Analysis of Injury Patterns and Contributory Factors Among Three-Wheeler Occupants Admitted to Teaching Hospital Karapitiya Following Road Traffic Accidents

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Abstract

Introduction: Increasing morbidity and mortality following road traffic accidents (RTA) is a major health and economic burden in developing countries. Among the increased number of registered vehicles in Sri Lanka 15% are three-wheelers and they are responsible for 11% of the road fatalities in the year 2021 with high impact incidence. The objectives in this study were to determine different patterns, nature, and mechanisms of the injuries, contributory factors, safety measures, and crash characteristics among the occupants of three-wheelers who are admitted following road traffic accidents to a tertiary care hospital in Southern Sri Lanka.

Methodology: Data on socio-demographic profile, mechanisms of causation of injuries, affected region and severity of injuries, and contributory factors for the collision were retrieved from Medico-Legal Examination Forms of the patients admitted following three-wheeler accidents to the teaching hospital Karapitiya from 2019 to 2021. The data were analyzed using the SPSS IBM Version 22.

Results: Rear-seat passengers (64%) were mostly injured than drivers. A bi-fold pattern of prevalence was observed at the time of incidents. The commonest incident was impacts with moving vehicles (41%) and most injuries were sustained by impacts of objects inside the vehicle (48%). The commonest injury seen was abrasion (69%) and the majority were seen over upper limbs (51%). There was no significant difference in the injury pattern between drivers and rear passengers. (11%) of the three-wheel drivers in this study did not possess a driving license and (24%) of them were drunk at the time of the accidents.

Conclusion: High vehicular instability, lack of safety measures, reckless driving, and unnecessary vehicular modifications increase the number of three-wheel accidents. Replacing more crash-worthy four-wheel light vehicles and enforcement of legal limits are recommended.

Keywords: Three-wheeler accidents, the pattern of injuries, crash characteristics

Received: 26 May 2022, **Revised version accepted:** 28 June 2022, **Published**: 30 June 2022. ***Corresponding author:** Jayarathna UGB, Email: gayathjayarathna@gmail.com ORCID: https://orcid.org/0000-0003-4290-0085

Cite this article as: Jayarathna UGB, Warushahennadi J. Analysis of Injury Patterns and Contributory Factors Among Three-Wheeler Occupants Admitted to Teaching Hospital Karapitiya Following Road Traffic Accidents. Medico-Legal journal of Sri Lanka. 2022;10(1):23-30. DOI: http://doi.org/10.4038/mljsl.v10i1.7452

Introduction

A road traffic accident (RTA) is defined as an accident involving at least one vehicle on road open to the public in which at least one person is killed or injured. It is a global health challenge and a huge burden to the world economy which leads to a significant increase in mortality and morbidity. In every country, the number of vehicles has increased disproportionately to the development of the roads. Although the regulations have been introduced for the safety of vulnerable road users, including vehicle occupants and pedestrians, the deaths following RTAs continue to rise steadily.

World health organization (WHO) global status report on road safety 2018 reveals, RTA is the 10th

leading cause of all deaths globally and the number of road traffic deaths has increased from 1.15 million in 2000 to 1.35 million in 2018.[1] Most of the global RTA fatalities are happening in developing countries with low economic status like Sri Lanka, India, Bangladesh, etc. Poor road conditions, bad weather, reckless driving, ignorance of road rules, high speed, effects of alcohol and drugs, and use of unsafe vehicles are some of the reasons. [2] Based on Census and Statistics report, 2019, RTAs are becoming one of the leading causes of death in Sri Lanka and RTA deaths reached 3,590 or 2.82% of total annual deaths. [3] Among them the majority of the RTA fatalities occur following motorbike and three-wheeler accidents.

Sri Lankan police traffic statistics reveal in the year 2020, from the 3,097 fatal accidents, 365 or 11% involved with three-wheelers. [4] This transport source has been popular among the locals as well as foreigners who are visiting Sri Lanka due to its high availability, convenience, low cost, speed in traffic jams, and easy maintenance. They are widely used in urban, suburban as well as very remote rural areas of the country. Hiring three-wheelers for transporting good and people provide thousands of job opportunities for the low socio-economical class. But the recent statistics show that the road traffic accidents involved with three-wheelers are becoming increasing day by day despite its benefits. With the introduction of the open economic policy to in Sri Lanka in 1977, a large number of three-wheelers and motorcycles were imported and they were recognized as the most susceptible vehicle types of for roadside collisions.[5]

The statistics of the ministry of transport and civil aviation 2018 revealed, that there were 7.7 million total vehicles in Sri Lanka, and among them, 1.1 million were three-wheelers. Annually about 20,000 new three-wheelers had been registered up to the year 2019. [6,7] The relatively unsafe manufacture of the triangular base, lightweight, compact passenger compartment, (add and) fragile and relatively open structure of this vehicle has led to its instability over four-wheel vehicles. [8,9] This unsafe vehicle with a highly unpredictable pattern of injuries does not do well in collisions due to the absence of safety measures like headrests, seat belts, airbags, and a proper braking system.[10,11] Therefore a significant number of patients are admitted to casualty wards daily, and it is a considerable burden over the health care system, as well as to the family members.

Three-wheeler accidents and their severity could depend on several factors related to occupants, characteristics of the vehicle, state of roads, weather, and many more. Injuries can be varying from minor to fatal injuries. Most of the accidents are in the predictable and preventable category and taking the necessary precautions can minimize the number of incidents and their severity. Despite its popularity and the wide range of usage, three-wheeler collisions have received relatively lower attention from the research community and the available literature sources regarding three-wheeler accidents in Sri Lanka are limited. According to the latest literature review, several types of research have been done on the characteristics of three-wheel accidents, including factors related to occupants and the vehicle. Despite its popularity, more detailed studies on crash characteristics including the post-crash events and different safety measures are less in the literature. The findings of this study will contribute the continuous injury surveillance to identify the latest changes in patterns of injury concerning the different contributory factors and inform the relevant authorities to get timely decisions to minimize the preventable incidences.

The main objectives of this study were to describe the characteristics of the three-wheeler (hyphen) crash including the injury patterns, mechanisms of the incident, post-crash events, contributory factors, and the importance of the safety accessories that need to prevent three-wheeler accidents and reduce their outcomes.

Methodology

This cross-sectional descriptive type analytical study was conducted at the Teaching Hospital Karapitiya, Galle which is one of the major hospitals in Sri Lanka. The information was gathered using the injured three-wheeler occupants who received medical and surgical treatments from ETU (Emergency Treatment Unit) and surgical wards from 2019 to 2021.

Data on socio-demographic profile, the relative position of the occupant, type, and mechanism of causation of the injuries, affected anatomical region of the body, severity of the injuries, and contributory factors for the collision were obtained from detailed history taking and clinical forensic examination. In addition to that, some of the information was gathered using the Medico-Legal Examination Forms (MLEF). Patients who did not give consent, children less than three years, and unconscious patients were excluded. Data were analyzed using the SPSS IBM Version 22 analytical package. Ethical approval for the research study was obtained from the Ethical Review Committee of the Faculty

of Medicine, University of Ruhuna, Karapitiya, Galle.

Results

A. Analysis of socio-demographic Profile

A total number of 390 inward patients who were three-wheeler occupants (TWO) were considered in the study. The total number of TWO were in 286 three-wheeled vehicles. The majority of the patients (61%, n=238) were males. Out of the total 36% (n=139) were three-wheeler drivers.

Table 01. Gender distribution among the Three-wheel occupants.

Gender	Drivers N = 139 n (%)	Rear Passengers N = 251 n (%)	Total N = 390 n (%)
Male	132 (94)	106 (42)	238 (61)
Female	07 (06)	145 (57)	152 (39)

Considering the age distribution of the of total number of victims (n=390), the majority (24.1%, n=94) were between 21 – 30 years of age. The majority (33%, 45/139)) of the three-wheeler drivers were between the age ranges of 31 – 40 years. Victims of less than 10 years (5%, n=19) and more than 70 years (4%, n=15) were the least injured patients.

Table 02. The age distribution of the occupants of three-wheelers

Age	Drivers N = 139 n (%)	Rear Passengers N = 251 n (%)	Total N = 390 n (%)
<10	00 (00)	19 (07)	19 (05)
11 – 20	06 (04)	29 (12)	35 (09)
21 – 30	35 (26)	59 (23)	94 (24)
31 – 40	45 (33)	37 (15)	82 (21)
41 – 50	23 (16)	55 (22)	78 (20)
51 – 60	19 (12)	23 (09)	42 (11)
61 – 70	09 (06)	16 (06)	26 (06)
>70	02 (01)	13 (05)	15 (04)

B. Analysis of the Incidents

Out of the total number of Three Wheelers (TW) (N=286) involved in traffic accidents, in most of the TW (36%, n=102) there were 2 occupants and in 3% (n=9) of the TW there were five or more passengers.

Table 03. The number of occupants inside the vehicle at the time of the incident.

Number of occupants inside a vehicle	N=286 n (%)
01	83 (29)
02	102 (36)
03	46 (16)
04	34 (12)
05	12 (04)
>05	09 (03)

The majority of the Three-wheeler accidents (37%, 108/286) had taken place from 4 pm – 8 pm followed by (31%, n=88) during 8 am – 12 pm.

Table 04. The distribution of the time of the incident

Time	N = 286 n (%)
12 AM - 04 AM	11 (04)
04 AM - 08 AM	28 (10)
08 AM - 12 PM	88 (31)
12 PM - 04 PM	34 (12)
04 PM - 08 PM	108 (37)
08 PM - 12 PM	17 (06)

There was no significant difference observed in the number of accidents (Total = 286) reported during the different days of the week.

Table No 05. The distribution of accidents in different days of the week.

Days of the week	N =286 n (%)
Monday	52 (18)
Tuesday	22 (08)
Wednesday	37 (13)
Thursday	25 (09)
Friday	61 (21)
Saturday	39 (14)
Sunday	50 (17)

C. Analysis of the crash characteristics

Out of the total number of three-wheeler accidents (n= 286) majority (41%, n=118) were due to the impact with a moving vehicle.

Table 06. The distribution of the type of impact.

Type of the impact	N = 286 n (%)
Impact with a moving vehicle	118 (41)
Impact with a pedestrian or an animal	65 (23)
Impact with a stationary object	72 (25)
Other Impacts	31 (11)

Among those impacts due to moving vehicles, 48% (n=27) were due to impact with four-wheeled vehicles.

Table 07. The analysis of tri-wheeler accidents with moving vehicles.

Type of the moving vehicle	N=118 n (%)
Three-wheel + Pedal cycle	09 (07)
Three-wheel + Motor bike	34 (29)
Three-wheel + Three-wheel	41 (35)
Three-wheel + Other four-wheel vehicles (Car, Van)	27 (23)
Three-wheel + Heavy vehicles (Lorry, Bus, Trucks)	07 (06)

The Impact from the side of the vehicle was the commonest type of collision followed by head-on collisions (33%, n=93).

Table 08. The analysis of the side of the collision

Type of collision	N=286 n (%)
Head on Collision	93 (33)
Side Impact	128 (45)
Rear Collision	45 (16)
Other	18 (06)

Considering the various patterns of injuries on the victims (48%, n=187) were following an impact on an object inside the vehicle mostly internal modification objects. Thrown away from the vehicle (35%, n=136) was the second commonest cause of injuries and was commonly observed on rear passengers (44%, n=112).

Table 09. The analysis of different impact objects causing injuries

Impacted object	Drivers N=139 n (%)	Rear Passengers N=251 n (%)	Total N=390 n (%)
Impact with an object inside the vehicle	100 (72)	87 (35)	187 (48)
Thrown Away from the vehicle	24 (17)	112 (44)	136 (35)
Toppled and fallen under the vehicle	11 (08)	39 (15)	50 (13)
Crushed inside the vehicle	04 (03)	13 (05)	17 (04)

D. Analysis of the injuries

Different types of injuries were observed on TWOs. Abrasions were the commonest injury seen in 69% (n=269) of the victims followed by contusions in 52% (n=202). Fracture of a bone was seen in 24% (n=93) of the victims.

Table 10. The distribution of different types of injuries observed on TWOs.

Type of injury	Drivers N=139 n (%)	Rear seat Passengers N=251 n (%)	Total N=390 n (%)
Abrasions	95 (68)	160 (64)	269 (69)
Contusions	58 (42)	128 (51)	202 (52)
Lacerations	40 (29)	50 (20)	148 (38)
Fractures	43 (31)	60 (24)	93 (24)
Cuts	28 (20)	07 (03)	35 (09)
Burn	02 (01)	05(02)	07 (02)

Abrasions were seen almost equally among the two groups of victims while contusions were seen more commonly among rear seat passengers. However, the lacerations and fractures were more commonly seen in drivers than rear passengers. The majority (20%, n=28) of the cut injuries were significantly seen in drivers. Burn injuries were the least common injury type and only 2% (n=07) of the victims. There was no significant difference of the type of injury between the drivers and rear passengers. ($p>0.05$), ($X2 = 21.74$, $df = 14$, p value = 0.0841)

Analysis of the region/ regions of the body injured following collisions revealed most of the patients had multiple impacts. The commonest region affected was the upper limbs 51% (n=198) followed by lower limbs 44% (n=171).

Table 11. The distribution of the injuries on TWOs on different anatomical areas of the body.

Anatomical area	Drivers N=139 n (%)	Rear Passengers N=251 n (%)	Total N=390 n (%)
Head	60 (43)	67 (27)	128 (33)
Face	74 (53)	39 (16)	113 (29)
Neck	33 (23)	29 (12)	62 (16)
Chest	24 (17)	57 (23)	81 (21)
Abdomen	39 (28)	54 (21)	93 (24)
Back	28(20)	50 (20)	78 (20)
Upper Limbs	48 (34)	150 (59)	198 (51)
Lower Limbs	52 (37)	119 (47)	171 (44)
Perineum	05 (03)	06 (02)	11 (03)

Drivers sustained head, facial and cervical injuries more than rear passengers. Injuries to the chest, abdomen, and upper and lower limbs were seen more commonly in rear passengers than in drivers. However, there was no significant difference in the region of the body injured between the two groups. ($p>0.05$), ($X2 = 28.41$, $df = 20$, p value = 0.112)

Considering all the injuries categorization of hurt was done according to the Penal Code of Sri Lanka. Among the total number of 390 victims, 58% (n=226) had non-grievous injuries and 24% (n=97) had grievous injuries. Thirteen percent (n=50) of the three-wheeler occupants had grievous injuries which endanger the life. Only 4% (n=17) of the patients had injuries that were fatal in the ordinary course of nature.

Table 12. The category of the hurt

Anatomical area	Drivers N=139 n (%)	Rear Passengers N=251 n (%)	Total N=390 n (%)
Head	60 (43)	67 (27)	128 (33)
Face	74 (53)	39 (16)	113 (29)
Neck	33 (23)	29 (12)	62 (16)
Chest	24 (17)	57 (23)	81 (21)
Abdomen	39 (28)	54 (21)	93 (24)
Back	28(20)	50 (20)	78 (20)
Upper Limbs	48 (34)	150 (59)	198 (51)
Lower Limbs	52 (37)	119 (47)	171 (44)
Perineum	05 (03)	06 (02)	11 (03)

E. Analysis of the Contributory Factors for three-wheeler collisions

The majority (42%, n=120) of three-wheeler accidents had occurred mainly on tar roads followed by carpeted roads 29% (n=83). The highest number of cases were reported under precise weather conditions like sunny 52% (n=148). Driving the vehicle in bad weather conditions like rain and mist also contributed to some of the three-wheeler collisions.

Table 13. The analysis of different contributory factors for three-wheeler collisions

Contributory factors		N=286 n (%)
Road Condition	Carpeted	83 (29)
	Tarred	120 (42)
	Concrete	37 (13)
	Gravel	46 (16)
Weather Condition	Sunny	148 (52)
	Rainy	89 (31)
	Misty	49 (17)

Out of the total number (N=139) of drivers, 24% (n=33) have consumed alcohol before the time of the collision and 11% (n=16) were without a valid driving licence.

Table 14. The contribution of alcohol and possession of a driving license among TW drivers.

Alcohol and driving license	Yes/No	N=139 n (%)
Alcohol Usage	Yes	33 (24)
	No	106 (76)
Driving License	Yes	123 (89)
	No	16 (11)

Discussion

Providing efficient, cost-effective, and environmentally friendly transport services is one of the challenges in every country. The rising urbanization, population, and industrial development have significantly augmented the demand for easy, readily available, and cost-effective urban transport services like three-wheelers over public transport such as buses and trains.[11] Three-wheeler is a popular and essential public and goods transporting method in many Asian countries such as Sri Lanka.

Three-wheeler is a light weighted motorized vehicle with three wheels that have two compartments; the driver's and the passengers' which are separated by metal bars. The sides of the vehicle are relatively open and some three-wheelers have a half door on one side of the passenger compartment. The structure of the vehicle is made out of metal bars covered by a canvass sheet making it more crashworthiness. The recommended maximum transporting capacity is three passengers at the rear compartment with the driver. The maximum recommended speed limit for the three-wheelers is 60 km/hr. [12]

There was a male predominance in both groups of three-wheelers occupants, but injured female proportion 57% is significantly higher among rear passengers compared to the drivers 6%. Several studies done in several districts in Sri Lanka show the same vulnerability of males, as well as among occupants of other types of vehicle accidents.[13,14,15] In our study, the majority of the victims were in the 21 – 30 years age group which was the most vulnerable for injuries which are compatible with the previous studies conducted in the central province, Sri Lanka.[8,12,13,15,16] and also in India and New Zealand .[16,23] There were few young 4% and older drivers 1% in this study but overall 57% of three-wheeler drivers were in between 21 – 40 years of age which is in keeping with a recent study.[18]

There was no significant difference in the number of causalities admitted to the hospital comparing the days of the week and also weekdays to the weekends. A bi-fold pattern of frequency was found when analyzing the time of the accidents during 24 hours of the day. The total incidents reported during 4 pm - 8 pm were 37% and during 8 am – 12 pm were 31% representing the morning and afternoon traffic peaks of average daily traffic. The analysis of the time of the accidents in this study is compatible with some of the recent research papers.[18,19]

Analysis of the total incidents revealed, most of the incidents involved at least two passengers inside the vehicle 36%, and in 3% incidents five or more passengers were inside the vehicle. In some areas, three-wheelers are used to transport workers and school children as an alternative method for public

transport. Accidents involving them lead to multiple causalities.

The commonest type of incident was the impact with another moving vehicle 41% and it is compatible with a study done in the western province.[18] Impact with four-wheeled vehicles like cars or vans 48% were observed commonly which is also compatible with the results of a study done in Panadura urban council.[20] Three-wheeler impact with another three-wheeler was noted in 30% of the total vehicular collisions. Among the types of incidents impact from the side of the vehicle 45% were the commonest type of collision followed by head-on collisions 33%.

The toppling of the vehicle is common in places where drivers tend to turn the three-wheeler abruptly for quick changing of the path of motion. According to the latest study done in the central province toppling the commonest type of incident.[21] The interference with the handle lock which has provided for over steering control is a major cause for toppling.[10] By breaking this safety lock drivers are used to increase the turning cycle of the three-wheeler for quick turning which leads toppling.

The majority (52%) of the three-wheeler accidents had occurred under clear weather conditions compared to the bad weather conditions like cloudy, rain, and fog/mist. These results are in keeping with the previous studies. A majority of crashes had occurred in daylight conditions. One possible reason for this could be that more three-wheelers are on the road during the daytime and breaching of the road rules during peak hours. According to the study, crashes were more common in tarred roads which could be due to the recent development of road infrastructure.

According to the current practice of the three-wheeler, owners modify the vehicle by fixing additional items, metal bars, and light and sound systems to make it more attractive. But those items usually aggravate the impact injuries causing bizarre injury patterns. Injuries to the head, face, and neck were common in drivers, and limb injuries were common in rear passengers. The impacts on the handlebar, windscreen and other modifications introduced to the vehicle causes the different injuries sustained by the driver. Rear passengers usually get impact on the front metal bar which was not padded and goods inside the vehicle and internal modifications cause atypical injuries.

Ejection or throwing away from the vehicle (44%) was the other common mechanism of injury. The study revealed rear passengers were more commonly thrown away from the vehicle than the drivers which are compatible with the study conducted in (add the) Central province. [21] Relatively open structure of the vehicle without side doors, (add the) absence of seat belts are some of the reasons for being thrown away.

80% of the total injuries seen in the three-wheeler occupants were soft tissue injuries like abrasions, contusions, and lacerations. Cut injuries (9%) following shattered windscreens were less commonly seen in this study compared to the other vehicular accidents. Most of the injuries were confined to the upper and lower limbs of the victims which is are in keeping with a recent study in the central province.[21] But this contrasts with the findings of Vadysinghe et al where the most commonly affected region of the body was the head.[12]

Categorization of the injuries according to the Penal Code of Sri Lanka revealed most of the injuries were non-grievous (58%) in nature which is compatible with the findings of a recent study.[21,24]

In our study, 24% of the injured three-wheeler drivers had consumed alcohol beverages at the time of the accident. In fact, consumption of alcohol by the drivers of this study has been diagnosed by the given history and clinical examination findings, which are nonspecific and vague at times. The real number of drivers who had consumed alcohol could have been higher than 24%. Though it is possible to determine the accurate alcohol level with invasive investigations like Blood Alcohol Concentration (BAC), it was not applied in this study due to the practical and technical issues. The estimation of alcohol levels with noninvasive modern electronic devices is now being introduced to the medico legal units in Sri Lanka and it will be an advantage for the future studies.

The terms traffic and tricycles are defined in the Section 240 of the motor traffic act of Sri Lanka. Further the mandatory use of seat belts in a vehicle is described in recent amendments of the road traffic act on 2009, under the section 157 (1).[25] Hence the three-wheeler is included in that legal definitions as a motor vehicle, any law relating to the motor vehicles in Sri Lanka also relates to the three wheelers.

Conclusions

According to the study males between 21–30 years of age were the most vulnerable group for three-wheeler accidents. Drivers were at risk of sustaining

more serious injuries than rear-seat passengers. High vehicular instability, Lack of safety measures, reckless driving such as high-speed driving exceeding the recommended speed limits, improper overtaking of the vehicles, overtaking multiple vehicles at a time, overtaking by the wrong side of the vehicle, improper turning, making quick U-turns without putting signal lights, unnecessary modifications to the vehicle lead to an increase in the number of three-wheeler accidents. The severity of the injuries depends on several factors including the force and speed of the vehicle at the time of impact, the direction of impact, intrusion of the external objects, post-crash effects of the vehicle. The absence of seat belts and airbags significantly aggravates the injury severity compared to other four-wheel vehicles. Lack of force absorbing protective structures like bonnets and bumpers increases the vulnerability for injuries.

Limitations

According to the motor traffic act of Sri Lanka, all road traffic accidents should be reported to the nearest police station. But a significant number of accidents are not reported to any institute due to minor impacts, personal issues like alcohol consumption at the time of the incident, not having a valid driving license or registration, and the involved parties come to a settlement not to report to the police or not to get treatments from the government hospitals. Information from these incidents was not included in this study.

Recommendations

This study ensures that:

1. The three-wheel drivers and the general public who use it as a mode of transport should be educated regarding the maximum goods and passenger capacity and the adverse effects of overcrowding.
2. Introducing seat belts for both the driver and the passenger compartments.
3. Banning the unnecessary external and internal modifications, decorating the vehicle with fancy items, using unnecessary lighting, sound systems, and horns.
4. Introducing protective doors with a locking system to avoid passengers being thrown away from the vehicle.
5. The road traffic rules should be abided and strict punishments for violation of them should be implemented.
6. The necessity of introducing more collision stable four-wheel light vehicles replacing the three-wheelers to reduce the incidence of road traffic fatalities.

Disclosure statement

Conflicts of Interest: The authors declare that they have no conflicts of interest.

Funding: None

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