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Research Article

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Road Traffic Injuries and Road Safety Measures-Can We Do Any Better?

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Abstract

Purpose: Road traffic injuries are the leading cause of death under 30 years, causing over a million deaths every year. Helmets, seat-belts and child-restraints have an important role in death and injury prevention. Our purpose was to analyze how safety measures relate to pediatric polytrauma severity in road traffic injury.

Methods: A retrospective observational study was conducted, including polytraumatized pediatric patients, hospitalized after road traffic accidents, from January 2011 to December 2015. Comparison groups were classified according to protective equipment use. Logistic regression and generalized liner models describe the probability of safety equipment use, head trauma, higher injury severity score and permanent sequelae.

Results: Of a total of 149 inpatients, 63.8% were male with a median age of 11 years. Absence of personal protective equipment was predictive for head trauma (p-value=0.014) and diffuse axonal injury associated with neurologic sequelae and death (p-value<0.01). Multivariate analysis confirmed a higher risk of protective equipment misuse in unsupervised children and in two-wheel accidents (p-value<0.05). Injury Severity Score (ISS) and Glasgow Coma Scale (GCS) were inversely proportional (p-value<0.001). Sequelae were more frequent with lower GCS (p<0.001) and diffuse axonal lesion (p<0.001).

Conclusions: Despite increasing alertness, helmet use in road accidents remains limited, reflecting on head trauma severity and subsequent neurological impairment. Absence of protective equipment on car collisions provoked more severe injury scores and prolonged hospital stay. In the "Decade of Action for Road Safety" we still find important handicaps in road safety measures, demanding more effective laws and alerting campaigns.

Keywords: Helmet; Traffic accidents; Traumatic brain injury

Introduction

Road traffic accidents are the leading cause of death for people between 15 and 30 years, causing over a million deaths each year [1,2]. According to the Global Burden of Disease Study 2013 [2], leading causes of death for young people aged 10-14 years were road injuries, HIV/AIDS and drowning (25.2%), for people aged 15-19 years and 20-24-years it was transport injuries, in 14.2% and 15.5% respectively.

Global Status Report on Road Safety 2015 [1] shows that low and middle-income countries have twice the mortality of high-income countries and 90% of global road traffic deaths. In addition to a huge health impact, road traffic accidents are estimated to cause economic losses around 5% of gross domestic product (GDP) in low and middle-income countries and approximately 3% of GDP globally [3].

Since 2007, road traffic deaths have reached a plateau, set against a 4% increase in global population and a 16% increase in motorization, proving that recent road safety politics are being more proficient [1].

Despite all efforts, it is projected that by 2020, road traffic injuries will be the sixth leading cause of death and the third leading cause of disability adjusted life years (DALYs), worldwide [4]. To face this pandemic, the World Health Organization and the United Nations regional commissions, in cooperation with the United Nations Road Safety Collaboration, prepared a Plan of Action for the Decade 2011-2020 [4,5], as a guiding document to reduce road traffic victims. The actions were based on five pillars and pillar four resumes measures to achieve safer road users, such as incentives to helmet, seat-belt and child restraint use [5].

In addition to the Decade of Action, the 2030 Agenda for Sustainable Development [6] has also drawn international attention to road safety, by setting the goal to halve the number of global deaths and injuries from road traffic accidents by 2020.

The main cause of death or injury, for two-wheel's accidents, are head, neck and abdominal injuries [4]. Motorcycle helmet use is associated with a decrease in head and neck severe injuries (around 69%) and death (around 42%) [7]. Considering its importance, motorcycle helmet use is legislated in 169 countries [1].

Pediatric patients are frequently victims of bicycle accidents with significant morbidity and mortality. Despite being a two-wheel vehicle that can reach high speed and lead to significant head and neck injury, helmet use in this case is scarcely legislated worldwide.

Seat-belt use limits occupant movement in an automobile accident and prevents projection out of the vehicle, reducing the risk of death by 45-50% [1]. Adequate legislation is available in 105 countries [1]. Considering pediatric patients under the age of 10, child restraints are more efficient in injury (77 to 90%) and death prevention (80-90%) than seat-belts [8]. Only 53 countries have adequate children restraint laws [1].

Portugal is a European Union country with approximately 10 million habitants. Portuguese legislation demands motorcycle helmet use, adequate seat-belt and child restraints but bicycle helmet is only recommended [9]. Statistics claim that Portuguese motorcycle helmet wearing rate is 96% (for passengers) to 99% (for drivers), seat-belt rate is 96% in front seats and 77% in back seats and the rate of children wearing child restraints is 85-88% [1].

Assuming that most road traffic injuries are preventable, our primary aim was to identify risk factors to adequate preventive politics. We conducted an observational retrospective study, to analyze how security measures (helmets, seat-belts, child restraints) relate to pediatric polytrauma severity, in road traffic accidents requiring hospitalization.

Methods

Inpatient data from traumatic injury records was searched retrospectively, from January 2011 to December 2015. Polytraumatized patients under the age of 18 years, hospitalized in a tertiary referral center of pediatric trauma, after road traffic injury were included. Patients with monotrauma, patients without hospitalization and with polytrauma injury from other traumatic mechanisms were excluded.

Data was collected from the patient clinical report, based on admission registries, inpatient data and discharge notes. Information collected included epidemiologic parameters, circumstances of the accident (season, time of the day, adult supervision), type of road accident (car collision, pedestrian run-over and bicycle/motorcycle accidents) and security measures (helmets and adequate child restraints). Trauma was classified by anatomical area (head, maxillofacial, thoracic, abdominal, vertebro-medular and pelvis/limbs), injury severity score (ISS), neurological status at the first medical observation (Glasgow Coma Scale-GCS), presence of diffuse axonal disease documented in head CT-scan or MRI, hospitalization length, need for surgical treatment and clinical outcome (general and neurologic sequelae, death).

To analyze the use of security measures in road traffic accidents, we sub-classified the population. For helmet use analysis we selected the patients involved in two-wheel vehicle accidents and, to analyze adequate use of seat-belts and child restraints, we designated patients involved in four-wheel vehicle accidents.

Two-wheel vehicle passengers were classified in 3 groups according to helmet use at the time of injury: helmeted, not helmeted or unknown status. Four-wheel vehicle occupants were classified in 3 groups according to the application of security measures at the time of injury (seat-belt and age-adjusted restraints): adequate, inadequate, unknown status.

All statistical analysis was performed with SPSS 21.0 and p-value<0.05 was considered statistically significant. Demographic data, injury characteristics and outcomes were compared by chi-square test for categorical variables and with t-student or Mann-Whitney test, for comparison of nominal and continuous variables, depending on the normality of sample distribution. For comparison of two continuous variables, Spearman correlation coefficient was used, since none had normal distribution.

Multivariate analysis was made with logistic regression to access the probability of security equipment use, the probability of head trauma and of permanent sequelae, with adjustment for relevant covariates. Generalized liner model was applied for multivariate analysis of the probability of higher injury severity score. Regression models only included patients with complete information, therefore excluding those with unknown status.

Results

Of a total of 149 patients which met inclusion criteria, 63.8% were male with a median age of 11 years (between 1 and 17 years). Light-day accidents occurred in 83% of cases and 36.2% in the summer season. At the moment of trauma, 34% had no adult supervision.

	Helmet (N=5)	No Helmet (N=35)	Helmet Unknown (N=8)
Age, years	14 (10-16)	13 (15-17)	12 (6-17)
Female sex	1 (20)	3 (8.6)	1 (33.3)
Accident circumstances			
Light-Day	3 (60)	28 (80)	2 (66.7)
Unaccompanied	2 (40)	28 (80)	2 (66.7)
Vehicle type			
Bicycle	2 (40)	31 (88.6)	2 (66.7)
Motocycle	2 (40)	2 (5.7)	0 (0)
All-terrain vehicle	1 (20)	2 (5.7)	1 (33.3)
Injury Severity Scores (ISS)	50 (27-50)	35 (9-75)	38 (30-57)
Injury by anatomical area			
Head	3 (60)	30 (85.7)	1 (33.3)
Maxilo-Facial	1 (20)	23 (65.7)	2 (66.7)

Thoracic	2 (40)	9 (25.7)	1 (33.3)
Abdominal	5 (100)	14 (40)	3 (100)
Orthopaedic	2 (40)	9 (25.7)	1 (33.3)
Vertebro-medular	0 (0)	0 (0)	0 (0)
Glasgow Coma Score	15 (11-15)	15 (5-15)	15 (10-15)
Diffuse Axonal Disease	0 (0)	4 (11.4)	0 (0)
Surgical treatment	2 (40)	10 (28.6)	1 (33.3)
Neurologic sequelae	0 (0)	5 (14.3)	0 (0)
Death	0 (0)	0 (0)	0 (0)

Table 1: Descriptive statistics for pediatric two-wheel vehicle accidents, by helmet status (categorical variables presented as N (%) and continuous variables as median (interquartile range).

	Adequate ISE (N=29)	Inadequate ISE (N=13)	Unknown ISE (N=3)
Age, years	8 (1-16)	13 (2-17)	6.5 (3-15)
Female sex	14 (48.3)	6 (38.5)	3 (37.5)
Accident circumstances			
Light-Day	23 (79.3)	5 (38.5)	5 (62.5)
Injury Severity Scores (ISS)	57 (21-75)	75 (30-75)	56.5 (33-75)
Injury by anatomical area			
Head	19 (65.5)	12 (92.3)	6 (75)
Maxilo-Facial	11 (37.9)	4 (30.8)	3 (37.5)
Thoracic	12 (41.4)	10 (76.9)	4 (50)
Abdominal	17 (58.6)	7 (53.8)	6 (75)
Orthopaedic	13 (44.8)	7 (53.8)	5 (62.5)
Vertebro-medular	7 (24.1)	2 (15.4)	1 (12.5)
Glasgow Coma Score	14 (3-15)	7 (3-15)	13 (4-15)
Diffuse Axonal Disease	6 (20.7)	6 (46.2)	1 (12.5)
Surgical treatment	10 (34.5)	7 (53.8)	5 (62.5)
Sequelae	11 (31.9)	4 (30.8)	3 (37.5)
Death	4 (13.6)	1 (7.7)	0 (0)

Table 2: Descriptive statistics for pediatric four-wheel vehicle accidents, by individual security equipment (ISE) status (categorical variables presented as N (%) and continuous variables as median (interquartile range).

Trauma mechanisms of injury were vehicle associated pedestrian accidents (37.6%), car collisions (33.6%) and bicycle/motorcycle accidents (28.9%). In 79% of bicycle/motorcycle accidents and in 26% of car collisions, no protective equipment was used. Injury severity score had a median of 50 (9-75).

Focusing on helmet use, we analyzed the 43 patients involved in two-wheel accidents (28.9%), finding that 5 were helmeted (11.6%), 35 non-helmeted (81.4%) and 3 had a missing status (7%). Descriptive statistics is provided in Table 1. Among children helmeted at the time of the accident, 60% had head trauma without diffuse axonal disease or neurologic impairment and all had abdominal trauma. Of children without helmet, 85.7% presented with head trauma, 11.4% of those with diffuse axonal disease and 14.3% with neurologic permanent injury.

On unadjusted binary analysis, helmet absence was a significant predictor for head trauma (p-value=0.049), but not for diffuse axonal disease, neurological sequelae, ISS or death.

Analyzing the 50 victims of four-wheel accidents for adequacy of security measure use: 29 had adequate individual security measures (58%), 13 did not fulfilled security conditions (26%) and 8 had an unknown status (16%). Descriptive statistics is provided in Table 2. Head trauma occurred in 92.3% of patients without individual security measures and in 65.5% of protected children. In what concerns abdominal injury, it was present in 58.6% of children without appropriate security restraints and in 53.8% of patients with adequate equipment.

Concerning four-wheel vehicles, an association between misuse of protective equipment and increased thoracic trauma was found (p-value=0.047). In this group, lack of individual protective equipment was statistically associated with prolonged hospital stay (p=0.015) and had a strong relation with a higher ISS (p-value=0.083).

On binary analysis, predictors of lack of security equipment were male sex (62.5% vs. 32.8%, p-value=0.013), older age (13 vs. 8, p-value<0.009), absence of adult supervision (63.3% versus 6.7%; p-value<0.001) and the use of two-wheel vehicles (69.0% versus 12.8%; p-value<0.001). Multivariate analysis did not confirm the age or sex effect (Table 3). The model showed that accidents during the night had 5 times more risk for inadequate protective equipment (OR 5.114; 95% CI 1.103-23.716, p-value=0.037) along with two-wheel accidents (OR 5.434; 95%CI 1.001-29.487, p-value=0.048) and, accidents without adult supervision had 15 times more risk for inadequate use (OR 15.386; 95% CI 1.299-183.455), p-value=0.031).

	Odds ratio	95% Confidence interval	p-value
Night Period	5.114	1.103-23.716	0.037
No Adult Supervision	15.386	1.299-183.455	0.031
Two-Wheel Vehicle	5.434	1.001-29.487	0.048

Table 3: Logistic regression model for the probability of protective equipment misuse at the time of the accident.

	Odds Ratio	95% Confidence Interval	p-value
Age, years	0.974	0.852-1.114	0.701
No Adult Supervision	2.461	0.361-16.752	0.357
Protective Equipment Use	0.240	0.058-0.998	0.050
Two-Wheel Vehicle	2.470	0.403-15.135	0.328

Table 4: Logistic regression model for the probability of head trauma after road traffic accident.

	Incidence N=149
Head	122 (81.9%)
Maxilo-Facial	68 (45.6%)
Thoracic	64 (43%)
Abdominal	78 (52.3%)
Hepatic	30 (21.1%)
Renal	14 (9.4%)
Splenic	9 (6%)
Vertebral-Medullar	12 (8.1%)
Pelvis/Extremities	70 (47%)

Table 5: Trauma incidence by anatomical area (described in % for N=149).

When bringing anatomical areas into focus, head trauma was the most frequent (81.9%), associated with diffuse axonal injury in 22% and with neurologic sequelae in 24%. Analysing the whole sample, patients without individual security equipment had a higher incidence of head trauma (p=0.014). Diffuse axonal injury was a significant predictor for neurologic impairment and death (p<0.01). Moreover, diffuse axonal injury was more frequent in four-wheel vehicle accidents than two-wheel vehicles (p=0.058).

Linear regression was made to access the likelihood of head trauma (Table 4), revealing that, when adjusted for other independent factors, the relation between head trauma and protective equipment does not remain statically significant.

Abdominal trauma had an incidence of 52.3% (20% hepatic trauma, 9.4% renal trauma and 6% splenic trauma), of which 19% needed surgery. Trauma by anatomical area is described in Table 5.

Binary analysis found statistically significant relations between ISS increase and lower-GCS scores (Spearman correlation coefficient of -0.675, with p-value<0.001), confirmed by generalized linear model. ISS increase was also correlated with the presence of diffuse axonal lesion and with four-wheel road accidents (both with p-value<0.001).

Median hospital stay was 8 days (range 1 to 420) and surgical treatment was needed in 39%. Children perished in 5.4% of the population (n=8). Of the survival population, 29.5% remained with permanent impairment at hospital discharge and 19% of those developed neurologic long-term sequelae.

Sequelae were more frequent with lower GCS (p-value<0.001), with head trauma (p-value=0.020) and with diffuse axonal lesion (p-value<0.001). On multivariate analysis only GCS and diffuse axonal lesion remained statistically significant contributors for permanent sequelae (p-value<0.001 and p-value=0.026 respectively).

Discussion

Children have an increased susceptibility to road traffic injury, either due to daily road interactions or to a range of other aspects associated with childhood [10]. Globally, road traffic death rate among children is 10.7 per 100 000 population, accounting for nearly 2% of all deaths among children [10]. Despite having a lower incidence in the European Union, road traffic injuries are still the fifth cause of death [11].

In our population there was a relative male dominance which is according to literature, that claims that boys are more likely to be involved in road traffic crashes than girls [1,10,12]. Most of our patients were injured in day-light, similarly to other studies [13], but in a slightly superior ratio comparing to national data (83% vs. 72%). Also consistent with literature review, we found a slightly higher incidence in summer season, coinciding with holiday months [12].

In one-third of our population, children had no adult supervision, which proved to be a significant risk factor for the absence of security equipment. The lack of security equipment was more prevalent in two-wheel vehicles (absence of helmet in 79%) than in four-wheel vehicles (26% inadequate child restraints and seat-belts). Nonetheless, the use was higher than in most studies [12,14,15].

Concerning two-wheel vehicles, all patients with diffuse axonal disease or definitive neurologic impairment did not have helmet at the time of the accident. In four-wheel accidents, absence of adequate child restraints was associated with prolonged hospitalization, with a statistically significant association.

In this study, male sex, older age, night-time accidents, unsupervised children and two-wheel vehicle road accidents were identified as predictors of security equipment misuse.

The type of traumatic mechanism plays an important role, since about 33% of all child deaths worldwide are pedestrians, while 65% are car occupants or bicycle/motorcycle riders [10]. In our sample, 37.6% were pedestrians and 62.5% were vehicle passengers/riders.

Considering that our population has embraced only hospitalized polytraumatized patients, the injury severity scores were as expectedly high, with a median of 50. In agreement with previous studies, head trauma was the most frequent [10], without independent risk factors on multivariate analysis.

Injury sequelae at hospital release were verified in 29.5%, more common with lower GCS and with diffuse axonal lesion, as tested in multivariate analysis. Death was verified in 5.4% of the sample.

Limitations of the present study include sample size restriction, being a single center and registry-based study and also the constraint inherent to a retrospective study.

Conclusion

Our observations suggest that helmet use in two-wheel vehicles needs to be encouraged, if not legislated, to avoid preventable trauma and morbidity. The identification of the population at increased risk of misused protective equipment (older age, male gender and absence of adult supervision) is very important to manage new preventive strategies.

Educational material is also needed to improve young children's parents and adolescents awareness of the dangers of unprotected road traffic injuries. This study corroborates that protective road equipment misuse has a negative significant impact in the outcomes of road traffic injuries in pediatric age.

Author Contributions

MM, FA and MG conceived and designed the study injuries. MM, FJ and SL were involved in data collection for the study. MM wrote the first draft of the manuscript and all authors revised and approved the final document.

Compliance with Ethical Standards

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