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Epidemiology of mass casualty incidents in a tertiary care trauma center in eastern India: A retrospective observational study

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Abstract:

OBJECTIVES: Disasters and mass casualty incidents (MCIs) that cause substantial mortality and morbidity have been increasing worldwide. The emergency department (ED) services manage MCIs by optimizing triage and providing health care with required resources. The present study attempted to describe the epidemiological characteristics and outcomes of MCIs presenting to the ED.

METHODS: The present retrospective observational study was conducted at the ED of a tertiary care hospital on patients of MCI for 4 years from 2017 to 2021. The data were extracted from the ED disaster records and other paper-based patient records. Information on patient demography, date and time of arrival, mode of transport, method of arrival (direct or referral), type and mechanism of MCI, ED management, and outcome were recorded. Statistical analysis was performed using R, version 4.1.0.

RESULTS: Analysis of 21 MCIs was conducted. Road traffic accidents (RTAs) were the predominant cause of MCIs. The majority of MCI victims, except for those of blast injuries, were men. The victims in medical emergencies were significantly younger than those in other MCI groups ($P < 0.001$). The majority of patients were brought to ED through ambulance services ($n = 120$ [47.1%]), followed by private vehicles ($n = 112$ [44.2%]). Most of the MCI victims ($n = 143$ [56.2%]) were brought to the ED during evening hours (4 pm–8 pm). The majority of victims belonged to the "Red" triage category ($n = 110$ [43.3%]). The injury severity score was significantly higher ($P = 0.014$) in the disaster group than in other trauma MCI groups (20 vs. 17). Autorickshaw occupants were the most common victims of mass casualty RTAs ($n = 38$ [40%]). Suturing ($n = 97$ [50%]) and dressing ($n = 167$ [88%]) were the most common ED procedures required by the victims of trauma MCIs. Of the total, 167 (66%) patients were discharged from the ED, 47 (19%) patients were admitted to wards, 13 (5%) patients were admitted to intensive care units, and 24 (9%) patients got referred to other centers. In addition, two patients died in the ED during treatment, whereas one patient was brought dead.

CONCLUSIONS: RTAs dominate the MCIs and are affecting the young productive male population. The present study exhibited the severity of the cases in MCIs and their impact in the health-care setting, therefore signifying the importance of standardized MCI management protocols.

Keywords:

Disaster, injury severity score, mass casualty, road traffic accident, trauma

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Box-ED Section

What is already known on the study topic?
- Disasters and mass casualty incidents (MCIs) resulting in substantial mortality and morbidity are increasing worldwide
- The emergency department services are crucial for managing MCIs by optimizing triage and providing health care.

What is the conflict on the issue? Has its importance for readers?
- A few studies have examined consecutive MCIs
- Epidemiology of such MCIs has not been covered in Indian literature and must be evaluated.

How is this study structured?
- The present single-center retrospective observational study was conducted on the data of 254 patients.

What does this study tell us?
- MCIs are becoming common in the eastern Indian region
- Road traffic accidents are the predominant cause of MCIs affecting the young productive male population
- The case severity in MCIs and its impact on the health-care setting underline the significance of standardized MCI management protocols with periodic simulation-based training.

Introduction

Disasters and mass casualty incidents (MCIs) that incur substantial mortality and morbidity are increasing worldwide.[1,2] Natural causes of MCIs include floods, cyclones, and earthquakes,[1] whereas technical causes include man-made causes such as road traffic accidents (RTAs), industrial disasters, group physical violence (GPV), terror-induced blasts, and war. A wide disparity exists between the causes and nature of MCIs between different regions influenced by geographical, political, sociocultural, and economic factors.[1] The emergency department (ED) services are crucial for managing MCIs by optimizing triage and providing health care with required resources.[3] However, its preparedness should be based on evidence related to the epidemiological characteristics of previous MCIs.[4]

The World Health Organization has defined MCIs as the events that generate more number of patients at one time than that manageable by locally available resources using routine procedures.[1] They usually require special emergency arrangements, improvisation, assistance, and resources.[1] In addition, MCIs, man-made in particular, occur without warning, resulting in a gross mismatch between demands and resources. The scenario is worse in densely populated and developing countries.[5] A few studies have examined consecutive MCIs,[6-10] and several studies and stakeholders consider these MCIs as specific individual incidents in a particular geographical area.[11] India differs from other countries due to its enormous but diverse geographical and sociocultural zones. Odisha is a tribal-dominated coastal Indian state that is regularly ravaged by natural disasters (ND) such as cyclones and other man-made MCIs.[12] Since these MCIs are typically managed by routine hospital resources without a major disaster response system, the local hospital resources may be temporarily overwhelmed to meet the situation requirements and patient demands even in organized medical systems.[1,13] The epidemiology of such MCIs, which is lacking in Indian literature, must be evaluated to strengthen our emergency response to any untoward event.

Thus, the present study attempted to describe the epidemiological characteristics and outcomes of MCIs presenting to the ED and highlight their incidences, mechanisms, injury patterns, and management, including the mortality and morbidity outcomes.

Methods

Study design and setting

A retrospective observational study was conducted in the ED of a tertiary care hospital in eastern India. The authors attest that the manuscript adheres to the strengthening of the reporting of observational studies in epidemiology statement guidelines.

Ethical approval and patient consent

The Institute Ethics committee of All India Institute of Medical Sciences, Bhubaneswar, approved the study (approval number: T/IM-NF/Nurs/19/30, approval date: October 31, 2019). Written consent from the participants was not required because of the retrospective nature of the study that involved data collection from records.

Study participants

The study sample comprised all patients of MCIs (events that generated ≥4 patients at a time)[7] reporting to the ED of our hospital during 4 years from June 1, 2017, to May 31, 2021. The inclusion criteria were: (1) victims of the MCI involving ≥4 people presenting to the ED, (2) victims with complete data including their outcomes, and (3) patients of all ages and either sex. Victims with incomplete data and non-MCI cases were excluded from the study. The data of 136,873 patients presenting to the ED during the study period were screened. The final analysis was conducted in 21 MCIs involving the data of 254 patients meeting the inclusion criteria.

Mass casualty management protocol in the emergency department

The ED mass casualty incident command system (ICS) during a disaster or MCI resorts to either of the three courses of a plan, namely plan A, plan B, and plan C, based on the number of critical and total patients expected during each MCI to optimize the triage, staff deployment, and infrastructure utilization [Figure 1]. "Plan A" is chosen if <7 red category patients or <25 total patients are expected in a given MCI, utilizing the existing ED setting. "Plan B" is chosen if >7 red category patients or 25–40 total patients are expected, whereas "Plan C" is chosen if >40 patients are expected. The "disaster area" is used for triage and management with additional staff deployment from other departments. The mass casualty ICS of the ED and hospital was activated following each MCI, either after receiving the official intimation regarding the event or following the arrival of the first patient in the ED. All the MCI victims underwent triaging at the screening desk by the triage nurse into categories of red, yellow, green, and black. They were subsequently stabilized as per the priority. The emergency registration procedures and identification of MCI victims were streamlined with name tags and simultaneous data entry in the emergency data board under the ICS. The additional workforce and material resources were mobilized from other hospital departments as per necessity. The radiological investigation and other laboratory services from the ED were prioritized for the MCI victims as per ICS.

Data collection

The data were extracted from the ED disaster records and other paper-based records of patients from the Medical Record Department and compiled on a predesigned structured pro forma and Microsoft Excel worksheet (Microsoft Corporation, Redmond, Washington, USA). Demographic data (age, sex, location of incident), date and time of arrival, mode of transport, method of arrival (direct or referral), MCI type, MCI mechanism, and prehospital interventions were recorded. The MCIs were categorized as traumatic (RTA, GPV, and disasters [natural and accidental]), nontraumatic (medical emergencies), and blast injuries. In addition, the injury patterns and their mechanism and details of a primary and secondary survey as per the advanced trauma life support guidelines for all patients of traumatic MCIs were recorded. The anatomical injury sites were classified and described as per the abbreviated injury scale as head injury (HI), maxillofacial injury (MFI), spine injury, chest injury, abdominal injury, extremity injuries (ExtI), and soft-tissue injuries (STI). The injury severity was calculated using the injury severity score (ISS). The emergency procedures performed in ED as part of patient management were also recorded. The outcome was recorded as brought dead, admitted, discharged, or referred.

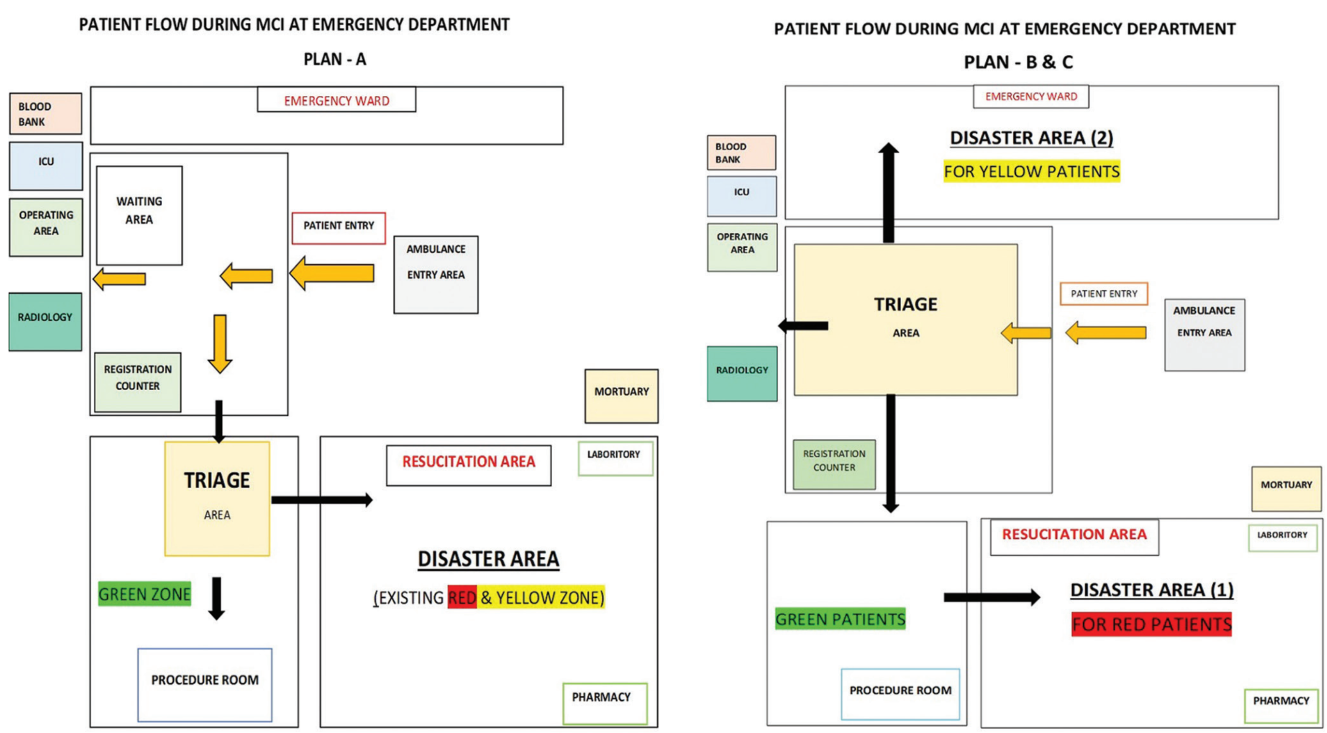

Figure 1: Patient flow during mass casualty incidents at the emergency department

Statistical analysis

Statistical analysis was performed using R version 4.1.0. (The R Foundation, Vienna, Austria), software for statistical computing and graphics. The categorical variables were expressed as counts or percentages. The Chi-square test was used to compare the categorical variables between different groups of mass casualty. Numerical variables were tested for normality by using the Shapiro–Wilk test. Parametric variables were expressed as mean ± standard deviation, whereas nonparametric variables were expressed as median with interquartile range. Kruskal–Wallis test was used to compare the nonparametric variables between different groups of mass casualty. $P < 0.05$ was considered statistically significant.

Results

Patient flow in the study is illustrated in Figure 2. Analysis was conducted on 21 MCIs comprising data of 254 patients. The demographic variables of MCI victims are presented in Table 1. The majority of MCI victims except for those of blast injuries were men. Victims in medical emergencies were significantly younger than those in other MCI groups. Blast injury MCIs included in the study were not terrorism related and occurred from either the explosion of a gas cylinder or firecrackers. The physical violence MCIs mostly involved blunt or sharp objects as a weapon and one incident of gun-shot injury. All medical emergency MCIs were due to food poisoning. The majority of patients were brought to ED through ambulance services (n = 120 [47.2%]), followed by private vehicles (n = 112 [44.1%]) and police control room vehicles (n = 22 [8.7%]). The time of ED presentation of MCI is illustrated in the bar plot [Figure 3], wherein the period between 4 pm and 8 pm was the most common in 143 (56.2%) cases, followed by the period between 12 am to 4 am in 50 (19.6%) cases. RTAs dominated the cause of MCIs, and detailed characteristics of trauma MCIs are depicted in Table 2. ND due to a tropical cyclone and one accidental disaster from bridge collapse was among the disaster MCIs. The injury mechanisms in RTA and disaster MCIs are depicted in Figure 4. The ISS was significantly higher (P = 0.014) in the disaster group than in other trauma MCI groups (20 vs. 17). Autorickshaw occupants were the most common victims of mass casualty RTAs (n = 38 [40%]). Suturing (n = 97 [51%]) and dressing (n = 167 [88%]) were the most common ED procedures required by the victims of trauma MCIs, followed by application of cast or splint [n = 38 (20%)]. Of the total, nearly 167 (66%) patients were discharged from the ED after primary treatment, 47 (19%) patients were admitted to wards, and 13 (5%) patients were in intensive care units, whereas 24 (9%) patients got referred to other centers. Two patients died in ED during treatment, whereas one patient was brought dead to our center.

Discussion

MCIs are major public health problems that require a rapid, synchronized, and coordinated response from the ED team and other stakeholders for optimal care delivery to the maximum population. The coping capacity for any given MCI depends primarily on the type and magnitude of the event, nature of injuries, time of patient arrival, and the available preparation time before patient arrival, and finally, the number of victims.[14] Being a densely populated nation, most public sector hospital EDs in India are habitually functioning at their maximum capacity to cater to routine emergency medical service needs. Therefore, MCIs inflict additional strain on the already stretched ED resources and hospital infrastructure. The task becomes more challenging particularly because the prehospital service in our nation is still in its infancy.

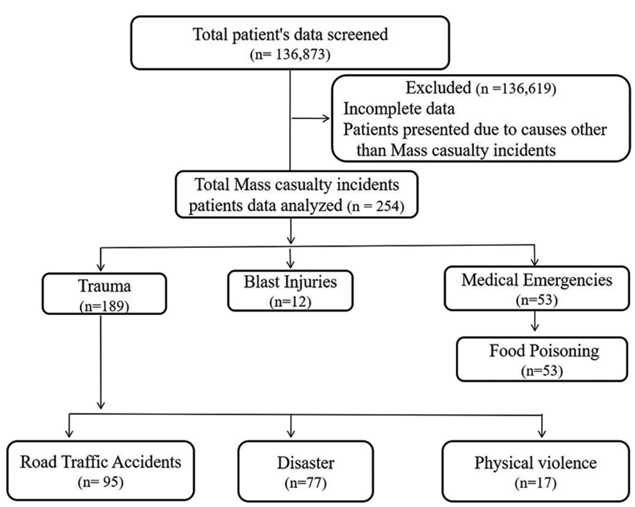

Figure 2: The flow diagram of patients recruited in the study

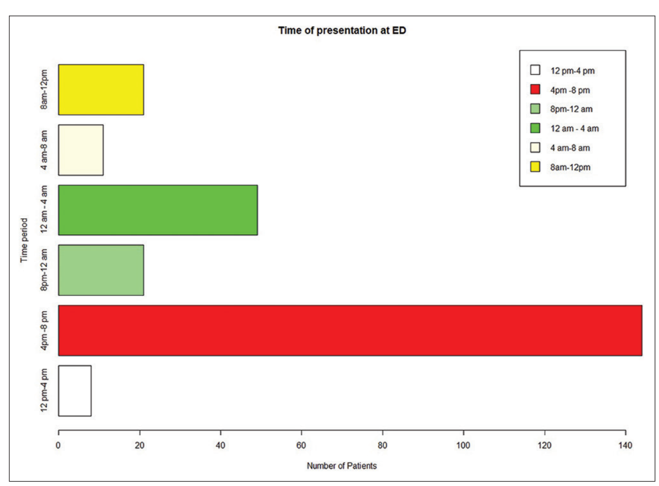

Figure 3: The time of emergency department presentation of mass casualty incidents

Table 1: Participant characteristics of mass casualty incident victims (*n*=254)

Variables	Road traffic accidents (*n*=95)	Disaster (*n*=77)	Group physical violence (*n*=17)	Blast injuries (*n*=12)	Medical emergencies (*n*=53)	*P*
Age (years), median (IQR)	26 (18-43)	40 (27-54)	37 (27-43)	32.5 (21-39)	19 (16-23)	<0.001
Sex						
Male	54	49	11	3	35	0.09
Female	41	28	6	9	18	
Triage category						-
Red	45	48	9	6	2	
Yellow	21	26	7	6	41	
Green	29	2	1	0	10	
Black	0	1	0	0	0	
Triage category						-
Red	45	48	9	6	2	
Yellow	21	26	7	6	41	
Green	29	2	1	0	10	
Black	0	1	0	0	0	

IQR: Interquartile range

Table 2: Comparison between different mass casualty incidents due to trauma (*n*=189)

Variables	Road traffic accident (*n*=95), *n* (%)	Disaster (*n*=77), *n* (%)	Group physical violence (*n*=17), *n* (%)	*P*
Injury severity score				
Median (IQR)	17 (10–25)	20 (14–28)	17 (12–19)	0.014
Polytrauma				
Count (%)	56 (58)	51 (66.2)	12 (70)	0.59
Pattern of injury				
Head injury	41 (43)	25 (33)	12 (70)	-
Maxillofacial injury	39 (41)	14 (18)	8 (47)	
Chest injury	25 (26.3)	16 (21)	1 (6)	
Abdominal injury	12 (12.6)	17 (22)	6 (35)	
Extremity injury	67 (70.5)	32 (42)	12 (70.5)	
External and soft-tissue injury	77 (81)	33 (43)	12 (70.5)	
Spine injury	2 (2)	10 (13)	0	

IQR: Interquartile range

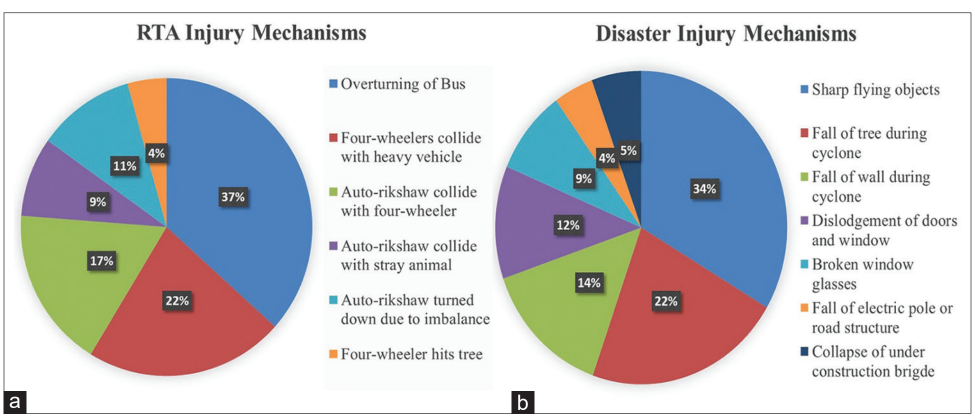

Figure 4: a. The injury mechanisms during road traffic accidents. b. The injury mechanisms during Disasters

The most commonly reported MCI in the present study was RTA (55%), consistent with other studies from other countries.[5-8] The growing motorization and availability of high-speeding vehicles pose a tremendous threat to road safety concerns and account for a significant cause of mass-trauma events.[15] A study from India revealed that RTAs claimed nearly 151,113 lives in 2019 and rendered 451,361 people injured among various age groups.[16] The study observed that autorickshaw occupants remained the most typical victims of mass casualty RTAs. Schmucker *et al*. reported characteristics of RTAs among autorickshaw users that involve dangerous mechanisms such as overturning the vehicle.[17] "Autorickshaw" accounts for a significant share of public transport in our country. It is generally ascribed to be a vehicle with low safety profile. Autorickshaw typically runs overloaded during the peak traffic hours, leading to accidents involving multiple victims, thus generating MCIs. None of the previous studies highlighted this finding.

Of the total MCIs included in the present study, three MCIs presented as a medical emergency due to food poisoning, which was not reported in studies from other nations. Indians are more social and have perennial social gatherings that have community feasts. India is also an educational hub, with many colleges having student hostels that have a large kitchen. Grewal and Khera reported food poisoning outbreaks among hostel indwellers that resulted in many sufferers due to a common food source.[18] The present study also reported two nonterror blast injuries involving women, which were unintentional, unlike another Indian study, in which the incident was intentional.[19] Among the NDs, the present study observed only tropical cyclones that ravage almost yearly and usually progress to super cyclones. Floods are common in some parts of the state, but the state disaster management preparedness nullifies any MCI due to floods, which was the most common ND MCI in one Korean study.[20] No terror blast injuries were observed in the present study. However, these are common MCIs in studies from Israel.[21] Odisha has rich mineral sources and flourishing industrial facilities; however, MCIs related to chemical accidents have not been reported in the present study. There is strict adherence to safety norms mandated by the safety laws in our country and compulsory health facilities for bigger industrial units.

A majority of the MCI victims (59%) were referred to our center from nearby local health-care facilities (HCF) and were not a direct presentation to the ED. This is in contrast to a study by Oboirien who reported direct patients from the disaster scene.[5] The prehospital services are suboptimal in India. Thus, the MCI victims are first taken to the nearest HCFs and further ferried to higher centers. This may explain a higher number of referral cases in the present study. Sharon *et al*. observed that most nonurgent and urgent patients were transferred to nearby HCFs in terror-stricken parts, and a few urgent victims were ferried to more distant trauma centers.[22] This enabled a judicious utilization of hospital facilities without overwhelming a single center.

Male predominance was noted in the trauma-related MCI victims, which is concurrent with the findings of other epidemiological studies related to trauma from India and other nations.[5,12,15] Females exhibited a preponderance in the gas cylinder blast injuries due to their increased involvement in household activities. A significant difference was observed in the median age of various trauma MCI victims, with RTA victims being the youngest of all. Unlike customary RTAs, the pediatric population was proportionately higher among the mass casualty RTAs. This finding is concurrent with those of other studies from eastern India.[23,15]

Approximately 74% of the MCIs were reported during the nonroutine working hours of the hospital (5 pm–8 am). This makes optimization of the surge capacity regarding workforce resources and other logistic supports and supplies challenging. Delgado *et al*. studied the MCI pattern in Spain and exhibited that two-time slots, namely 2–3 pm and 6–8 pm, had the greatest surge.[7] Hendrickson and Horowitz highlighted that the timing of MCI presenting to ED largely determines the response speed, surge capacity, and resource optimization.[14]

Most victims were categorized as "Red" (43.3%) in the triage. This necessitates not only urgent attention but also the exploitation of the volume of resources in care. Delgado *et al*. and Park *et al*. reported that a majority of their MCI victims sustained minor injuries, suggesting green or yellow triage categories.[6,7] The study participants were primarily referrals rather than direct admissions, which could be a possible reason for severity in our MCI victims. Victims of NDs such as a cyclone where injuries occurred from sharp flying objects or tree fall exhibited higher ISS than other trauma victims. The ISS conveys a strong bearing on the outcome following trauma.[24] Marchigiani *et al*. also observed that cyclone victims sustained grievous injuries by mechanisms such as the fall of a tree, poles, wind-born debris, and even concrete structural collapse.[25] The final injury pattern due to various means dictates the preparatory needs of ED for a response. ExtI and STIs were the most common injury patterns in RTA, followed by HI. However, high proportions of HI and MFIs were observed in victims of GPV. These findings are concurrent with those of Hazra D *et al*. who reported on assault injuries from South India,[26] where the victims mostly suffered STIs to the head, neck, face, and extremities, with blunt objects or body parts primarily being used for inflicting harm. Aharonson-Daniel and Peleg observed severe HI with a low Glasgow coma scale (<3) in patients in bomb explosions, with internal injury being more than external injury.[27]

Limitations

The present study was based on the data from a single center in the eastern geographical part of a vast country with a diverse landscape, and data collection was retrospective. Moreover, as many patients were referral cases, the minor injuries, which have been the maximum in many studies, could have been omitted with treatment in local HCFs. However, to the best of our knowledge, the present study is the first to describe consecutive MCIs in India over a period of 4 years.

Conclusions

MCIs are becoming increasingly common in eastern India. RTAs dominate the MCIs and are affecting the young productive male population. Medical emergency MCIs were due to food poisoning. Autorickshaw occupants remained the most common victims of mass casualty RTAs. The ISS was higher among the disaster victims than among other trauma victims. The present study exhibited the severity of the cases in MCIs and their impact in the health-care setting. Therefore, standardized MCI management protocols with periodic simulation-based training are of major significance.

Author contributions statement (CRedIT statement)

CRM and RVR: Conceptualization (lead); Methodology (lead); writing – original draft (lead); formal analysis (lead); writing – review and editing (equal). SS and MJ: writing – original draft (lead); writing – review and editing (equal). CRM: Software (lead). APS and AI: review and editing (equal). IMS and SC: Investigation; writing – review and editing (supporting). APS: Conceptualization (supporting); Writing – original draft (supporting). RVR did the overall supervision of the whole study and all authors had made substantial contribution to the study. All authors have read and agree to content of the final manuscript.

Conflicts of interest

There are no conflicts of interest.

Ethical approval

The Institute Ethics Committee, All India Institute of Medical Sciences Bhubaneswar, Odisha, India, Date of the ethical approval: October 31, 2019, Number of Approval: IEC Ref No: T/IM-NF/Nurs/19/30).

Consent to participate

No written consent was needed from the participants as it was a retrospective observational study based on data from records.

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