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Predictors of paediatric injury mortality

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Background. Childhood injury is a major public health issue in many parts of the world, contributing significantly to paediatric morbidity and mortality. World Health Organization recently projected that with the current trends, trauma and infectious diseases will account for equal numbers of year of potential life lost worldwide by the year 2020.

Aim. This study aimed to investigate factors predictive of childhood injury mortality.

Design. A prospective hospital-based cross-sectional study.

Methods. All attendances and admissions to the Children's Emergency Room at the Wesley Guild Hospital, Ilesa, Osun State, Nigeria, over a period of 2 years (1 June 2007 - 30 May 2009) were serially documented and all patients with injury were recruited into the study. The socio-demographic variables, injury characteristics, Pediatric Trauma Score (PTS) and Glasgow Coma Score (GCS) were tested against outcome by binary logistic regression analysis.

Results. Five hundred and seventy-six children presented with injury during the study period with 22 deaths, giving an injury mortality rate of 3.8%. Logistic regression modelling found infancy (odds ratio (OR) 1.14, 95% confidence interval (CI) 0.04 - 0.37), head injury (OR 2.51, 95% CI 0.10 - 0.61), low PTS (≤8) (OR 8.95, 95% CI 0.86 - 0.94) and low GCS (<9) (OR 5.22, 95% CI 0.40 - 0.69) to be significant independent predictors of childhood injury mortality.

Conclusion. Prompt identification of the above factors in children with injury may prevent many deaths.

Injuries continue to contribute significantly to childhood mortality and morbidity worldwide, despite various efforts and advances in emergency medicine.[1] In many parts of the developing world where infections and under-nutrition are still the leading causes of childhood death, World Health Organization projections indicate that the years of potential life lost due to trauma will equal those lost from infectious diseases by the year 2020.[2] At present, more than 90% of global deaths due to injuries in children occur in low-income countries.[3]

Although paediatric trauma is recognised as a major public health issue,[1] effective prevention of injuries and associated deaths has been limited. Several studies have demonstrated that socio-demographic factors such as the age and sex of the child, parental occupation and level of education, premorbid state of the child, poor adult supervision and poor home and road conditions are associated with an increased risk of injury.[4,5] Some potentially avoidable secondary complications have also been identified as factors contributing to death from paediatric trauma.[4] Unlike other diseases with strong genetic components to their causes, the current thinking is that variations in childhood injury rates as well as injury mortality rates result from the child's physical and psychological environments. A recent meta-analysis showed that if proper attention is paid to these factors, both the paediatric injury rate and deaths will be drastically reduced.[6] It is therefore important to determine which of these socio-demographic variables, injury characteristics and injury scoring systems is independently related to an increased risk of death.

We prospectively studied children with various forms of injury to determine the mortality rate from childhood injury and the contribution of individual factors as predictors of death.

Materials and methods

The study was a 2-year prospective study carried out between 1 June 2007 and 30 May 2009 at the Children's Emergency Room (CHER) of Wesley Guild Hospital, Ilesa, a tertiary hospital unit of Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife, Osun State, Nigeria. The hospital is the main referral facility providing both general and specialist paediatric care for the semi-urban communities of the Osun, Ondo and Ekiti states in south-western Nigeria.

Ethical clearance was obtained from the Research and Ethical Clearance Committee of the hospital. Informed consent was also sought and obtained by carefully explaining the purpose and benefits of the study to parent(s), accompanying caregiver(s) and/or the subjects when feasible. All attendances and admissions to the CHER were serially documented and consecutive children attending or admitted with injury were recruited into the study. For the purpose of the study injury was defined as physical damage to the body resulting from falls, cuts, burns, road crashes, assaults (physical, including sexual), blunt injury, poisoning, drowning and near-drowning, gunshots, human or animal bites and nonspecific causes.[3]

Each patient was assessed and data on age, sex, social class, cause of injury, site of injury, symptoms and signs, radiological and other

operative findings, management and outcome were documented in a specially designed data pro-forma.

Assessment of injury severity was based on the Pediatric Trauma Score (PTS).[7] Injuries with scores >8 were classified as minor while those with scores ≤8 were classified as severe or potentially life-threatening. The PTS consists of six components, each with a score of +2, +1 or -1. The components include weight, airway patency, systolic blood pressure, level of consciousness, open wounds and skeletal injury. Also, the Glasgow Coma Scale (GCS) or Modified Glasgow Coma Scale was used to assess the degree of consciousness for those with coma[8] (GCS <9 = severe, 9 - 12 = moderate, and >12 = mild). Duration of coma was graded into short (less than 30 minutes) or long coma (longer than 30 minutes). Patients with bleeding were grouped into those with profuse bleeding requiring blood transfusion and those with minor bleeding requiring no blood transfusion. Outcomes were categorised into those who survived and those who died. Patients who took discharge against medical advice (DAMA) and those who were transferred to another hospital were excluded from the study because their final outcome was unknown. The remaining patients were then analysed.

Data were analysed using the Statistical Package for Social Sciences (SPSS) version 17. Means, modes, medians, standard deviations (SDs), proportions and percentages were determined, as applicable. The means and SDs were calculated for continuous variables while ratios and proportions were calculated for categorical variables. Proportions and ratios were compared using Pearson's chi-square test, and means (SD) using Student's *t*-test (with Yates' correction for sample size less than 5 in at least one cell). The relationship between outcome and clinical variables (socio-demographic variables, injury characteristics, PTS and GCS) was tested using binary logistic regression analysis. *p*-values of <0.05 were accepted as statistically significant.

Results

During the study period (1 June 2007 - 30 May 2009), 6 365 children (3 811 males and 2 554 females, male/female ratio 1.5:1) were managed in the CHER at the Wesley Guild Hospital. Of these, 592 had injuries, giving a hospital injury prevalence of 9.3%. However, 16 of them were eventually transferred to other hospitals for further management or took DAMA, and were therefore excluded. The remaining 576 injured children who were analysed comprised 354 males and 222 females (male/female ratio 1.6:1). The mean age of the children was 6.4 (SD 3.1) years (range 5 weeks - 15 years). Table I shows the age and gender distribution. Forty-nine (8.5%), 60 (10.4%), 121 (21.0%), 188 (32.6%) and 158 (27.4%) of the children were from socio-economic classes I, II, III, IV and V, respectively. Hence, 109 (18.9%) were from high socio-economic classes (I and II) and the majority, 467 (81.1%), from lower social classes (III - V).

Injury characteristics

Site of injury. The majority of the children (237, 41.1%) sustained injuries at home, followed by on the road (209, 36.3%) and at school (84, 14.6%). The remaining 44 (7.6%) were injured in other places such as farms, shops and religious centres.

TABLE I. AGE AND GENDER DISTRIBUTION OF THE INJURED CHILDREN

Age group	Gender		Total (*N* (%))
	Male	Female	
Infants	14	9	23 (4.0)
Preschool	134	94	228 (39.6)
School-aged	128	91	219 (38.0)
Adolescents	78	28	106 (18.4)
Total	354	222	576 (100.0)

Injury-presentation interval. The interval between injury and presentation ranged from 6 minutes to 30 days (mean 40.0 (SD 147.1) hours, median 2 hours). About two-thirds of the children (369, 64.1%) presented within 6 hours of sustaining the injury.

Mode of admission. A total of 477 children, comprising all the 369 early presenters and 108 of those who presented after 6 hours, were transported directly from the site of the injury to the CHER. Of the 207 children who presented late, 82 (39.6%) were referred from other hospitals and 17 (8.2%) came from traditional bone setters.

Nature of injuries. The majority (538, 93.4%) of the patients sustained accidental injuries, while only 38 (6.6%) had intentionally inflicted injuries.

Types of injury. Falls were the leading cause of injuries during the study period (217 children, 37.7%). This was followed by road traffic accidents (189, 32.8%), burns (47, 8.2%), cuts (38, 6.6%), bites (38, 6.6%), assaults (26, 4.5%), poisoning (7, 1.2%), and gunshot injuries (2, 0.3%).

Parts of the body affected. The extremities were most commonly affected (331 children, 57.3%), followed by the face (278, 48.3%), head (183, 31.8%), trunk (111, 19.3%), perineum/pelvis (73, 12.7%) and neck (7, 1.2%). In 397 cases (68.9%) multiple parts of the body were injured.

Injury severity measures. The mean (SD) PTS was 8.67 (2.35), with scores ranging from -6 to +12. Comparing the mean PTS of the 554 survivors with the 22 non-survivors, i.e. 10.3 (SD 2.4) v. 3.7 (SD 3.1) respectively, the mean PTS of those who died was significantly lower (t=12.50, df=574, p<0.001). Similarly, the GCSs of the patients ranged from 3 to 15, with a mean of 13.99 (SD 2.84). The mean GCS of the children who died, 4.4 (SD 3.5), was also significantly lower than that of the survivors, (12.1 (SD 2.3) (t=15.04, df=574, p<0.001)).

Injury severity measure and mode of admission. The mean GCS and PTS of the patients who were referred to our unit from another hospital were 10.7 (SD 3.1) and 9.6 (SD 0.9), respectively. For those who were transported directly from the site of injury the scores were 13.4 (SD 1.8) and 11.2 (SD 2.2), respectively. Children who were referred had a significantly lower mean PTS (t=6.49, df=557, p<0.001) and GCS (t=16.01, df=557, p<0.001) when compared with those who were transported directly from the site of injury.

Outcome

Twenty-two children died from injuries during the period of study, giving an injury mortality rate of 3.8%. Tables II, III and IV compare socio-demographic variables, injury characteristics and injury severity measures/-complications with outcome. More infants, as well as more children of mothers with a low level of education (no formal education or only primary school education), died (<0.05) (Table II). Tables III and IV show that, road traffic accidents, falls, multiple injuries, head injuries, low PTS (≤8), low GCS (<9), prolonged coma (>30 minutes), convulsions, and profuse bleeding requiring blood transfusion (packed cell volume <20%) were significantly associated with death.

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Table V shows the socio-demographic data, injury characteristics and injury severity measures that independently predict outcome using binary logistic regression analysis. Of the variables that were significantly associated with death (Tables II - IV), only age (infancy), head injuries, low PTS (≤8) and low GCS (<9) significantly predicted paediatric injury mortality.

Discussion

Although millions of children die from injuries worldwide every year, more than 95% of all these unintentional childhood deaths

TABLE II. RELATIONSHIP BETWEEN SOCIO-DEMOGRAPHIC VARIABLES AND INJURY OUTCOME

Socio-demographic variables	Survivors (*N* (%))	Dead (*N* (%))	Total	χ^2	*p*-value
Infants	18 (78.3)	5 (21.7)	23	20.941	**<0.001**
Male	346 (96.9)	11 (3.1)	354	1.268	0.260
Female	211 (95.0)	11 (5.0)	222	1.268	0.260
Low SES	106 (97.2)	3 (2.8)	109	0.135	0.713
Low maternal education	261 (94.2)	16 (5.7)	277	5.676	**0.017**
Mothers younger than 20 years	148 (4.3)	9 (5.7)	157	2.150	0.143

The figures in parentheses are percentages of the total in the rows. Bold fonts indicate statistical significance.
SES = socio-economic status.

TABLE III. RELATIONSHIP BETWEEN INJURY CHARACTERISTICS AND INJURY OUTCOME

Injury characteristics	Survivors (*N* (%))	Dead (*N* (%))	Total	χ^2	*p*-value
Accidental	516 (95.9)	22 (4.1)	538	0.694	0.405
Late presentation (>6 hours)	198 (95.7)	9 (4.3)	207	0.246	0.620
Referred	78 (95.1)	4 (4.9)	82	0.052	0.819
Multiple injuries	268 (94.4)	16 (5.6)	284	5.020	**0.025**
RTI	175 (92.6)	14 (7.4)	189	9.858	**0.002**
Falls	214 (98.6)	3 (1.4)	217	4.614	**0.032**
Head injuries	169 (92.3)	14 (7.7)	183	10.715	**0.001**

The figures in parentheses are percentages of the total in the rows. Bold fonts indicate statistical significance.
RTI = road traffic injuries.

TABLE IV. RELATIONSHIP BETWEEN INJURY SEVERITY MEASURE/COMPLICATIONS AND OUTCOME

Criteria	Survivors (*N* (%))	Dead (*N* (%))	Total	χ^2	*p*-value
PTS ≤8	188 (89.5)	22 (10.5)	210	37.065	**<0.001**
GCS <9	21 (52.5)	19 (47.5)	40	19.311	**<0.001**
Prolonged coma	42 (68.9)	19 (31.1)	61	3.938	**0.047**
Presence of seizure	30 (71.4)	12 (28.6)	42	75.555	**<0.001**
Focal seizure	8 (66.7)	4 (33.3)	12	0.003	0.957
Severe anaemia (PCV <20%)	82 (85.4)	14 (14.6)	96	36.333	**<0.001**

The figures in parentheses are percentages of the total in the rows. Bold fonts indicate statistical significance.
PTS = Pediatric Trauma Score; GCS = Glasgow Coma Score; PCV = packed cell volume.

TABLE V. SOCIO-DEMOGRAPHIC DATA, INJURY CHARACTERISTICS AND INJURY SEVERITY MEASURES INDEPENDENTLY ASSOCIATED WITH MORTALITY BY BINARY LOGISTIC REGRESSION ANALYSIS

Variables	B	SE	OR	95% CI	*p*-value
Infancy	-2.127	0.572	1.14	0.04-0.36	**<0.001**
Low maternal education	-1.064	0.493	3.34	0.13-0.91	0.631
RTI	-1.332	0.453	2.64	0.11-0.64	0.300
Falls	1.033	0.560	2.81	0.94-8.42	0.065
Multiple injuries	1.046	0.486	2.85	1.10-7.38	0.310
Head injuries	1.383	0.453	2.51	0.10-0.61	**0.002**
Low PTS (≤8)	-1.332	0.453	8.95	0.86-0.94	**0.003**
Low GCS (<9)	-3.226	0.217	5.22	0.40-0.69	**<0.001**
Prolonged coma	14.498	1070.567	6.99	0.60-0.81	0.989
Presence of convulsion	-3.043	0.468	4.80	0.02-0.12	0.072
Severe anaemia (PCV <20%)	-2.282	0.459	7.9	0.04-0.24	0.051

Bold fonts indicate statistical significance.
B = β-coefficient; SE = standard error of the mean; OR = odds ratio; CI = confidence interval; RTI = road traffic injuries; PTS = Pediatric Trauma Score; GCS = Glasgow Coma Score; PCV = packed cell volume.

occur in low- and middle-income countries.[1] The contribution of injuries to paediatric mortality was low about 50 years ago, but has geometrically increased in the last 20 years. Data in many developing countries currently suggest an increase in both paediatric injury rates and deaths.[9] Some of the factors responsible include increasing rates of road traffic crashes due to proliferation of motorcycles as a means of transportation in Nigeria, careless and unlicensed driving, bad roads and road design, poor adult supervision of children at home, at school or on the road, and poor home design.

The epidemiological and clinical characteristics of our study population are comparable with those in the literature. While the injury rate of 9.3% is slightly higher than previously documented rates, the predominance of males and children in the preschool age group was essentially similar.[5] The findings that homes were the commonest site of injury, falls and road traffic crashes the leading causes of injury, and the extremities the commonest body parts affected are also similar to previous reports. The overall injury mortality rate of 3.8% is also comparable to fatality rates of between 1.6% and 7.4% in some hospital studies from African countries, but lower than rates in many developed nations, where most studies were community based.[9-11]

This study showed that low parental socio-economic status, including low maternal education (no formal education or only primary school education), was significantly related to death from childhood injury (p<0.05). This is consistent with the findings of Emerick *et al.*,[12] who also reported that these factors are independent predictors of death from childhood injury. In a study by Scholer *et al.*,[13] other socio-demographic disparities predicting infant injury mortality included maternal age, number of children in the family, marital status of the mother, and infant birth weight. Interventions to reduce injury rate and mortality should therefore target these socio-economically disadvantaged children. While we found that infants were more likely to die from injuries than other paediatric age groups (p<0.05), there was no significant gender variation (p>0.05). Although males are more likely to sustain injury,[4,5] the risk of death from injury has been reported as similar in both sexes.[12,14]

Eighty-two (14.2%) of our patients were referred by other hospitals and 17 (3.0%) came from traditional bone setters. Apart from causing a delay in presentation, going to traditional bone setters or hospitals with poor emergency services before being brought to our unit was associated with low GCSs and PTSs in this study. The mean GCS and PTS were significantly lower in patients who were not transported directly from the site of injury. Bulut *et al.*[15] observed a similar pattern in their study on children with falls. It seems clear that direct transportation from the injury site improves outcome in trauma patients.

Head injury accounted for 63.6% of deaths in this study. Other studies have reported that head injuries were the only cause of death, or that they were responsible for up to 90% of deaths.[4,5,9] We found that head injury was not only significantly related to death, but was one of the independent predictors of death. The reason for this high mortality may be that children have softer cranial bones and therefore less cerebral protection. Using the test of association only, factors such as presence of convulsions and prolonged coma (more than 30 minutes) were found to be significantly related to injury death, but regression analysis did not find them to be independent predictors of paediatric injury death, possibly because they are attributes of severe head injury. Many researchers have reported that head injury is the main determinant of outcome in patients with trauma, in terms of mortality and development of neurological sequelae.[4-7,16] In children, head injury more commonly causes diffuse oedema than focal space-occupying lesions. In centres where prompt and effective neurosurgical intervention is possible, paediatric injury mortality is limited. In addition to early presentation and proper pre-hospital management, this explains the difference in injury mortality rates between developed and developing countries.

The PTS is a well-known, reliable, highly accurate, predictable and easy-to-use scoring system in paediatric trauma.[7] Despite all these attributes, many paediatricians, especially in developing countries, are not fully aware of its existence and usefulness. Although our study did not document a direct linear relationship between PTS and injury severity, it did show PTS to be an independent predictor of paediatric injury mortality (OR 8.95, CI 0.86 - 0.94, p=0.003). Children with a PTS of >8 had 0% mortality, since all those who died had a PTS of <8. The GCS or its modification for young children also provides an accurate, reliable and easily reproducible measure of a child's neurological state. In our study, the death rate increased with decreasing GCS, the highest mortality rate occurring when the GCS was <9. This suggests that patients with such high GCSs need aggressive monitoring and treatment such as intensive care and advanced life support.

This study shows that factors such as low maternal education, injury types such as road traffic injuries and falls, multiple injuries, prolonged coma, presence of convulsions and profuse bleeding were important in paediatric injury mortality. However, factors such as head injuries and low GCS and PTS, which directly measure the anatomical and physiological severity of injury, were the main factors significantly predicting death. In sub-Saharan Africa, where mortality from injuries is among the highest in the world, a paediatric index of injury mortality with heavy emphasis on these factors should be developed.

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