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Case Series

Haddon's matrix for spectrum of road-related major injuries in rural adolescents: a case series analysis

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ABSTRACT

Unintentional injuries in children pose public health threat that often leads to serious consequences in the child and the family, especially in case of major injuries. Prevention strategies need to be worked out for all injuries, particularly for major injuries which cause considerable disability and mortality. We present three road-related major injury events which had occurred during the entire period of a larger study, which have been analyzed using the Haddon's matrix through an epidemiological tetrad model involving host, vector, physical environment and socio-economic environment. Intervention strategies for prevention of similar injuries in future have been outlined at various time points for each case, as well as general measures, in various levels of care. Of the three major road-related injury cases (12 years, female; 17 years, female; and 17 years, male), two were automobile accidents in 17 years old adolescents and one was a case of injury of a 12-year-old girl due to fall on road. Risk factors were present in all three cases related to host, vector, physical environment and socio-economic environment. Strategies for prevention have been outlined at various time points i.e. pre-event, event, post-event at various levels for each case, as well as intervention strategies that can be implemented in general by the individual, family, community including panchayat, and both State and National governments. All major road-related injuries and their complications that occurred in subjects of the present study could have been prevented by taking responsibility at various levels.

Keywords: Haddon's matrix, Road-related injuries, Injury prevention, Traffic injury

INTRODUCTION

Unintentional injuries continue to be a major global health problem. Worldwide 19% of the unintentional injury burden is among children and adolescents, with road traffic, drowning, burns, falls, and poisoning as leading causes.[1] Road traffic injuries alone constitute the leading cause of death in the age group of 15-19 years and the second leading cause of death in the age group of 5-14 years.[2] Unintentional injuries in children pose public health threat, especially in case of major injuries. Prevention strategies need to be worked out for all injuries, particularly for major injuries which cause considerable disability and mortality that often lead to serious consequences in the child and the family.

Injuries occur as a result of a complex array of several factors that can be described through an epidemiological tetrad model involving host, vector, physical environment and socio-economic environment. This conceptual model, named the Haddon matrix, was developed by William Haddon Jr. more than two decades ago to understand the realm of traffic safety by applying basic principles of public health.[3] Since then, the matrix has been used as a tool for developing implementation strategies in prevention at various points in the sequence of the injury

event. Present study aims to explore these factors as well as design prevention strategies at various time points i.e. pre-event, event and post-event at various levels of care.

We present three cases of major road-related injury events from a larger intervention study on unintentional injuries in children and adolescents. These three cases have been analyzed using the Haddon's Matrix through an epidemiological tetrad model involving balance between host, vector, physical environment and socio-economic environment. Risk score was calculated for variables that were found to be associated with significantly raised relative risk for injuries by bivariate analysis earlier in the main study. Each variable was scored as 1 for raised risk and 0 for lower risk. Maximum attainable risk score was 8, with higher score associated with higher risk. Strategies for prevention of similar injuries in future, have been outlined at various time points i.e. pre-event, event, post-event at various levels for each case, as well as intervention strategies that can be implemented in general, for the individual, family, community including panchayat, and both State and National governments.

CASE SERIES

Case 1

Case 1 was a 12-year-old female from a lower-middle socio-economic background who suffered a fall in the evening in the month of September while she slipped on cow dung while walking on road close to her house. She sustained fracture of both bones of right arm – radius and ulna. She sought care next morning at a government hospital, where she was initially treated with conservative management with closed reduction and plaster cast. One month later, she underwent surgery with open reduction of fracture dislocation, internal fixation with nails and plate, followed by physiotherapy for three weeks. The total cost of treatment was INR 17,151/- and time for recovery was two months. Risk score for this case was 5. Epidemiological tetrad model of Haddon's Matrix at time points pre-event, event, post-event and at various levels viz. individual, family and community, for this case is depicted in Table 1.

Case 2

Case 2 was a 17-year-old female from a lower-middle socio-economic background who had a fall in the afternoon in the month of October while she slipped and fell while driving a two-wheeler vehicle on road. She suffered multiple grazing abrasions on left side of face with bleeding, sharp cut on left upper eyebrow, and dislocation of the left elbow. Care was sought on the same day at a private hospital. The sharp cut was stitched, and dressing was done for all wounds. Tetanus Toxoid injection was administered, antibiotic medication was prescribed and local dressing was done with antiseptic ointment, crepe bandage was applied on the elbow. The total cost of treatment was INR 1,450/- and she recovered in two weeks. This case had a low risk score of 1. Epidemiological tetrad model of Haddon's Matrix at time points pre-event, event, post-event and at various levels viz. individual, family and community, for this case is depicted in Table 2.

Table 1: Haddon's matrix for case 1.

Parameters	Pre-event	Event	Post-event
Risk factors			
Host	Very young age	Slip and fall	-
Vector	Wet slippery cow dung	Gave away under impact	-
Physical environment	Unclean road	Rural area with cattle on road	Nearby health facilities closed during evening hours
	Low visibility in evening	Cow dung could not be seen	
Socio-economic environment	Low socio-economic status	-	Treatment sought next morning
	High risk score of 5		
Preventive measures			
Individual	Safe, careful attitude and behaviour	Careful behaviour	-
Family	Safety education to children of the family	Understand seriousness of the injury and seek immediate management	Take community help to seek immediate treatment
	Accompany young children while outside home		
Community	Maintain cleanliness of common areas	Extend help and social support to victims and their families, as required	Help with manpower/vehicle as necessary to enable families to seek immediate treatment

Table 2: Haddon's matrix for case 2.

Parameters	Pre-event	Event	Post-event
Risk factors			
Host	Young age Less than legal age for driving	Lack of safe driving skills	-
Vector	Automobile: Two-wheeler	Loss of balance	
Physical environment	-	Vehicle not under proper control	-
Socio-economic environment	Low socio-economic status Low risk score of 1	-	-
Preventive measures			
Individual	Safe, careful attitude and behaviour Strict adherence to driving and traffic rules	Careful behaviour No driving without driving license	-
Family	Safety education to children of the family Education of children for proper adherence to driving and traffic rules Strict vigil on children	-	-
Community	Counselling of children with high-risk behaviour Discussion with families on safety education of children	Extend help and social support to victims and their families, as required	Help with manpower/vehicle as necessary to enable families to seek immediate treatment

Table 3: Haddon's matrix for case 3.

Parameters	Pre-event	Event	Post-event
Risk factors			
Host	Young age Less than legal age for driving	Drunk driver	-
Vector	Automobile: Car Obstacle: Tree	Windscreen broke and pieces of glass hit the face	-
Physical environment	Low visibility due to fog	Tree could not be seen Vehicle not under proper control	Nearby health facilities closed during evening hours
Socio-economic environment	Low SE status High risk score of 6	-	Treatment sought next morning
Preventive measures			
Individual	Safe, careful attitude and behaviour Strict adherence to driving and traffic rules	Careful behaviour No driving while on alcohol	-
Family	Safety education to children of the family Education of children for proper adherence to driving and traffic rules Strict vigil on children	Understand seriousness of the injury and seek immediate management	Take community help to seek immediate treatment
Community	Counselling of children with high-risk behaviour Discussion with families on safety education of children	Extend help and social support to victims and their families, as required	Help with manpower/vehicle as necessary to enable families to seek immediate treatment

Case 3

Case 3 was a 17-year-old male belonging to lower-middle socio-economic background suffered an accident in an afternoon in December. He was a passenger in left front seat of a car, which hit a tree. The car was being driven by his friend. He suffered multiple abrasions on the face, a sharp cut on right upper eyelid, sprain of the right wrist, and abrasions on chest and both arms. Care was sought next morning at a government hospital. The sharp cut was stitched and dressing was done for all wounds, tetanus toxoid injection was given, antibiotic medication was presceibed and local dressing of wounds were done with antiseptic ointment. The total cost of treatment was INR 683/- and he recovered in two weeks. This case had a very high risk score of 6. Epidemiological tetrad model of Haddon's matrix at time points pre-event, event, post-event and at various levels viz. individual, family and community, for this case is depicted in Table 3.

DISCUSSION

Injuries occur as a result of a complex array of several factors, and thus for prevention of road traffic injuries all these factors must be addressed. As outlined by Haddon, "a logical system for preventing injury and death in motor vehicle crashes is based on the sequence of events (pre-crash, crash, and post-crash) and types of factors involved (human, vehicle and equipment, physical environment and roadway, and socioeconomic environment)".[3] The present study aimed to explore these factors as well as strategies for their prevention for three major road-related injury events, according to epidemiological tetrad model of Haddon's matrix at time points pre-event, event, post-event and at various levels viz. individual, family and community.

The Haddon matrix is a transformational tool to understand the complex determinants of road traffic injuries by integrating the epidemiological triad of disease (agent, host and environment) and levels of prevention with the temporal context of pre-event, event and post-event.[4] The framework has been widely used globally in injury and disease prevention in several contexts which were not limited to road traffic accidents.[5-11]

Road traffic injuries have increased in incidence over the years from 1.15 million in 2000 to 1.35 million in 2018 and is the leading cause of death in children and young adults aged 5-29 years.[12] Road injuries contributed to 2.87% of total DALYs globally and 3.33% of the total DALYs in India in 2019.[13] The rates of death due to road traffic injuries are disproportionately high in low- and middle-income countries, with highest deaths in Africa followed by South-East Asia. Most determinants of road injuries and their outcomes are behavioural including speed, drunk-driving and poor adherence to seatbelt and helmet use. Almost all of these factors are preventable.[14]

Of the three major road-related injuries described in our study, two were automobile accidents in 17-year-old adolescents and one was a case of injury of a 12-year-old girl due to fall on road. All the injury events had occurred in the afternoon or evening, in the last quarter of the year. All injuries led to musculoskeletal and soft tissue involvement. In two cases treatment was taken from government health care facility on the next morning, while in one case the victim was taken to a private facility on the same day. Risk factors were present in all three cases related to host, vector, physical environment and socio-economic environment. Preventive measures have been outlined at various levels in different time points i.e., pre-event, event, post-event, as well as at various levels of care. All the injuries could have been prevented by simple measures taken by the individuals who suffered the injuries, and the families and the community they belonged to. General intervention strategies and responsibilities can also be implemented at various levels of stakeholders, including the government, to prevent injuries in children and adolescents. Table 4 depicts the general intervention strategies and responsibilities that can be implemented at various levels of stakeholders, including the government, to prevent injuries in children and adolescents.

Table 4: Intervention strategies at various levels for prevention of major injuries.

Level	Possible interventions
Individual	Development of safe, careful attitude and behaviour
	Following guidelines and advice from parents and school
	Strictly following traffic rules
Family	Safety education to children of the family
	Counselling of children for proper implementation of rules
	Strict vigil on children
	Accompanying young children while outside home
Community	Maintaining cleanliness of peri-domestic and common areas
	Proper lighting arrangements of public spaces
	Discussion with parents regarding counselling of children with high-risk behaviour
	Extending help and social support to victims and their families
Government	Maintenance of proper infrastructure in roads and public spaces
	Awareness generation through: information, education, communication (IEC) program in community for adults and adolescents; school health education for school children; strict implementation of rules with necessary punitive action; and counselling of children with high-risk behaviour through health facilities, and schools.

Few studies have used the Haddon matrix to assess the determinants of road traffic injuries and evaluate preventive measures. A study on road crash victims in Delhi reporting to a government hospital for treatment found that in case of motorized victims, pre-event factors contributing to accident included young age, male gender, two-wheeler riders, bad weather conditions, slippery and unpaved roads, mobile phone use, driving under the influence of alcohol and poor compliance to helmets. Crash factors included poor compliance to seatbelt and helmet use and poor sense of traffic rules while post-crash factors comprised time to seeking treatment, distance to trauma care facility and availability of transport to reach trauma centre.[15] These are similar to our study findings. Another study from Delhi and one from Gujarat reported similar results where host factors involved in the accidents were speeding, young age, alcohol intake, fatigue of the driver and non-compliance to safety measures. Vehicular risk factors were motorized vehicles, two wheelers and overloaded vehicles whereas environmental factors included poor weather conditions.[16,17] Studies outside India have also reported traffic rule violations to be the major cause of road accidents, along with environmental factors like poor street lighting and lack of road signs.[18-21] These studies emphasize the importance of enforcing traffic regulations, and conducting behavior change education regarding traffic safety rules and their adherence.

Road traffic injury prevention has gained importance and is part of the sustainable development goals target 3.6 which aims to halve the number of global deaths and injuries from road traffic accidents by 2030. Road traffic accidents can be prevented by a number of methods including vehicle maintenance, well maintained roads, appropriate traffic and road signages, adherence to driving and road safety rules by drivers and pedestrians and enforcement of legislations on traffic safety. In a systematic review of evaluation of road traffic injury prevention initiatives in low- and middle-income countries, legislation was found to be the most commonly evaluated intervention with promising outcomes.[22] According to World Health Organization (WHO) estimates, 22 countries have amended their laws to address one or more key risk factors for road injuries over the past three years.[23] The Ministry of Road Transport and Highways, Government of India, has put forth five pillars to road safety: building road safety management capacity; improving the safety of road infrastructure; further developing the safety of vehicles; enhancing the behaviour of road users; and improving emergency and other post-crash services.[24]

One unique mode of road-related injury in our study was fall by slipping on wet cow dung. Cattle rearing is commonly seen in rural areas as well as urban slums in India, and free roaming cattle on roads is not an unusual phenomenon. Though no studies were reported on this, news articles from India have continued to cite road accidents due to cattle menace and slip on cow dung and this highlights the need for further research.[25-29]

One major limitation of this study is that the data is based on response of the subjects and/or their parents/guardians as respondents, due to which minor details might have been missed. Also, since the data was collected after the events had already occurred, some recall failure cannot be ruled out. However, these are common problem in any interview-based method of data collection. To minimize recall failure and improve quality of data, the subjects were told to keep a written record in an injury diary and recall period was kept short i.e., one week by enquiring about injury events that had occurred in the previous week.

CONCLUSION

All the three major road-related injuries that occurred in subjects of the present study had important preventable risk factors viz. unclean environment in one case and below the legal age of driving in two cases. All these injuries and their complications could have been easily prevented by following simple prevention strategies and taking responsibility at various levels starting from National and State Governments, to community including Panchayat, as well as parents and the children themselves during all time points i.e., before, during and after the injury occurrence, in the sequence of events.

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