Agent–host–environment model of blunt abdominal trauma in children: 5-year experience and preventive inferences in Zagazig University-Egypt

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Background/Purpose **Among children aged from 1 to 14 years, approximately 50% of mortality is related to trauma. Abdominal injuries account for approximately 10% of trauma deaths in childhood. Child injury has great effects on communities and countries. The agent–host–environment model has been used to describe the epidemiology of communicable diseases. It can be adapted for understanding childhood injuries. This study aims to evaluate the Zagazig University experience with blunt abdominal trauma (BAT) in children in light of the epidemiological (agent–host–environment) model.**

Patients and methods **This study included 590 consecutive patients aged from 1 to 14 years, who were admitted to the Emergency Unit at the Zagazig University Hospital, after BAT incidents in the period January 2006–2010. A predesigned format was used to collect targeted data.**

Results **The study included 590 children with BAT. They made up approximately 18% of total children trauma cases. Multisystem trauma occurred in 72.5% of patients. The causative energy in this study was mechanical energy that was most commonly transmitted through road traffic accidents (55.8%). When mechanisms of trauma were related to age groups, we found that road traffic accidents were significantly more common among children aged from 5 to 14 years (*P* value <0.001), whereas falls were significantly more common among children aged from 1 to 4 years (*P* value <0.001). The most common physical environment was streets. BAT was more in urban areas (65%) and in low socioeconomic states (67%).**

Conclusion **According to this study, most BAT vulnerable children are boys aged from 5 to 14 years, living in urban areas, and with low socioeconomic status. The agent–host–environment model can be used to study causative and contributing factors to trauma. It can be utilized to structure and plan preventive interventions against BAT in children. *Ann Pediatr Surg* 7:61–65 © 2011 Annals of Pediatric Surgery**

Annals of Pediatric Surgery 2011, **7**:61–65

Keywords: abdominal trauma, agent–host–environment model, blunt trauma, epidemiological model

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Received 8 January 2011 **Accepted** 1 March 2011

Introduction

Trauma is the leading cause of death in childhood. Among children aged from 1 to 14 years, approximately 50% of mortality is related to trauma. Abdominal injuries account for approximately 10% of trauma deaths in childhood [1].

The commitment to reduce the burden of childhood diseases has been announced by international and national declarations. However, high levels of childhood mortality, morbidity, and disability persist. A principal reason for this is the impact of childhood injuries, affecting children of all ages [2].

According to a world report by the WHO and UNICEF (United Nations International Children's Emergency Fund) in 2008, more than 2000 children die every day as a result of unintentional or accidental injuries. Every year, 10's of millions of children worldwide are taken to hospitals with injuries that often leave them with lifelong disabilities. More than 260 000 children and teenagers die from road traffic injury each year [3].

In terms of motor-vehicle-related blunt trauma, the frequency of injury is as follows: extremities (43%), head and neck (40%), abdomen and pelvis (10%), and chest (7%). Abdominal injuries account for approximately 10% of trauma deaths in childhood, and mortality of visceral injury associated with serious head injuries account for 70% of deaths [1].

Child injury has great effects on communities and countries. Unexpected child loss has a huge impact on families and communities. Nonfatal injuries may cause temporary or permanent disability that hinders social development, education, ability to work, and so on. Healthcare systems suffer great burden. Injury prevention is a cost-effective public health strategy [4].

There are several models available to help practitioners design interventions that prevent health problems including blunt injuries and deaths.

The agent–host–environment model has been used to describe the epidemiology of communicable diseases. It can be adapted for understanding childhood injuries. The agent of injury is the form of energy that damages body tissues and the vector transmitting this energy. The host or injured child can be described by age, sex, race, developmental level, and behavior characteristics. Finally, the environment includes the physical situation, in which injuries occur, and the psychosocial environment [5]. Injuries occur when the elements of agent, host, and environment come together in a critical manner and within a precise time period [6].

1687-4137 © 2011 Annals of Pediatric Surgery DOI: 10.1097/01.XPS.0000397987.37985.3d

The aim of this study was to evaluate the Zagazig University's experience with blunt abdominal trauma (BAT) in children in light of the epidemiological (agent–host–environment) model.

Patients and methods

This prospective study included 590 consecutive patients aged from 1 to 14 years, who were admitted to the Emergency Unit of General Surgery Department, Zagazig University Hospital, after BAT incidents in the period January 2006–2010.

A predesigned format was used to collect data of sex, age, residence (urban or rural, number of rooms), work, number of other siblings, father/guardian's occupation, parent's educational level and mechanism, time, and place of trauma.

BAT included either direct or indirect incidents. These included road traffic accidents (RTAs), falls, animal kick, swing hit, building breakdown, and physical abuse.

The socioeconomic level was determined according to El-Sherbini and Fahmy scoring systems for socioeconomic status [7] Table 1. Patients were divided according to the sum of points into:

(1) Low socioeconomic level (< 12): 130 patients.
(2) Intermediate socioeconomic level (12–22): 65 patients.
(3) High socioeconomic level (24): five patients.

Physical abuse was suspected in the following cases:

(1) Adults bringing an injured child to the emergency room with marked discrepancy between clinical findings and historical data [8].
(2) Bruise marks shaped like hands, fingers, or object (such as belt), or unexplained bruises in areas where normal childhood activities would not usually result in bruising [9].
(3) Human bites and lash marks [9].
(4) Unsubstantiated stories such as falling out of bed, sibling stepping on infant, and rolling onto a child sleeping in bed should arouse suspicion of child maltreatment [10].
(5) Multiple different stories about how the child sustained injury [10].
(6) Delayed seeking medical care without adequate explanation [11].

All the children were investigated and treated according to the protocol followed in the Emergency Unit of General Surgery Department, Zagazig University Hospitals.

Statistical analysis

Data were checked, entered and, analyzed using SPSS (version 15, Chicago Illinois, USA). Data were expressed as percentages. Chi-squared test or *P* value of Fisher's exact test was used when appropriate. *P* value of less than 0.05 was considered to be statistically significant.

Results

(1) This study included 590 children who had BAT incidents. Total trauma admissions in Zagazig University Hospitals in the same period were 3325 cases, which meant that BAT made up approximately 18% of total children trauma cases.
(2) Actual intra-abdominal injuries occurred in 502 cases (85%).
(3) Multisystem trauma occurred in 428 patients (72.5%), whereas 162 patients had isolated BAT (27.5%).

The study results in light of the agent–host–environment model:

Agent

The form of energy causing injuries in this study is mechanical energy that was most commonly transmitted through RTAs (55.8%), followed by falls (34.2%) Table 2. Pedestrian injury is the most common of RTAs (69%) Table 3.

Host criteria

(1) Sex: 399 boys (67.6%) were injured versus 191 girls (32.4%), with a male-to-female ratio of approximately 2 : 1 and a *P* value of 0.0017.
(2) Age: BAT is the most common among ages 5–9 years (43.6%).

Table 1 Scoring system for socioeconomic status [7]

Item	Score
Parent's educational level	
Illiterate	0
Read and write	2
Basic education	4
Secondary education	6
University and above	8
Father's occupation	
Unskilled worker (e.g. farmer, constructing worker, cleaner, servant)	0
Skilled worker (e.g. tailor, carpenter)	2
Intermediate class (e.g. teacher, nurse, governmental employer)	4
Professional class (e.g. physician, engineer, lawyer, leading administrative, and well-established commercial and industrial owner)	6
Crowding index	
Five or more/bedroom	0
Four/bedroom	2
Two or three/bedroom	4
One/bedroom	6
Income	
Insufficient	0
Just sufficient	2
Sufficient and more	4

Table 2 Distribution of trauma mechanisms

Mechanism of trauma	Number (*N*=590)	Percentage
Road traffic accidents	329	55.8
Falls	202	34.2
Animal kick	24	4.1
Building breakdown	14	2.4
Swing hit	12	2.0
Child abuse	9	1.5

Table 3 Distribution of injured children in road traffic accidents

Road traffic accidents	Number (*N*=329)	Percentage
Pedestrian	227	69
Passenger	66	20
Bicyclist	36	11

(3) Developmental level: injuries were most common among young school children.

When mechanisms of trauma were related to age groups in this study, we found that RTAs were significantly more common among children aged from 5 to 9 years and 10 to 14 years (P value < 0.001), whereas falls were significantly more common among children aged from 1 to 4 years (P value < 0.001) Table 4.

Environment

Physical situation

The most common physical environment was the streets where RTAs occurred. Injured children were pedestrians (227 cases), car occupants in motor crash (59 cases), or on motorbikes (seven cases) Table 5.

All pedestrians injured were walking alone on the street (unaccompanied with adults), whereas all passengers injured in motor vehicle collisions were unrestrained neither by seat belt nor in the child car seat.

Psychosocial environment

According to this study, BAT is more in urban areas (65%) with significant P value (< 0.001), and among children living in low socioeconomic states (67%) with significant P value (< 0.001), Table 6.

Discussion

In this study, and in reference to agent–host–environment model, the most critical context that carries the risk for BAT was: boys (aged: 5–9 years) walking alone in the city with a low socioeconomic status as well as teenagers (aged: 10–14) with a low socioeconomic status. The agent of injury is the form of energy that damages body tissues. In RTAs wherein the child is walking on the street and is suddenly hit by high speed motor vehicle, the transmitted kinetic energy resulting from rapid deceleration of the body conveys serious damage to the body tissue. Similarly in automobile collision, when rapid deceleration of vehicle occurs, the body of unrestrained child flies and strikes the interior parts of the car or ejected outside the car by transmitted kinetic energy [6].

The host (injured child) can be described by age, sex, and developmental level. According to Kraus *et al.* [12] and Peden *et al.* [4], toddlers are at greatest risk of falls, whereas young school age children are at greatest risk of pedestrian injuries, bicycle-related, and motor-vehicle occupant injuries. Granger [13] found that starting at 1–2 years of age and until the seventh decade of life, male patients have higher rates of injuries than female patients. Crawling infants and toddlers who explore their new environments, kindergartner's who walk to school for the first time, and adolescents taking new risks on motor cycles are all more exposed to injuries [6].

The environment is the physical and psychosocial context in which injury occurs. The socioeconomic status is one of the most important risk factors for childhood injury. The higher the income is, the lower is the death rate. Mortality rates from motor vehicle crashes are two-fold to fourfold higher among poor than nonpoor children [14]. Poverty increases the risk of injury to children at least in part through ill effects on the environment [15]. Poor children live in poor housing, which is less likely to be protected by adequate safety features. Their neighborhood is more likely to be violent [16]. Serious stresses within the family may create an environment in which a child is more likely to be injured [17].

According to a World Report (2008) on Child Injury Prevention, implementing interventions could save lives of more than 1000 children a day. The Report describes 24 proven interventions [4]. The question is how to use these study results to design preventive strategy? Many begin their plans to prevent injuries to children and adolescents by considering only health education aiming at changing individual behaviors. This approach is right, but not enough [18,19].

Table 5 Physical situation distribution

Situation	Number ($N=590$)	Percentage
Street	329	55.8
Pedestrian (alone)	227	38.5
Car	59	10.0
Bicycle	36	6.1
Motorbike	7	1.2
House	75	12.7
Park	19	3.2
School	42	7.1
Field	23	3.9

Table 6 Psychosocial environment criteria

Psychosocial environment criteria	Number	Percentage	χ^2	P value
Residence				
Urban	379	64	93.41	<0.001
Rural	211	36		
Socioeconomic states				
Low	485	82	946.7	<0.001
Middle	67	11		
High	38	7		

Table 4 Mechanisms of trauma in relation to age groups

	1–4 years ($N=208$)		5–9 years ($N=257$)		10–14 years ($N=125$)			
Mechanism of trauma	N	Percentage	N	Percentage	N	Percentage	χ^2	P value
RTA (329)	78	31.5	167	65.0	84	67.2	43.2	<0.001
Falls (202)	109	52.4	66	25.7	27	21.6	47.7	<0.001
Animal kick (24)	4	1.9	13	5.1	7	5.6	3.85	0.14
Building breakdown (14)	5	2.4	6	2.3	3	2.4	0.001	0.99
Swing (12)	7	3.4	2	0.8	3	2.4	3.97	0.13
Child abuse (9)	5	2.4	3	1.2	1	0.8	1.73	0.42

RTA, road traffic accidents.

Fig. 1

Phase/Factor	Host	Agent	Environment	
			Physical	Social/Cultural
Pre-Event The build-up of uncontrolled energy is released	Will an event (e.g.crash) with the potential to cause injury occur? Interventions in the pre-event phase are designed to reduce the number of events with the potential to cause injury.			
Event Energy is transferred	Will an injury occur? Interventions in the event phase don't stop the event, but reduce the number of injuries that occur as a result.			
Factors about Post-Event the state of the person, agent, or environment affect what the energy does.	What will the outcome of the injury be (e.g. how severe will it be)? Interventions in the post-event phase don't stop the event or the injury from occurring, but reduce the severity of injury and optimize the outcome for the injured party. Interventions that affect the post-event phase would mostly need to be accomplished prior to an injury event occurring.			

Haddon matrix [20].

Dr Haddon is widely considered as the father of modern injury epidemiology. Dr Haddon was a physician and an engineer who worked in the USA on the design of safer roads in the late 1950's. He combined his skills to develop a framework for analyzing injury based on the host, the agent, and the environment [20]. These aspects are looked at over the time/phases leading up to the injury event, the injury event itself, and directly after the event. From this study, he developed a tool called Haddon's Matrix, which can be used to assess the injury and identify the methods of prevention. It is a conceptual model for developing injury prevention strategies. It looks at injuries in terms of casual and contributing factors, and also in terms of a time sequence consisting of pre-event, event, and postevent phases. It helps to recognize major modifiable factors that lead to unhealthy outcomes. Analyzing trauma in this way helps to develop a three-dimensional approach to injury prevention, which includes behavioral, environmental, and policy changes [21–25]. The matrix is an useful tool for planning where and when to conduct interventions Fig. 1.

Applying this matrix to our study results means that education should be primarily directed to young school children aged from 5 to 9 years (kindergartner and elementary schools) and also to teenagers (aged 10–14 years), giving boys more attention. Education also will benefit motor vehicle drivers and families in urban low socioeconomic states. Efforts should be directed to car designers and engineers to drive their attention to safer designs considering children. In many industrialized countries, there are safety regulations and laws that are supported by control measures. However, in developing countries, although regulations for safety measures often exist, they are seldom enforced [18]. More efforts should encourage enactments of laws protecting children safety on the roads [19].

According to these study results, 72.5% of children had multiple injuries. However, the study focused on BAT only in one locality (Zagazig University Hospitals). It is not enough as a data source for planning local or national child injury prevention strategy. This entails more comprehensive study to child injury patterns all over Egypt. Nevertheless, this study allowed us to study one type of trauma from the preventive perspective by applying the agent–host–environment model. Working through framework or matrix such as Haddon's helps designing comprehensive preventive approaches.

Recommendation

The Multidisciplinary/Multicenteric Study of Child Injury Model in Egypt through preventive conceptual framework is recommended as a prerequisite for National Child Injury Prevention Strategy.

Conclusion

According to this study, most BAT vulnerable children are boys aged from 5 to 14 years, living in urban areas, and in low socioeconomic states.

The agent–host–environment model can be used to study causative and contributing factors to trauma. It can be utilized to structure and plan preventive interventions against BAT in children.

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