Epidemiological and Clinical Profile of Fatality in Vulnerable Road Users at a High Volume Trauma Center

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**Abstract**

**Background:** Motorized two-wheelers, pedestrians, and cyclists are termed vulnerable road users (VRUs). Globally up to 50% of road deaths involve VRU and up to 80% in developing and rapidly motorizing economies. **Objective:** The objective of this study is to study the prehospital and clinical profile of fatally injured VRU. This would help in informed decision-making regarding prevention and trauma care infrastructure. **Materials and Methods:** A hospital-based study was performed at a Trauma Centre in Puducherry from January 2013 to June 2014 (18 months). Puducherry is a union territory of India in the state of Tamil Nadu. A total of 193 deaths due to road traffic accident were included in this study. The demographics, prehospital findings, and the clinical progress of fatally injured VRU are described. **Results:** More than 80% of road traffic collision/crash deaths involved VRU of which the elderly comprised a significant proportion. Alcohol was a serious issue even in the elderly pedestrian. This study revealed specific injury patterns and severity. Head injury was the most common cause of death. Early deaths, that is within 24 h of injury was common at 50%. **Conclusion:** The majority of deaths were in the early phase of trauma hence mandating a strong call for prevention, along with strengthening of trauma care.

**Keywords:** Alcohol, early deaths, vulnerable road users

**Introduction**

Vulnerable road users (VRUs) are those having a small mass relative to other road users with little or no external protective devices that would absorb energy in a collision. They include pedestrians, cyclists, and motorized two-wheelers and contribute to 50% of fatalities (WHO 2009). Most changes in motor vehicle crash mortality associated with economic development were explained by changes in rates among VRU. Fatality in the VRU group varies dramatically across epidemiological WHO subregions at 55% to 80% in developing nations to 15% in the developed countries. In India, road traffic collision (RTC) is one of the leading causes of death and disability with 400,000 road crashes, 85,000 deaths, and 1.2 million seriously injured cases every year in India. The fatality rate is expected to escalate 5-fold by the year 2020 as projected by the WHO. Rapid motorization in India in the last few decades has resulted in motorized two-wheelers constituting up to 70% of road users. Mohan in a review of traffic injuries and fatalities in India emphasized that nearly 80% of those killed in Delhi and Mumbai, belong to the group of VRUs.

The most extensively evaluated effective interventions do not directly focus on efforts to protect VRUs, who bear the brunt of rapid motorization. According to the European Transport Safety Council, the death risk per 100 million person kilometers traveled is 13.8 for motorized two-wheelers, 6.4 for pedestrians, and 5.4 for bicyclists in Europe. This is to be compared with a death risk of 0.7 for car users and 0.07 for bus and coach passengers. The severity of VRU injuries is also higher than those of four-wheelers. An awareness of the challenge posed by VRU injuries is now highlighting the agenda of international aid organizations. A recent United Nations resolution encourages Member States to increase road safety efforts with special attention toward VRU.

Puducherry and the adjoining state of Tamil Nadu have the highest fatal collision rate of 881 per million populations

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against the national average of 30.5 according to the National Crime Record Bureau 2014. A previous study had shown a high incidence of VRU. Understanding of the epidemiology of fatality in VRUs is vital to integrate and maximize trauma services. The effective design, implementation, and management of facilities for VRUs need to be informed by good quality evidence, for example, data on the exposure of different road users and the circumstances surrounding injury. Given the expense involved in developing infrastructure solutions, it is essential that decisions are evidence informed. VRU has to be seen in the perspective of the larger scenario which also includes the four-wheelers and other larger vehicles. Clinical outcome of trauma patients is available only in 40% of cases. This severe paucity of information is the main stumbling block during planning of a policy on trauma care. Hence, this study investigated the injury pattern, mechanisms, severity, and mortality in VRU.

**Materials and Methods**

We used a cross-sectional, prospective, descriptive study to profile fatal trauma involving VRUs presenting to the trauma center at the Government General Hospital, Puducherry, from January 2013 to June 2014 (18 months). This government headquarters hospital at Puducherry is a tertiary trauma care center as per Recommendations for prehospital trauma care in India, catering to a large volume of trauma cases, with a drainage area radius of 200 km. Annually 1200 cases of moderate and severely injured are treated.

There has been a significant rise in the trauma caseload at this center over the past decade. Seriously injured patients (Injury Severity Score [ISS] >9) on reaching this facility are directly transported to the designated trauma room under the care of the General Surgery Department. Subsequent to initial resuscitation and evaluation, injury is prioritized and the relevant specialists are involved as and when needed. The standard of trauma care is uniform across all units. The ISSs was computed with clinical imaging, intraoperative, and postmortem findings and a final score determined. Seriously injured VRU who were alive at admission were included. Patients brought dead or for the purpose of postmortem were excluded. All patients who died in hospital had autopsy. The main data collection was undertaken by the principal investigator (AR) and was assisted by colleagues.

**Ethical considerations**

Study permission was granted by the Medical Superintendent of the Indira Gandhi Government General Hospital, Puducherry, and the Director of Medical Services, Government of Puducherry. We had adhered to ethical principles while gathering the information. Confidentiality of the subjects was maintained in the Department of General Surgery.

**Statistical methods**

No formal sample size was calculated. All fatally injured VRU were included. Data were analyzed using means, standard deviations, medians, interquartile ranges, and proportions.

**Results**

There were 193 deaths due to RTC during the study. VRUs comprised 155 (80%) [Table 1]. Two-wheelers and pedestrians had an equal share of 45.8% and 45%, respectively. Nine percent involved cyclists. The male-to-female ratio was 27:4. The median age of motorcycle riders was 32 years (interquartile range [IQR] 30–59.5) while that of pillion-riders, pedestrians, and cyclists was 45 years. Thirty-three percent of fatalities involved the elderly (>65yrs) with the majority being pedestrians followed by pillion-riders [Figure 1]. There was a steep rise in fatal collisions toward the end of the week as 71.7% of fatalities happened on weekends [Figure 2]. Most collisions occurred during the evenings and early part of the night 68/155 (43%) [Table 2]. Thirty-one (20.1%) were positive for alcohol on clinical and or biochemical testing. The largest group was pedestrians 8/22 (36.36%). Nine out of 40 (22%) elderly VRU were alcohol positive. The median ISS was 25 (IQR 18–30.5). In the elderly, it was 9 in pillion-riders and 34 in cyclists [Table 3]. The majority (62%) were referred from other facilities while 38% of cases reached our center directly from the scene of the injury. The median distance traveled from the site of injury was 45 km (range: 3 km to 360 km) The median prehospital time was 2 h 30 min (range: 30 min to 24 h). Half of the patients died within 24 h of the incident. There was a peak again after 48 h (25%) between 48 h to 1 week (10%) and late deaths (>1 week) was 15% [Figure 3]. The most common cause of death was isolated traumatic brain injury (up to 80%) irrespective of age and...
mechanism, followed by polytrauma. Elderly pillion-riders had a high risk for significant spinal injury.\footnote{Figure 4} Median life years lost was 22 years (IQR 12–38).

**Discussion**

There were 193 deaths due to RTA during the study where VRUs comprised 155 (80%). This is much higher than the reported 61.4% at Bengaluru and the 74.6 from Mumbai.\footnote{[11]} These are major metropolises, compared to our area, which is a town. This is also slightly higher than our own previous study from the same center 5 years ago.\footnote{[8]}

Two-wheelers and pedestrians had an equal share of 45.8\% and 45\%, respectively and 9\% involved cyclists which is still a major mode of travel in towns, rural areas, and even cities.\footnote{[3]} The majority were males (87\%) with median age of 32 (range: 19–54) similar to a study from Brazil.\footnote{[12]} Pillion-riders, pedestrians, and cyclists were older with a median age of 45 years (range: 10–90). One-third of fatalities involved the elderly (>65yrs) with the majority being pedestrians followed by pillion-riders. Life expectancy has increased from 63 to 67 years between the last two censuses in India.\footnote{[13]} The projected increase in the size of this aged population will surely lead to more elderly being fatally injured on our roads. There are many causes for the delays during the prehospital phase in an immature trauma system, including extensive documentation at each referral, nontherapeutic intervention for the seriously injured and a lack of predetermined systems in place for appropriate referral,\footnote{[8]} and it negatively impacts survival rates beyond doubt.\footnote{[11]}

There was a steep rise in fatal accidents toward the end of the week. This is expected as Puducherry is a popular tourist destination for all the southern states of India. Studies have reported that any critically-ill patients (not necessarily trauma) have poorer outcomes when admitted on weekends.\footnote{[14]}

| VRU | 0-4 h | 4-8 h | 8-12 h | 12-16 h | 16-20 h | 20-24 h |
|-----|-------|-------|--------|---------|---------|---------|
| Two wheeler (n) | 5 | 7 | 8 | 18 | 23 | 10 |
| Pedestrians (n) | 1 | 9 | 14 | 17 | 22 | 7 |
| Cyclists (n) | 1 | 1 | 2 | 4 | 3 | 3 |

VRU: Vulnerable road users

| Mechanism | Age (years) | ISS (median) |
|-----------|-------------|--------------|
| Rider     | 32 (median) | 25           |
| Pillion   | 45 (median) | 25           |
| Pedestrian| 45 (median) | 25           |
| Cyclist   | 45 (median) | 25           |
| Rider (n) | >60 year (6)| 25           |
| Pillion (n)| >60 year (8)| 9            |
| Pedestrian (n) | >60 year (29) | 25 |
| Cyclist (n) | >60 year (2) | 34 |

ISS: Injury severity scoring

**Table 2: Timing of fatal accidents**

**Table 3: Mechanism, age, and injury severity scoring**

**Figure 2: Occurrence of fatal accidents by day of the week**

**Figure 3: Survival time**

**Figure 4: Cause of death**

However, we did not find any such correlation in seriously injured patients, similar to a study by Laupland et al.\footnote{[15]}

Most collisions occurred during evenings and early nights, and this is expected since illumination levels are independent risk factors for RTC with the maximum impact on the VRU group.\footnote{[16]} Developing countries invariably have poor street lighting and conspicuity aids are of particular interest where cyclists and pedestrians are often not properly visible.\footnote{[1]}

However, Harnam Singh reported significant fatal crashes during daytime.\footnote{[17]} This may be explained by the fact that different road users would be competing for the same limited space during peak traffic hours.

Twenty percent were positive for alcohol and 9 out of 40 (22\%) elderly were alcohol positive. The largest group was pedestrians similar to other reports from India.\footnote{[18]} The alcohol positive rates may be as high as 42% in Brazil.\footnote{[12]} The incidence was highest in the pedestrian group 8/22 (36.36\%). Overall, alcohol incidence was ten times higher than the...
The public must be made aware that alcohol is an independent risk for mortality. The public must be made aware that alcohol is a risk to all types of VRU. Enforcement of laws against driving under the influence of alcohol have been shown to also reduce the incidence of RTC.

The median ISS was 25 (range: 9–49), lower than the 38.5 reported by Carrasco. Median ISS was far lower at 9 in the elderly pillion-riders. It is a well-known fact that advanced age is a poor prognostic factor in trauma outcome. Cyclists were more seriously injured at ISS of 34. We are not able to explain why the cyclist group were more seriously injured [Image 1]. The quantum of injury per se does not predict bad outcome as quality of care matters too.

The most common cause of death was isolated head injury (up to 80%) irrespective of age and mechanism. Head injury varies from 56.6% to 67%. Serious injury to the torso being direct cause of death was found only in 8%. The VRUs do not have significant torso injuries as compared to motor vehicle occupants. Serious injury to torso for example rupture of lung and liver is likely to lead to immediate death, as reported in a postmortem study.

Elderly pillion-riders had a high risk for significant spinal injury. Pillions are likely to be injured more as they are less protected and protective reflexes will be obviously delayed in them.

Of the mortalities, 50% died within 24 h of the collision. There was second peak after 48 h (25%). Ten percent deaths occurred between 48 h to 1 week. Late deaths (>1 week) was 15% [Figure 3]. The majority of deaths are early (<24 h) in multiple reports from developing countries. Early deaths can be best tackled by prevention, hence, strengthening the call for preventive interventions in VRU fatality. Median active life years lost was 22 (range: 57–0) as life expectancy is 67.3 and 69.3 for male and female, respectively. The cost of a fatality is estimated to be rupees 1.3 million. Hence, an isolated medical approach is insufficient to tackle this scourge. We as trauma surgeons do need to develop and strive for more robust prevention policies.

Engineering, education, and enforcement are the three pillars of prevention and will be discussed in light of the VRU. Given the expense involved in developing infrastructure solutions, it is essential that decisions are evidence informed. Studies done decades apart in Puducherry revealed that helmet use was nil in riders or pillions. This is also found in other parts of India, Southeast Asia, and Africa despite systematic reviews that have proved helmets do reduce fatality rates by 42%. Lack of separate sidewalks remains a common situation in developing countries and doubles the risk of pedestrian crashes.

However, China has shown a 35% reduction in crashes due to separate bicycle tracks. V-alert, smartphone-linked concept warns vehicles of pedestrian movement. Cell phone penetration in India is rapid, and this is quite a practical issue to take forward by stakeholders. Motor vehicles with safer car fronts and onboard sensing may not be cost-effective in developing countries.

Multiple reviews have not shown much benefit from awareness training programs, but still widely advocated and thus blind faith in the education and training of road users continues in many developing countries. However, awareness needs to be targeted at the attitude of pedestrians who believe that crash avoidance is up to motorists. Apart from the inevitable economic growth and motorization of fast-expanding economies, cross-cultural differences in attitudes toward road safety, vary widely.

Lowering the speed limit in population-dense areas is probably the most effective and affordable intervention to stem traffic crashes in both high- and low-income countries. However, traffic infractions are quite common (26%–50%) among VRU as reported by observational studies from India and Colombia and motorists in India are only too aware of the lax enforcement of penalties for traffic infractions. Significant improvement in road user behavior has been only brought about by the strict enforcement of laws and since developing countries continue to be rapidly motorized, enforcement will become more important. However, law enforcement is costly and subject to corruption, a phenomenon not only observed in developing countries. Systematic review showed that traffic-calming engineering does work as reported in a study from South Africa. The traffic calming humps improved safety in two areas in South Africa with respect to the severity of collisions. Serious pedestrian-vehicle collisions (PVCs) dropped by 23% and 22% while fatal collisions decreased by 68% and 50% in Chatsworth and Kwa Mashu, respectively, and a significant drop in the overall rate of Pedestrian Vehicle

[Image 1: Cyclist run over by bus (with permission from patient)]
Collision, but their effects in developing countries needs to be assessed further. Ultimately, RTCs can only be reduced when individual maturity regarding road-safety practices is attained.

**CONCLUSION**

RTCs, specifically the fatalities in VRU, are the flip-side of our transportation growth. This study has sought to estimate the current burden of injury arising from collisions involving “vulnerable road users”, in an attempt to provide knowledge to inform the decision-making around safety of VRU. They consume the least amount of fuel energy but are at the receiving end of this scourge. As is often the case in road safety, only a multipronged approach will be successful, combining passive and active devices with regulations, enforcement, and awareness campaigns from all the stakeholders. When traffic separation is not possible, other users need to learn how to safely share their road space with more vulnerable users with different behaviors, speed, situational awareness, and conspicuity. The health sector armed with evidence should also give impetus to prevention efforts in addition to strengthening postcrash trauma care.

**Strengths**

This is a prospective study in the area with the highest trauma fatality rate in India. All cases had autopsy hence the description/quantum of injuries was accurate, even in cases of polytrauma the immediate and direct cause of death was ascertainable.

**Limitations**

It is a single-center study. Details about the exact mechanism, for example, whether acceleration/declaration/crush injury was not available. Information whether VRU had infracted traffic rules was not available.

**Future directions**

A multicenter study comparing the outcomes in seriously injured VRU may help elucidate the impact of quality of postcrash care in mitigating the fatality in this hapless group of road users. In fact, we have initiated a proposal toward this aspect.

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Nil.

**Conflicts of interest**

There are no conflicts of interest.

**References**

1. WHO/OMS. Global Status Report on Road Safety: Time for Action. Geneva: World Health Organisation; 2009. Available from: http://www.whoqlbdcw.who.int/publications/2009/9789241563840_eng.pdf. [Last accessed on 2017 May 20].
2. Naci H, Chisholm D, Baker TD. Distribution of road traffic deaths by road user group: A global comparison. Inj Prev 2009;15:55-9.
3. Mohan D. Road safety in less-motorized environments: Future concerns. Int J Epidemiol 2002;31:527-32.
4. Ameratunga S, Hijar M, Norton R. Road-traffic injuries: Confronting disparities to address a global-health problem. Lancet 2006;367:1533-40.
5. ETSC. Transport Safety Performance in the EU. A Statistical Overview. Brussels: European Traffic Safety Council; 2003. Available from: http://www.etsc.eurosite.statoverv.pdf. [Last accessed on 2017 May 20].
6. Constant A, Lagarde E. Protecting vulnerable road users from injury. PLoS Med 2010;7:e1000228.
7. National Crime Record Bureau; 2014. Available from: http://www.ncrb.nic.in/StatPublications/ADSI/ADSI2014/chapter-1A%20traffic%20accidents.pdf. [Last accessed on 2017 May 20].
8. Radjou AN, Mahajan P, Baliga DK. Where do I go? A trauma victim’s plea in an informal trauma system. J Emerg Trauma Shock 2013;6:164-70.
9. Mock C, Joshupura M, Goosen J. Global strengthening of care for the injured. Bull World Health Organ 2004;82:241.
10. Recommendations for Pre-Hospital Trauma Care in India. Report of a 2 day National Consultation on Pre Hospital Trauma Care in India on 26th and 27th October, 2006 at NIHFW, Munirka, New Delhi, India. Available from: http://www.whoindia.org/LinkFiles/Injury_Prevention_and_Rehabilitation_Pre_hospital_trauma_care.pdf. [Last accessed on 2017 May 20].
11. Gururaj G. Road traffic deaths, injuries and disabilities in India: Current scenario. Natl Med J India 2008;21:14-20.
12. Carrasco CE, Godinho M, Berti de Azevedo Barros M, Rizoli S, Fraga GP. Fatal motorcycle crashes: A serious public health problem in Brazil. J World J Emerg Surg 2012;7 Suppl 1:S5.
13. Census of India 2011. Population Composition. Available from: http://www.censusindia.gov.in/vital_statistics/srs_report/9chap%20-%202011.pdf. [Last accessed on 2017 May 20].
14. Bell CM, Redelmeier DA. Mortality among patients admitted to hospitals on weekends as compared with weekdays. N Engl J Med 2001;345:663-8.
15. Laupland KB, Ball CG, Kirkpatrick AW. Hospital mortality among major trauma victims admitted on weekends and evenings: A cohort study. J Trauma Manag Outcomes 2009;3:8.
16. Beyer FR, Ker K. Street lighting for preventing road traffic injuries. Cochrane Database Syst Rev 2009;21:CD004728.
17. Singh H, Dattarwal HK, Shilek M, Aggarwal A, Sharma G, Chawala R. Review of pedestrian traffic fatalities. J Indian Acad Forensic Med 2007;29:55-8.
18. Das A, Gjerde H, Gopalan SS, Normann PT. Alcohol, drugs, and road traffic crashes in India: A systematic review. Traffic Inj Prev 2012;13:544-53.
19. Harwood FM, Hauer CE, Hughes WE, Vogt A. Prediction of the Expected Safety Performance of Rural Two-Lane. Publication no. FHWA-RD-99-207; December, 2000. Available from: http://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf. [Last accessed on 2017 May 20].
20. Prijon T, Ermene B. Influence of alcohol intoxication of pedestrians on injuries in fatal road accidents. Forensic Sci Int Suppl 2009;1:3-4.
21. Jacobs DG, Plaisier BR, Barie PS, Hamilton J, Hovel MR, Sinclair KE, et al. Practice management guidelines for geriatric trauma: The EAST practice management guidelines work group. J Trauma 2003;54:391-416.
22. Schluter PJ. The trauma and injury severity score (TRISS) revised. Injury 2011;42:90-6.
23. Töörö K, Hubay M, Sötony P, Keller E. Fatal traffic injuries among pedestrians, bicyclists and motor vehicle occupants. Forensic Sci Int 2005;151:151-6.
24. Bhattacharya S, Alberini A, Czopner ML. The value of mortality risk reductions in Delhi, India. J Risk Uncertain 2007;24:21-47.
25. Fitzharris M, Dandona R, Kumar GA, Dandona L. Crash characteristics and patterns of injury among hospitalized motorised two-wheeled vehicle users in urban India. BMC Public Health 2009;9:11.
26. Liu BC, Ivers R, Norton R, Bousfous S, Blows S, Lo SK, et al. Helmets for preventing injury in motorcycle riders. Cochrane Database Syst Rev 2008;23:CD004333.
27. Ossenbruggen PJ, Pendharkar J, Ivan J. Roadway safety in rural and small urbanized areas. Accid Anal Prev 2001;33:485-98.
28. O’Neill B, Mohan D. Reducing motor vehicle crash deaths and injuries in newly motorising countries. BMJ 2002;324:1142-5.
29. Ryb GE, Dirschinger PC, Kufera JA, Soderstrom CA. Social,
behavioral and driving characteristics of injured pedestrians: A comparison with other unintentional trauma patients. Accid Anal Prev 2007;39:313-8.
30. Wallén Warner H, Ozkan T, Lajunen T. Cross-cultural differences in drivers’ speed choice. Accid Anal Prev 2009;41:816-9.
31. Afukaar FK. Speed control in developing countries: Issues, challenges and opportunities in reducing road traffic injuries. Inj Control Saf Promot 2003;10:77-81.
32. Morales-Quintero FJ, Gómez-Salazar GS, Bonilla-Escobar FJ, Fandiño-Lozada A, Santaella J, Gutierrez-Martinez MI. Assumed risk by vulnerable roadway users; traffic rules transgressions in a capital of South Western Colombia, 2009. Inj Prev 2012;18:A1-246. Available from: http://www.injuryprevention.bmj.com/content/18/Suppl_1/A201.3. [Last accessed on 2017 May 20].
33. Nadesan-Reddy N, Knight S. The effect of traffic calming on pedestrian injuries and motor vehicle collisions in two areas of the eThekwini municipality: A before-and-after study. S Afr Med J 2013;103:621-5.
34. Bunn F, Collier T, Frost C, Ker K, Roberts I, Wentz R, et al. Area-wide traffic calming for preventing traffic related injuries. Cochrane Database Syst Rev 2003;1:CD003110.
35. Amador L, Willis CJ. Demonstrating a correlation between the maturity of road safety practices and road safety incidents. Traffic Inj Prev 2014;15:591-7.