Epidemiology and patterns of road traffic fatalities in India pre- and post-Motor Vehicle (Amendment) Act 2019: An autopsy-based study

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ABSTRACT

Background: Road traffic accidents (RTAs) are a preventable cause of death. The government of India enacted the motor vehicle amendment (MVA) act on September 01, 2019, to curtail the alarming trend of RTAs and their associated fatality. The study objective was to compare the epidemiology and pattern of fatal RTAs before and after the MVA Act 2019 of India.

Methods: An autopsy-based cross-sectional study was conducted at the Department of Forensic Medicine and Toxicology (FMT) of a tertiary-care hospital from March 2019 to February 2020. The sample comprised 75 fatal RTA victims who underwent postmortem at FMT. Patients were studied in two groups: One pre-MVA group (n = 47) and one Post-MVA group (n = 28). The data were obtained from medical records and inquest reports with autopsy correlation. Data pertaining to sociodemographic profile, mechanism, injury profile including injury-severity-score (ISS) and survival-time was recorded.

Results: There was a 40.4% decline in mortality among RTA victims (P = 0.057) in the post-MVA group. The case fatality rate also declined during post-MVA implementation months compared to pre-MVA months (1.61 vs. 1.96). A significant correlation was noted between the ISS and survival-time of victims (P < 0.001, r = −0.522). The mean age of patients was 39.87 ± 17.44 years. Heavy motor vehicles along with motorized two-wheeler were the most common offending-vehicle. The median ISS of all victims was 41 (33–57). Head injury was the most common cause of death (60%).

Conclusion: Study results signal-toward early triumph of the new MVA act, probably due to enhanced adherence to safety gears and constructive behavioral change.

Key Words: Autopsy, epidemiology, injury severity score, mortality, traffic accidents

INTRODUCTION

Road traffic accidents (RTAs) are the leading cause of death among children and young adults and the eighth leading cause of death for all age groups globally.[¹] Worldwide, vulnerable road users (pedestrians, cyclists, and motorcyclists) represent more than half of deaths due to RTA as they are often not protected by any shield during the collision.[¹⁻³] Alarmingly, 85%–90% of these RTA deaths occur in low- and middle-income countries.[⁴]
countries (LMIC) like India, claiming young productive age group incurring substantial economic burden and disability-adjusted-life-years.\textsuperscript{1,2,4} In the South-East-Asia region, most deaths are among riders of motorized two- and three-wheelers and head injury is the predominant cause of death among them.\textsuperscript{11} In India, RTA claimed about 154,732 lives and injured almost 439,262 people in 2019, signifying the magnitude of such unfortunate incidents.\textsuperscript{5}

The increasing trend of population growth, urbanization, industrialization, and exceptional motorization rate coupled with high-speeding vehicles has made the Indian roads unsafe to the commuter’s.\textsuperscript{14} Various factors are suggested for the occurrence of RTAs that includes human errors in the form of traffic rule violations such as over-speeding, driving under the influence of alcohol and drugs, distracted driving, and other factors such as unsafe road infrastructure, the menace of stray animals, old vehicles without safety features, and deficient implementation of regulations.\textsuperscript{6-8} Non-use of safety features such as motorcycle helmets, seatbelts, and child restraints adds to the morbidity and mortality from many RTAs.\textsuperscript{11,6}

Surprisingly, most of the RTAs are preventable by effective interventions such as vehicle separation on roads, improvement in road user behavior and vehicle quality, strict law enforcement, and safer road designs.\textsuperscript{1,4} In India, the implementation of the motor vehicle amendment (MVA) act on September 1, 2019, having a key focus on road safety and behavior modification among road users with hefty penalties for traffic violations, was a major initiative by the Government of India to curb the alarming trend of RTAs and its associated fatality in the country.\textsuperscript{9} The effectiveness of any implemented act could be measured by studying the differences of factors (that the act intends to change) before and post-implementation of the act. Hence, the current study aimed to compare the epidemiology and pattern of fatal RTAs before and after the MVA Act 2019 of India.

**METHODS**

After approval by the institutional review board, this autopsy-based cross-sectional study was conducted at the Department of Forensic Medicine and Toxicology (FMT) of a tertiary care hospital in eastern India. The study was approved by the local institutional ethics board. The manuscript adheres to the strengthening of the reporting of observational studies in epidemiology (STROBE) statement guidelines. The study sample was comprised cases of fatal RTA victims who underwent post-mortem (autopsy) at the Mortuary of the FMT department during the one-year period of March 01, 2019, to February 29, 2020. The RTA victims were studied in two groups; (1) Pre-MVA group that comprises RTA victims before the implementation of the new MVA act on September 01, 2019 (n = 6 months), and (2) the post-MVA group included victims after September 01, 2019 (n = 6 months).

The inclusion criteria were as follows; (1) All cases of RTA of all ages and both genders who were presented or referred to our center and subsequently died during treatment and those who were found dead on arrival at the emergency department (ED) (2) Dead bodies brought by the investigating agencies for a medico-legal autopsy that had died due to direct result of injury from RTAs. Victims of RTAs who died >30-days postinjury, victims with unreliable/doubtful history, and decomposed dead bodies with significant artifactual alteration of tissue structures while presentation to the autopsy\textsuperscript{10} was excluded from the study. A detailed medical history was obtained from the relatives of deceased or other eyewitnesses of accidents at the time of postmortem examination about age, education, occupation, socioeconomic status, drug or alcohol addiction if any, any previous medical history, time of the accident, offending vehicle, etc. The autopsy was carried out after receiving the documents such as dead body challan, inquest report, medical record (if hospital stay), and the autopsy requisition. Thorough scrutiny of all these records was carried out to collect relevant clinical information. All external and internal injuries over the body were recorded in a structured proforma during the autopsy. Data about injury severity score (ISS) calculated from the abbreviated injury scale based on the victim’s anatomical site of injury was obtained from the case sheet. The survival time (ST) following RTA was calculated as the time interval between injury and time of death. The cause of death was ascertained from the records with correlation based on autopsy findings. The data were compiled with a focus on analyzing injuries and organs most affected in RTAs and epidemiological factors concerning victim’s vehicles, sites of impacts, etc. A comparison between the profile and injury severities of both the groups was attempted to ascertain the effect of the MVA act on the outcome following RTAs.

**Statistical analysis**

Statistical analysis was performed using R version 3.6.1, a software for statistical computing and graphics (The R Foundation, Vienna, Austria). Categorical variables are expressed as frequency or percentages. The data were analyzed for normality using the Shapiro–Wilks test. Numerical variables are expressed as median (interquartile range). The Mann–Whitney U test and Wilcoxon signed-rank were performed to compare two independent and paired groups, respectively. Kruskal–Wallis test was used to compare more than two independent groups. Spearman’s correlation was used to analyze the correlation between numerical variables. A $P < 0.05$ was considered statistically significant.
RESULTS

A total of 2391 RTA associate injuries resulted in 47 deaths in the pre MVA group, and 1739 RTA-associate injuries resulted in 28 deaths in the post-MVA group. During the study period, 225 autopsies were carried out in the FMT department, of which 75 were RTA-associate injuries. Thirteen (17.3%) patients were dead on arrival (DOA), and 62 (82.7%) patients died during treatment. The demographic variables of patients are depicted in Table 1. The mean age of victims was 39.87 ± 17.44 years, and the most common age group was 21–40 years. The trend of patients per month and mortality during the study are shown in the bar plot [Figure 1]. The time of injury of patients is shown in the bar plot [Figure 2]. The most common time of injury was from 4 to 8 pm ($P = 0.0002$). The median ST of all victims was 6.25 (2.8–29) hours. The median ISS of all victims was 41 (33–57). There was a statistically significant correlation between the ISS and ST of victims ($P < 0.001$, $r = −0.522$). Figure 3 shows the scatter plot depicting a linear correlation between ISS and ST. The median ST of victims due to collisions with different dashing vehicles was 2.6, 6.0, 25.0, and 6 h, respectively, in the heavy motor vehicle (HMV), light motor-vehicle (LMV), motorized two-wheelers (MTW), and unknown vehicle ($P < 0.001$). Figure 4 shows a boxplot depicting comparative ISS of victims caused by different types of dashing vehicles. The median ISS due to RTA in different road types was 41, 33, 52, 49.5, and 36.5, respectively ($P = 0.278$). The pattern of organ injury in the postmortem findings of the victims was depicted in Table 2. Head injury was the most common cause of mortality 45 (60%), followed by hemorrhage and shock 29 (38.6%). The comparative variables between the pre-MVA and post-MVA groups are shown in Table 3.

DISCUSSION

Road traffic injuries are a growing public health problem worldwide. The causes of RTAs are multipronged, and the prevention requires multimodal efforts. The current study noted a reduction in the number of RTA-associate injuries cases attending to the ED of our hospital during the post-MVA implementation months compared to pre-MVA months (1739 vs. 2391). The findings corroborate

| Table 1: The demographic variables of road traffic accident victims |
|-----------------|----------------|-----------------|-----------------|-----------------|
| Variables       | Class          | Frequency (%)   | $P$             |
| Age (years)     |                |                 |                 |
| <20             | 6 (8)          | $<0.001$        |
| 20-40           | 40 (53.3)      |                 |
| 41-60           | 18 (24)        |                 |
| >61             | 11 (14.7)      |                 |
| Sex             |                |                 | $<0.001$        |
| Male            | 57 (76)        |
| Female          | 18 (24)        |
| Occupation      |                |                 | $<0.001$        |
| Housewife       | 14 (18.6)      |
| Laborer         | 11 (14.6)      |
| Farmers         | 5 (6.6)        |
| Driver          | 4 (5.3)        |
| Others          | 41 (54.6)      |
| Income type     |                |                 |                 |
| Above poverty line | 51 (68)  |
| Below poverty line | 24 (32)  |
| Road type       |                |                 | $<0.001$        |
| National highways | 37 (49.3)    |
| State highways  | 10 (13.3)      |
| City roads      | 18 (24)        |
| Approach/service roads | 2 (2.6) |
| Village roads   | 8 (10.6)       |
| Vehicle causing accident |                |
| Heavy motor vehicle | 25 (33.3) |
| Light motor vehicle | 15 (20)   |
| Motorized two-wheeler | 24 (32) |
| Unknown         | 9 (12)         |
| Road user type  |                | $<0.001$        |
| Pedestrian      | 25 (33.3)      |
| Bicyclist       | 5 (6.6)        |
| Motorcyclist    | 39 (52)        |
| Heavy motor vehicle occupants | 1 |
| Light motor vehicle occupants | 1 |
| Mechanism of injury |                |
| Front or rear impact | 30 (40) |
| Fall from the vehicle | 14 (18.6) |
| Run over by vehicle | 4 (5.3)   |
| Vehicle striking other objects | 25 (33.3) |

Figure 1: Bar plot showing time trends of road traffic accident cases and mortality.
an earlier study by Sasmal et al., who reported a 41% drop of RTA-associate injuries during the initial 2-month post-MVA implementation. Furthermore, our study noted a 40.4% decline in mortality in the post-MVA group compared to the pre-MVA group. The case fatality rate among RTA victims also declined during the post-MVA months compared to pre-MVA months (1.61 vs. 1.96).

Most of the RTA victims were males (76%), which is consistent with the findings of earlier studies reported from India and other nations.[10,12-15] Furthermore, more than half of the victims were in the age group of 20–40 years, reflecting an incredibly young productive age group. The authors observed similar findings in earlier studies where strong gender bias on RTAs was reported among males.[7,8,10,13,14] Men were found to be more out-door and are the primary breadwinners for the family, mostly using road transport by own vehicle, walk or public transport. In the present study, nearly half of the deaths due to RTA occurred in the national highways (49.3%), followed by city roads (24%) and state highways (13.3%). The findings are in discordance with a study conducted in India by Farooqui et al. that reported most fatal RTAs occurred in state highways followed by district and rural roads.[10] This difference can be explained by the fact that our center being closer to the national highways (<3 km distance), under close surveillance of police control room vans, and likely to be the first treatment center for these grievous RTA victims. Furthermore, in the present study, the most common dashing vehicle causing fatal RTAs were HMVs (33.3%), whereas MTWs (32%) also comprised a nearly equal share. The findings agree with earlier studies by Reddy et al. and Kanchan et al. that reported HMVs were the most common offending vehicle for fatal RTAs.[12,14] However, contradicting their findings, we had MTW as the second common offending vehicle resulting in

| Region of injury | Injury type or organ injured | Frequency (%) |
|------------------|-----------------------------|---------------|
| Head injury      | Scalp injuries              | 54 (72)       |
|                  | Skull fracture              | 37 (49.3)     |
|                  | EDH                         | 8 (10.6)      |
|                  | SDH                         | 37 (49.3)     |
|                  | SAH                         | 47 (62.6)     |
|                  | ICH                         | 11 (14.6)     |
| Chest injury     | Contusion/laceration        | 24 (32)       |
|                  | Ribs fracture               | 25 (33.3)     |
|                  | Lung contusion              | 17 (22.6)     |
|                  | Lung laceration             | 13 (17.3)     |
|                  | Pericardial injury          | 4 (5.3)       |
|                  | Heart injury                | 4 (5.3)       |
| Abdominal injury | Liver injury                | 12 (16)       |
|                  | Spleen injury               | 3 (4)         |
|                  | Renal injury                | 6 (8)         |
|                  | Mesentery injury            | 9 (12)        |
|                  | Urinary bladder injury      | 1 (1.3)       |
| Extremity injury | Abrasion                    | 62 (82.6)     |
|                  | Contusion/laceration        | 38 (50.6)     |
|                  | Bone fracture               | 25 (33.3)     |
|                  | Shock and hemorrhage        | 29 (38.6)     |
| Cause of death   | Head injury                 | 45 (60)       |
|                  | Respiratory complication    | 1 (1.3)       |

EDH: Extrudural hematoma, SDH: Subdural hemorrhage, SAH: Subarachnoid hemorrhage, ICH: Intracerebral hemorrhage
focal RTAs than LMVs, as reported in their series.\(^{[12,14]}\) Interestingly, we noted that MTWs were constituting a nearly equal share as HMVs in causing fatal RTAs, and none of the previous studies highlighted this finding. MTW remains the significant share of the vehicle on Indian roads. They were being a traditionally unstable vehicle, coupled with over-speeding and traffic rule violations by these motorcyclists posing a valid threat to the road commuters.

In the present study, occupants of MTWs (52%) were the most common victims of fatal RTAs, followed by pedestrians (33.3%). The findings are in line with earlier studies from India that reported two-wheeler occupants are among the majority to be affected in RTA.\(^{[10,12,14]}\) However, this contrasts with the road user demography of fatal RTA victims in Iran, where HMVs (41.9%) and LMVs (36.8%) comprised the majority, as reported by Ghadipasha et al.\(^{[15]}\) Amongst the mechanism of the accident, front or rear impact collisions on the victim or victim’s vehicle were most common (40%), followed by victim’s vehicle striking other objects. The head-to-head collisions with the dashing vehicle comprise high-energy collisions and likely result in fatal outcomes. The findings agree with Kual et al.; however, only a few studies reported such details of injury mechanisms.\(^{[16]}\) The MVA act 2019 had provisions to check on overspeeding, considerably reducing the impact of vehicle collisions on the road.\(^{[8]}\) Our study found that evening time (4 pm to 8 pm) was the most common time of injury among RTA victims, which coincides well with other earlier studies.\(^{[7,8,10,11]}\) Evening time corresponds to peak vehicle and people density on roads as people go back to their home after work, along with reduced attention of drivers and pedestrians due to work fatigue and improper road-infrastructures like an absence of footpath, all may contribute to increased incidence of RTAs.\(^{[17,18]}\)

We found head injury (60%) as the most common cause of mortality among RTA victims, which agrees with earlier studies reported from India and other countries.\(^{[10,12,19]}\) In addition, hemorrhage and shock (38.6%) comprised the second-leading cause of mortality among our samples, which agree with the study by Reddy et al. where the persistent irreversible shock has been reported as the cause of death among 42% of their samples.\(^{[12]}\) In our sample of RTA victims, among the head injuries, a majority had subarachnoid hemorrhage (62%) followed by subdural hemorrhage (49.3) and brain contusion or laceration (32%) where skull fractures are noted in 49.3% of the victims. Similar observations are noted in a study by Jakhari et al., where 67.92% of fatal RTA victims of MTWs reported having an intracranial hematoma and 39.62% having skull fractures.\(^{[20]}\) Helmet use can significantly lessen the severity of head injuries and mortality among MTW users.\(^{[21]}\) The MVA act 2019 mandates compulsory helmet use for drivers and pillion riders of the MTWs. Among the internal abdominal injuries, liver injury was noted mostly (16%), followed by mesentery injury (12%), whereas renal and spleen injuries were observed in 8% and 4% of victims. This is in discordance with the study by Reddy et al., where spleen injury (18.3%) was reported to be the 2nd common solid-organ injury in the abdomen next to liver injury (32.6%).\(^{[12]}\) Among the internal thoracic injuries, lung injuries were the most common, followed by heart injuries, whereas rib fractures are noted in 33.3% of the victims. Similar observations are reported by Reddy et al. among fatal RTA victims in their series.\(^{[12]}\)

Furthermore, we observed the median ST of all fatal RTA victims be 6.25 (2.8–29) hours. Almost 17.3% of victims were dead on arrival to the hospital following accidents, signifying the severity of injuries and the need for additional investments in prehospital care and services.\(^{[22]}\) The results are in line with the findings of Husain et al., where 18% of victims died within 1 h, and a study by Kanchan et al. reported that nearly one-fourth of their RTA victims died within 3 h of injury.\(^{[14,23]}\) The median ISS among our study participants was 41 (33–57), suggesting severe or critical injuries. The ISS of injured victims remains a strong predictor of mortality following RTAs, as highlighted by earlier studies.\(^{[23–26]}\) Furthermore, we noted a statistically significant correlation between the ISS and ST of victims, where ST decreases with increased ISS. Findings coincide well with the study by Husain et al. that reported ISS had a negative correlation with the ST of accident victims.\(^{[23]}\) Interestingly, we noted the median ST of victims across different dashing vehicles, where the HMV had the least ST (2.6 h). The MTWs had a ST of 25 h; only a few studies highlighted this finding. The Limitations of our study were that it was a single center study, and the study center was a tertiary-care hospital. The state government was forced to give a time-bound wave-off period of almost 3 months after implementing the new MVA act to get acquainted with

### Table 3: Comparison between road traffic accident victims of pre-and post-motor vehicle amendment group

| Parameters                          | Pre-MVA          | Post-MVA         | Percentage change | P     |
|-------------------------------------|------------------|------------------|-------------------|-------|
| Number of RTA cases                 | 2391             | 1739             | 27.2              | 0.031*|
| Mortality                           | 47               | 28               | 40.4              | 0.057 |
| Case fatality rate                  | 1.96             | 1.81             | 17.8              | 0.312 |
| Injury severity score median (IQR)  | 41 (33-59)       | 40 (33.5-58)     |                   | 0.55  |
| Duration of survival (h) median (IQR)| 5.5 (2.4-38)   | 8.8 (5.2-64)     |                   | 0.75  |
| Helmet users among two-wheeler (%)  | 5 (15)           | 2 (18.1)         |                   | 0.25  |

*Wilcoxon signed-rank exact test. MVA: Motor vehicle amendment, RTA: Road traffic accidents, IQR: Interquartile range
new mandates, which may have diluted the impact of the law amendments in earlier months.[27]

CONCLUSION

The study results reflect early positive impacts of the new MVA act 2019, which showed a reduction of almost 40.4% in the mortality among RTA victims during the first 6 months of the post-MVA act. There was also a significant reduction (27.2%) in the number of RTA cases presenting to the ED during the post-implementation months. The decline in mortality and case fatality rates may be attributed to the augmented adherence of safety gear while driving and increased compliance with strict enforcement of traffic rules during post-implementation months.

Research quality and ethics statement

This study was approved by the Institutional Review Board/Ethics Committee at the All India Institute of Medical Sciences (Approval # T/IM-NF/FMT/19/61; Approval date Nov 9, 2019). The authors followed the applicable EQUATOR Network (http://www.equator-network.org/) guidelines, specifically the STROBE Guidelines, during the conduct of this research project.

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Conflicts of interest

There are no conflicts of interest.

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