ARC Journal of Forensic Science
Volume 9, Issue 3, 2025, PP 10-16
ISSN No. (Online) 2456-0049
DOI: https://doi.org/10.20431/2456-0049.0903002
www.arcjournals.org

Role of Forensic Medicine in Determining Cause and Manner of Death in Road Traffic Accidents-A Retrospective Study of 120 Cases

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Received: 23 September 2025 Accepted: 10 October 2025 Published: 14 October 2025

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Abstract:

Background: *Road traffic accidents (RTAs) are among the leading causes of preventable deaths worldwide and present complex challenges for forensic pathologists in determining the cause and manner of death. Forensic medicine plays an essential role in reconstructing events, evaluating injury mechanisms, and distinguishing accidental from non-accidental causes. In low- and middle-income countries like Bangladesh, where RTAs are rapidly increasing, medicolegal autopsies provide critical insights into the epidemiology and fatal injury patterns associated with vehicular trauma.*

Objectives: *This study aimed to analyze 120 medicolegal autopsies of RTA victims to determine the spectrum of injuries, immediate and underlying causes of death, toxicological findings, and medicolegal classification, thereby highlighting the importance of forensic medicine in accurately establishing the cause and manner of death.*

Methods: *This is a retrospective descriptive study of 120 autopsy reports of RTA fatalities performed at Mymensingh District, Mymensingh, Bangladesh from January 2024 to December 2024. Data were collected from postmortem reports, police inquest papers, hospital records, and toxicological findings. Each case was analyzed in relation to demographic characteristics, role of the victim (pedestrian, rider, passenger, driver), type and site of injuries, cause of death, and manner of death. Ancillary investigations such as radiology, histopathology, and toxicology were reviewed for diagnostic correlation. The results were expressed as frequencies and percentages and discussed in relation to published literature.*

Results: *Out of 120 cases, 73.3% were males, with the highest incidence in the 20–39-year age group. Pedestrians (38.3%) and motorcyclists (30%) were the most commonly affected. Head and neck injuries were the predominant cause of death (71.7%), followed by thoraco-abdominal trauma (45.8% and 31.7% respectively). Traumatic brain injury accounted for 39.2% of immediate causes of death, and hemorrhagic shock for 25%. Alcohol was detected in 23.3% of victims. The majority of deaths (90%) were accidental, while 2 were homicidal and 3 suicidal.*

Conclusion: *Forensic autopsy remains indispensable in establishing the cause and manner of death in RTA cases. Comprehensive injury documentation, supported by toxicology and scene evidence, not only aids justice delivery but also contributes to public health data essential for formulating road safety policies and preventive strategies.*

Keywords: *Road Traffic Accident; Forensic Autopsy; Cause of Death; Manner of Death; Injury Patterns; Trauma; Medicolegal.*

1. INTRODUCTION

Road traffic accidents (RTAs) represent one of the leading causes of mortality and morbidity worldwide, particularly in low- and middle-income countries (LMICs), where rapid motorization has not been matched by corresponding improvements in road safety

infrastructure and enforcement. According to the World Health Organization (WHO), approximately 1.19 million people die annually due to RTAs, and between 20 and 50 million more sustain non-fatal injuries that often lead to long-term disability and socioeconomic burden (1).

In developing countries, RTAs disproportionately affect males and individuals within the economically productive age range of 15–45 years (2). Forensic medicine plays a pivotal role in investigating RTA fatalities by establishing the cause, manner, and mechanism of death through detailed autopsy examination, injury analysis, and correlation with scene evidence (3,4). Determining the cause of death involves identifying the physiological derangement leading to death—such as traumatic brain injury or hemorrhagic shock—while the manner of death classifies it as accidental, suicidal, homicidal, natural, or undetermined (5). Accurate determination has far-reaching medicolegal implications, influencing insurance claims, criminal liability, and public safety strategies (6).

In RTAs, the complexity of injuries often complicates the medicolegal evaluation. Victims may suffer from polytrauma involving multiple organ systems, with overlapping external and internal injuries that obscure the fatal lesion. Head injuries are reported as the most common cause of death, followed by chest and abdominal trauma (7,8). The forensic pathologist must, therefore, perform a meticulous autopsy supported by ancillary investigations—including radiology, histopathology, and toxicology—to reconstruct the sequence of events leading to death (9). Toxicological evaluation is especially critical, as alcohol and psychoactive substances contribute significantly to crash causation and injury severity (10).

In some instances, natural diseases such as myocardial infarction or epileptic seizures may precipitate accidents, requiring careful differentiation between natural and traumatic causes (11). Furthermore, proper forensic assessment aids in identifying deficiencies in road safety measures-such as non-use of helmets or seatbelts-that inform preventive interventions (12). This study analyzes 120 medicolegal autopsies of RTA fatalities to determine the spectrum of injuries, immediate and underlying causes of death, and their medicolegal classification. By correlating autopsy findings with toxicological and circumstantial data, it seeks to highlight the essential role of forensic medicine in accurately determining cause and manner of death and to provide evidence-based insights for improving road safety and medico-legal practices.

2. Materials and Methods

2.1. Study Design and Setting

This is a retrospective descriptive study of 120 autopsy reports of RTA fatalities performed at Mymensingh District, Mymensingh, Bangladesh from January 2024 to December 2024. Cases were selected consecutively from the department's records over a one-year period. Inclusion criteria were: (1) death attributed to an RTA either at the scene or in-hospital; (2) availability of a full autopsy report including external and internal examination, and (3) sufficient ancillary data (police/scene report, prehospital/hospital records when available). Cases with incomplete records were excluded.

2.2. Data Collection

For each case the following data were extracted: age, sex, date and time of incident, location (urban/rural), role of the deceased (driver, passenger, pedestrian, motorcyclist, cyclist), estimated speed or mechanism when available, use of protective devices (helmet, seatbelt), external injuries, internal injuries by organ system, presence and severity of head injury, chest and abdominal trauma, fractures, toxicology results (alcohol and other substances), radiology (if performed), and the final cause and manner of death recorded by the examining forensic pathologist.

Injury classification followed standard forensic trauma descriptors: blunt force injuries (abrasions, contusions, lacerations), penetrating injuries (rare in RTAs without secondary objects), fractures, organ lacerations, intracranial hemorrhages, and thoracic injuries (rib fractures, pulmonary contusions, cardiac injury). Hemorrhagic shock was used as a proximate physiological cause when massive hemorrhage from major vessels or solid organ injury was documented.

2.3. Autopsy Procedures

All autopsies followed institutional protocols: external examination with thorough photography, measurement of body dimensions and wounds, internal examination with organ-by-organ inspection and dissection, collection of

samples for histology and toxicology, and radiographic imaging when indicated. Brain examinations were performed in cases with suspected head injury; the skull was opened with standard techniques and the meninges and brain examined for hemorrhage, contusions, and diffuse axonal injury. Thoracoabdominal cavities were inspected for hemorrhage, organ lacerations, and ruptured vessels.

2.4. Toxicology and Ancillary Testing

Blood and/or urine samples were collected in appropriate containers and submitted for alcohol and common drug screening. Concentrations of ethanol were reported in g/dL or mg/dL. Other substances (benzodiazepines, opioids, stimulants) were reported qualitatively or quantitatively where available. Selected cases underwent PMCT or conventional radiographs as adjuncts to autopsy findings, particularly for complex fractures, occult foreign bodies, or skeletal trauma reconstruction.

2.5. Determination of Cause and Manner of Death

The cause of death was categorized hierarchically: immediate cause (physiological derangement at death, e.g., hemorrhagic shock, traumatic brain injury), underlying cause (the injury or pathologic process leading to the immediate cause, e.g., severe liver laceration), and contributing causes (e.g., preexisting cardiovascular disease). The manner of death was recorded as accidental if the weight of evidence indicated an unintentional injury related to a road traffic event, homicidal if deliberate force by another person was implicated, suicidal if self-inflicted vehicular action was determined, natural if a medical event precipitated the crash and death, or undetermined where evidence was insufficient.

2.6. Statistical Analysis

Descriptive statistics were used to present frequencies and percentages for categorical variables and means with standard deviations for continuous variables. Comparisons between groups (e.g., pedestrian vs. occupant fatalities) were performed with chi-square tests for categorical data and t-tests for continuous variables where appropriate. A p-value <0.05 was considered statistically significant.

3. RESULTS

A total of 120 road traffic accident (RTA) fatalities were analyzed in this study. Males predominated overwhelmingly, accounting for 88 cases (73.3%), while females comprised 32 cases (26.7%), giving a male-to-female ratio of approximately 2.8:1. The victims ranged in age from 3 to 78 years, with a mean age of 34.7 ± 14.9 years. The majority of deaths (61.7%) occurred among individuals aged 20–39 years, followed by 20.0% in the 40–59-year group, 10.0% in those below 20 years, and 8.3% in the elderly (≥60 years). Most accidents occurred in urban areas (58.3%), whereas 41.7% took place in rural locations. Temporal analysis revealed that 55.8% of the incidents occurred during daytime hours, and 44.2% during the night. Alcohol was detected in 23.3% of cases overall, underscoring its significant role as a contributory factor in nighttime collisions.

With regard to the role of the deceased in traffic dynamics, pedestrians represented the single largest group (38.3%), followed by motorcyclists (30%), vehicle occupants—both drivers and passengers—(24.2%), cyclists (5.8%), and a small number (1.7%) involving other transport modes such as animal-drawn vehicles. Use of protective devices was notably poor. Among motorcyclists, only 27.8% (10 out of 36) were wearing helmets at the time of the crash, while 34.5% (10 out of 29) of vehicle occupants were found to have used seatbelts. Lack of helmet or seatbelt use strongly correlated with the severity of head and thoracic injuries and contributed to a higher proportion of fatal outcomes, particularly among unhelmeted riders and unbelted occupants.

Injury analysis revealed that head and neck trauma were the most frequently affected regions, observed in 71.7% of cases (86 victims). These injuries included skull fractures, extensive intracranial hemorrhages (subdural, subarachnoid, and intracerebral), and brain contusions. Traumatic brain injury (TBI) emerged as the most common immediate cause of death, being responsible for 39.2% of all fatalities. Thoracic injuries were documented in 45.8% of cases (55 victims), typically consisting of multiple rib fractures, pulmonary contusions, cardiac ruptures, and great vessel lacerations. Abdominal trauma was recorded in 31.7% of cases (38 victims), with liver and spleen lacerations being the predominant fatal lesions leading to massive hemoperitoneum and hemorrhagic shock. Pelvic fractures were seen in 12.5% of cases and were often accompanied by significant retroperitoneal bleeding. Spinal injuries, including cervical dislocation and spinal

cord transection, occurred in 15% of cases, while fractures of long bones and extremity crush injuries were identified in 44.2%. Notably, 61% of all victims exhibited multi-system trauma involving two or more anatomical regions, highlighting the complex and often unsurvivable nature of high-energy vehicular impacts.

When immediate causes of death were categorized, traumatic brain injury accounted for the highest proportion (39.2%), followed by hemorrhagic shock resulting from internal thoracic or abdominal bleeding in 25% of cases. Combined multi-system trauma with irreversible shock accounted for 18.3%, while asphyxia due to chest compression or crush injury represented 5.8%. Cardiac rupture or laceration accounted for 4.2%, and other causes-such as extensive burns, sepsis, or delayed post-traumatic complications-made up 7.5% of deaths. These findings demonstrate that blunt force impact remains the predominant mechanism of fatal injury in RTAs, with head and internal organ damage forming the major fatal triad.

Toxicological examination was performed in 102 cases (85% of the total). Ethanol was detected in 27.5% (28 cases), with concentrations ranging up to 0.26 g/dL. Other substances were less frequent: benzodiazepines were detected in six cases (5.9%), opioids in three (2.9%), and stimulants such as amphetamines in two (2.0%). Poly-substance detection—most commonly alcohol in combination with sedatives—was noted in a few instances. Approximately 62% of tested victims were negative for all screened substances. The presence of alcohol and sedative drugs was associated primarily with nighttime collisions, reduced reaction time, and poor judgment leading to high-impact crashes.

Regarding the medicolegal categorization of deaths, accidental deaths constituted the vast majority, accounting for 90% (108 cases). Homicidal manner of death was established in two cases where deliberate vehicular assault was supported by eyewitness and scene evidence. Three cases were classified as suicidal, based on scene reconstruction and corroborative personal histories indicating intentional self-collision or road entry. Natural manners were identified in four cases, each involving acute medical events such as myocardial infarction or cerebrovascular stroke precipitating the accident. In three cases (2.5%), the manner of death remained undetermined due to conflicting or incomplete scene information.

Ancillary investigations significantly enhanced diagnostic accuracy. Postmortem computed tomography (PMCT) was performed in 22 cases and was particularly helpful in delineating complex skull and skeletal fractures, detecting intracranial air, and identifying retained foreign bodies. Conventional radiographs, obtained in 38 cases, aided in mapping skeletal injuries and reconstructing impact vectors. Histopathological analysis was conducted in 40 cases and confirmed vital reactions, organ-specific trauma, and microscopic features such as diffuse axonal injury (DAI) in brain specimens. Toxicological testing, performed in 102 cases, provided critical evidence of impairment and contributory substance use.

Table 1. *Demographic Characteristics of RTA Victims (n = 120)*

Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	88	73.3
	Female	32	26.7
Age group (years)	0–19	12	10.0
	20–39	74	61.7
	40–59	24	20.0
	≥60	10	8.3
Mean age (±SD)	34.7 ± 14.9 years	—	—
Location of accident	Urban	70	58.3
	Rural	50	41.7
Time of occurrence	Daytime (06:00–20:00)	67	55.8
	Nighttime (20:00–06:00)	53	44.2
Alcohol detected	Positive	28	23.3
	Negative	92	76.7

Table 2. *Victim Role and Circumstantial Data*

Role of Deceased	Frequency (n)	Percentage (%)
Pedestrian	46	38.3
Motorcyclist	36	30.0
Vehicle occupant (driver/passenger)	29	24.2
Cyclist	7	5.8
Other (animal-drawn, etc.)	2	1.7

Protective Device	Used	Not Used	% Use
Helmet (motorcyclists, n=36)	10	26	27.8
Seatbelt (vehicle occupants, n=29)	10	19	34.5

Table 3. *Distribution of Major Injuries by Body Region*

Injury Region	Frequency (n)	Percentage (%)	Principal Lesions Observed
Head/Neck	86	71.7	Skull fractures, intracranial hemorrhage, brain contusion
Thorax	55	45.8	Rib fractures, lung contusions, cardiac rupture, great vessel injury
Abdomen	38	31.7	Liver/spleen laceration, mesenteric tear, hemoperitoneum
Pelvis	15	12.5	Pelvic fractures, retroperitoneal hemorrhage
Spine	18	15.0	Cervical dislocation, spinal cord transection
Extremities	53	44.2	Long bone fractures, crush injuries

Table 4. *Immediate Causes of Death*

Cause of Death	Frequency (n)	Percentage (%)
Traumatic brain injury	47	39.2
Hemorrhagic shock (thoracic/abdominal)	30	25.0
Multisystem trauma with irreversible shock	22	18.3
Asphyxia (crush/chest compression)	7	5.8
Cardiac rupture/injury	5	4.2
Others (burns, sepsis, etc.)	9	7.5

Table 5. *Toxicological Findings (n = 102 tested)*

Substance Detected	Positive Cases	Percentage (%)
Ethanol	28	27.5
Benzodiazepines	6	5.9
Opioids	3	2.9
Stimulants (amphetamines, etc.)	2	2.0
Negative for all	63	61.8

Table 6. *Manner of Death*

Manner	Frequency (n)	Percentage (%)
Accidental	108	90.0
Homicidal	2	1.7
Suicidal	3	2.5
Natural (medical event preceding crash)	4	3.3
Undetermined	3	2.5

Table 7. *Ancillary Investigations*

Investigation Type	Cases Performed (n)	Key Contributions
Postmortem CT (PMCT)	22	Clarified fracture patterns, vascular injuries, intracranial air
Radiography	38	Identified skeletal injuries, guided autopsy
Histopathology	40	Confirmed vital reactions, organ damage, DAI evidence
Toxicology	102	Determined impairment and contributory substances

4. Discussion

Road traffic accidents (RTAs) remain a major global public health concern, particularly in low- and middle-income countries, where rapid motorization outpaces the implementation of road safety measures. The present study analyzed 120 autopsy cases to assess the role of forensic medicine in determining cause and manner of

death, injury patterns, and contributory factors. The predominance of males (73.3%) and the 20–39-year age group aligns with previous reports indicating that young adult males are the most exposed demographic to high-speed traffic and risk-prone behavior (3,4).

This demographic trend has significant socioeconomic implications, as the loss of economically productive individuals imposes both family and national burdens. Pedestrians and motorcyclists comprised the majority of fatalities, reflecting their vulnerability on urban roads, consistent with global trends (5). Notably, helmet and seatbelt usage were markedly low (27.8% and 34.5%, respectively), emphasizing the protective role of safety devices. Prior studies have demonstrated that proper helmet use reduces the risk of fatal head injuries by up to 42% among motorcyclists, and seatbelt compliance significantly decreases mortality in vehicle occupants (6,7). In our study, lack of protective devices strongly correlated with severe head and thoraco-abdominal injuries, highlighting the need for strict enforcement of safety legislation. Head injuries were the leading cause of death, observed in 71.7% of cases, with traumatic brain injury accounting for 39.2% of immediate deaths. This finding is consistent with other autopsy-based studies indicating that cranial trauma is the predominant lethal mechanism in RTAs (8,9). Thoracic and abdominal injuries contributed significantly to hemorrhagic deaths, particularly in cases involving unbelted vehicle occupants or pedestrians struck by heavy vehicles. Multi-system trauma was common, observed in 61% of victims, underlining the high-energy impact mechanisms and the complexity of forensic interpretation (10). Forensic pathologists must reconstruct the chain of lethal events, differentiating between primary fatal injuries and secondary or contributory lesions to provide an accurate cause of death. Toxicological analysis revealed alcohol in 23.3% of victims, corroborating the established association between alcohol consumption and impaired driving, reduced reaction time, and increased crash severity (11).

Although other psychoactive substances were less frequently detected, poly-substance use remains a concern due to synergistic impairment. These findings support the integration of toxicological data into medico-legal assessments to determine contributory factors in RTA fatalities (12). Determination of manner of death is challenging in complex RTA cases. In our study, 90% of deaths were accidental, while a small proportion was classified as homicidal or suicidal based on scene investigation and corroborative evidence. This highlights the necessity of combining autopsy findings with police reports, eyewitness testimony, and vehicle examination to avoid misclassification, which can have serious legal consequences (13,14). Ancillary investigations, including postmortem CT, histopathology, and radiographs, enhanced the detection of occult injuries and provided additional evidence to support medico-legal opinions, consistent with recent literature emphasizing multi-modal forensic approaches (15). Overall, the study underscores the critical role of forensic medicine in RTA investigation. Comprehensive autopsy examination, integration of toxicology, and correlation with scene evidence not only ensure accurate determination of cause and manner of death but also generate epidemiological data essential for formulating preventive strategies, improving road safety, and guiding public health interventions. In summary, the results of this study demonstrate that the typical RTA fatality in this series was a young adult male, often unhelmeted or unbelted, sustaining severe head or multi-system injuries in an urban setting, sometimes under the influence of alcohol. Traumatic brain injury and hemorrhagic shock were the leading immediate causes of death, and most cases were unambiguously accidental. The combination of thorough autopsy, scene correlation, and ancillary investigations proved indispensable for accurate determination of both cause and manner of death.

5. Conclusion

Road traffic accidents remain a leading cause of preventable fatalities, predominantly affecting young adult males and vulnerable road users such as pedestrians and motorcyclists. This study of 120 RTA-related autopsies underscores the pivotal role of forensic medicine in accurately determining the cause and manner of death. Traumatic brain injury and hemorrhagic shock were identified as the primary immediate causes of death, with multi-system trauma commonly observed in high-energy collisions.

The findings highlight the protective impact of helmets and seatbelts, the contribution of alcohol to crash risk, and the importance of ancillary investigations-including toxicology, radiology, and histopathology-in providing comprehensive

medicolegal assessment. Determination of manner of death requires careful integration of autopsy findings with scene evidence, eyewitness reports, and vehicle examination, particularly to differentiate accidental from homicidal or suicidal events.

Forensic evaluation not only ensures legal clarity and justice but also generates critical epidemiological data for public health interventions. Enforcement of traffic safety measures, targeted awareness campaigns, and improved roadway design can be guided by such data. Standardized autopsy protocols, routine toxicological screening, and multidisciplinary collaboration are essential to enhance accuracy, reliability, and forensic utility.

In conclusion, forensic medicine serves as both a scientific and preventive tool in RTA management-providing legal resolution for individual cases while informing broader strategies aimed at reducing fatalities and mitigating the socioeconomic impact of road traffic injuries.

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Citation: *Md. Shohab Nahyan, Md. Nurul Amin. Role of Forensic Medicine in Determining Cause and Manner of Death in Road Traffic Accidents-A Retrospective Study of 120 Cases. ARC Journal of Forensic Science. 2025; 9(3):10-16. DOI: https://doi.org/10.20431/2456-0049.0903002.*