. SK Dhattarwal. 2024 Jan;18(1):45.
14. Chaturvedi RK, Mishra A, Chaturvedi P. Pattern of head injuries in fatal road traffic accidents in Indore Region, MP. Journal of Evolution of Medical and Dental Sciences. 2014 May 26;3(21):5645-52.
15. Rahman MH, Zafri NM, Akter T, Pervaz S. Identification of factors influencing severity of motorcycle crashes in Dhaka, Bangladesh using binary logistic regression model. International journal of injury control and safety promotion. 2021 Apr 3;28(2):141-52.
16. Gopi S, Amalraj A, Nair A, Chandradhara D, editors. Clinical Studies on Nutraceuticals and Dietary Supplements. CRC Press; 2022 Oct 29.
17. Ahmad M, Rahman FN, Chowdhury MH, Islam AK, Hakim MA. Postmortem study of head injury in fatal road traffic accidents. Journal of Armed Forces Medical College, Bangladesh. 2009;5(2):24-8.
18. Bidelniko R, Masoudi N, Jebraeily M, Rahimi B, Hasanzadeh S, Faghisolouk F. Evaluation of the characteristics and outcome of hospitalized patients due to traffic accidents based on the data of Urmia trauma registry from 2017 to 2022. Payesh (Health Monitor). 2023 Oct 15;22(5):547-58.
19. Aloudah AA, Almesned FA, Alkanan Jr AA, Alharbi T, Almesned F, Alkanan Jr A. Pattern of fractures among road traffic accident victims requiring hospitalization: single-institution experience in Saudi Arabia. Cureus. 2020 Jan 3;12(1).
20. Hashmi ZA, Deepak GC, Khan MT. Different Patterns and Distribution of Skull Fractures in Road Traffic Accidents. Indian Journal of Forensic Medicine & Toxicology. 2022 Jan 1;16(1).
21. Pati S, Mallick DK, Shukla AK, Bisoyi CK, Das S, Sahoo N. Comprehensive Analysis of Fatal Road Accidents: Patterns and Characteristics of Injuries in a Forensic Medicine Setting. Journal of Indian Academy of Forensic Medicine. 2024 Apr 23;46(1):67-70.
22. Ravi HL. Socio Demographic Profile of Suicidal Deaths in Ramanagara Population–An Autopsy Based Study Done at Rajarajeswari Medical College & Hospital Bengaluru (Master's thesis,

Rajiv Gandhi University of Health Sciences (India)).

23. Waghmode AH, Phad L, Jankar JS, Makade J, Mohite PM. Study of Two-wheeler Accident Cases Admitted in the Konkan Region of Maharashtra. Journal of Datta Meghe Institute of Medical Sciences University. 2024 Jul 1;19(3):551-4.
24. Srivastava R, Khan I. Pattern of injuries in road traffic accidental cases (An autopsy-based study). Int. J of Lifesciences, Biotechnology and Pharma. 2024;13(10):601-6.
25. Sagah G, Hasan S, Elhawary A. Pattern of injuries among victims of motor car accidents admitted to Tanta University Emergency Hospital. Ain Shams journal of forensic medicine and clinical toxicology. 2023 Jul 1;41(2):1-3.
26. Shakya B, Bidur KC. Evaluation of the Impact of Helmet Use on the Severity of Traumatic Brain Injury. Journal of Nepalgunj Medical College. 2024 Dec 31;22(2):12-7.