Research article

Evaluation of the SEVERITY of FACIAL and GENERAL TRAUMA in child and adolescent victims of traffic accidents

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1. Introduction

In the paediatric population, a high number of factors may be associated with mortality, disability and multiple injuries. In this regard, maxillofacial and cranioencephalic injuries have a significant influence, among which traffic accidents are the most common cause, representing 34.2–57.8% of all cases [1,2,3,4,5]. Such accidents are commonly associated with recklessness and disobeying the local traffic laws [6,7].

To better define the standard summary measure of human trauma, Baker and collaborators in 1974 proposed the creation of the Injury Severity Score based on the Abbreviated Injury Scale [8,9] Some methods, such as the Trauma and Injury Severity Scale (TRISS) [10] offered changes using characteristics such as age, the Glasgow Coma Scale, systolic systemic pressure and respiratory rate to quantify the probability of survival following the consequences of the trauma. Thus, assigning a numerical score that provides a standardized epidemiological profile is of great importance for decisions regarding hospitalization, for improving the proper treatment of injuries and concomitant complications and also for preventing irreversible damage [11,12].

Previous studies performed some adjustments to the TRISS to improve its accuracy [12,13]. One of these was the TRISS peripheral oxygen saturation (TRISS SpO_2), which in emergency situations allows the quality of tissue perfusion in trauma patients to be assessed more quickly and measured more easily compared to the respiratory rate [14]In addition, more specifically in the maxillofacial region, the Facial Injury Severity Scale (FISS) is widely used for classifying the severity of facial injuries, verifying numerical scores for fractures and lacerations in all regions of the face [15,16].

Facial fractures in young people are proportionally rare (5–15%) compared with adults [6,7,17] [–] [21]. However, the singularities of this age group make the treatment a challenge due to the difficulty of the youngest in expressing their symptoms, as well as the influence on anatomical development and the psychosocial influences that trauma causes [19,22,23].

Although an efficient scale has been established to measure patient trauma, it is not possible to accurately determine the severity in paediatric patients. Thus, it is necessary to establish a better measure for more accurate verification of the trauma severity and mortality in paediatric patients [24,25]. This study aims to evaluate the possible relation between the FISS and TRISS SpO2 for facial

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trauma in child and adolescent victims of traffic accidents, and the characteristics associated with each scale, in a referral urgency and emergency hospital in the north of Brazil.

2. Materials and methods

2.1. Study design

A cross-sectional retrospective observational study was carried out based on an analysis of electronic medical data records of cases involving oral and maxillofacial fracture in a referral urgency and emergency hospital in the north of Brazil. The fracture establishments were determined by retrieving computed tomography images and three-dimensional reconstruction. The presented institution receives high complexity trauma, meeting the demands of one of the main cities in the region and supporting 75 neighbouring cities, covering a population of more than 5.5 million people. The study was carried out in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [26].

2.2. Eligibility criteria

Data from medical records of patients aged 0–19 years with maxillofacial traumas and aetiology strictly related to traffic accidents from January 2014 to December 2019 were included. This study defines the group ages according to the World Health Organization (WHO): 0–4 years, early childhood; 5–9 years, late childhood; 10–14 years, early adolescence; 15–19 years, late adolescence [27]. All electronic medical records were used in the research and none were considered inconsistent or incomplete.

2.3. Data collection

Data regarding age, gender, bone fracture [temporal/frontal bone, orbital, zygomatic complex, naso-orbital-ethmoid complex, nasal bone, maxilla and mandible (including fractures of the symphysis, parasymphysis, body, angle, ramus, coronoid, extra-articular condyle and intra-articular condyle)], traffic trauma aetiology (motorcycle, car, cycling, maritime, pedestrian and animal riding accidents), the affected facial third (upper, middle and lower), the FISS, the TRISS SpO2 and hospitalization days to treatment were collected.

The SpO2 was evaluated in this study because it was the measure adopted by the medical team and presented in the electronic medical records.

Ethical approval

The Ethics Committee of approved the realization of the present study (CAAE 34572820.3.0000.0018).

2.4. Severity scales

The FISS is a numerical scale that measures the severity of maxillofacial bone injuries by considering the patient's individual fracture pattern. The scale divides the face into three horizontal thirds (mandible, middle face and upper face) and also incorporates the sum of the size of all lacerations on the face. The score is obtained by the sum of each fracture, and the total sum predicts the hospital length of stay and recovery. The scale assists the communication between clinicians and health professionals in surgical planning as a tool for researching maxillofacial injuries [13]. Among the scales presented in previous studies, the FISS is considered to

Table 1
Types of traffic accidents (%).

Aetiology of traffic accidents	Gender		Age (years)								Total
	Male	Female	0–04		05–09		10–14		15–19		
			Male	Female	Male	Female	Male	Female	Male	Female	
Number of cases	257 (77.88)	73 (22.12)	9 (2.73)	3 (0.91)	11 (3.33)	3 (0.91)	23 (6.97)	11 (3.33)	214 (64.85)	56 (16.97)	330 (100.00)
Motocicle	211 (63.94)	53 (16.06)	1 (0.3)	1 (0.30)	2 (0.61)	1 (0.30)	12 (3.64)	3 (0.91)	196 (59.39)	48 (14.54)	264 (80.00)
Run over	20 (6.06)	11 (3.33)	4 (1.21)	1 (0.30)	5 (1.51)	2 (0.61)	5 (1.51)	4 (1.21)	6 (1.82)	4 (1.21)	31 (9.39)
Maritime	6 (1.82)	4 (1.21)	1 (0.30)	–	2 (0.61)	–	1 (0.30)	1 (0.30)	2 (0.61)	3 (0.91)	10 (3.03)
Car	8 (2.42)	1 (0.30)	1 (0.30)	1 (0.30)	1 (0.30)	–	1 (0.30)	–	5 (1.51)	–	9 (2.73)
Cycling	8 (2.42)	4 (1.21)	–	–	1 (0.30)	–	3 (0.91)	3 (0.91)	4 (1.21)	1 (0.30)	12 (3.64)
Transport animal	4 (1.21)	–	2 (0.61)	–	–	–	–	–	2 (0.61)	–	4 (1.21)

be the most reliable and specific for facial trauma [28].

The TRISS SpO2 offers an accurate and personalized standard approach for assessing trauma care outcome using the original TRISS variation with adjusted coefficients. Anatomical, physiological and age characteristics are used to quantify the probability of survival in relation to the severity of the injury. The values obtained are based on the data for age, the Glasgow Coma Scale, systolic systemic pressure, injury severity score and SpO_2 [10,14].

2.5. Statistical analysis

Averages and percentages are presented as descriptive statistics. Statistical analysis was performed using R statistical software (version 3.0.1). Data normalization of the severity scales involved was performed and the variables were tested using the t-test. The degree of statistical significance was considered to be $p < 0.05$.

3. Results

A total of 93,250 patients who suffered any trauma were reviewed during the research. Among them, 20,516 (22%) were aged 0–19 years. Of these, 537 children and adolescents with oral and/or maxillofacial fractures were admitted, 330 due to traffic accidents. Male patients (257; 77.88%) were more affected than females (73; 22.11%), with a male/female ratio of 3.5:1 (Table 1). Motorcycle accidents were the most commonly reported aetiology (264; 80%), followed by being run over (31; 9.39%) and cycling accidents (12; 3.64%).

Averages of 154.83 cases per year and 2.81 fractures per patient were presented. The middle third of the face was the most affected (578; 62.22%), followed by the lower (280; 30.14%) and upper (71; 7.64%) thirds. When the mandible was observed, the angle (61; 6.57%) and condyle (61; 6.57%) were mostly affected, followed by the body (56; 6.03%) and parasymphysis (56; 6.03%) (Table 2). The mean values obtained on the FISS were 5.20 for male and 4.96 for female. On the TRISS SpO2, the corresponding values were 0.148 for male and 0.160 for female.

To assess general trauma severity, the TRISS SpO_2 was performed. It is observed that when the trauma involves a bicycle accident (0.059) or riding accident (0.058), the mean score is relatively low, with higher values for car accidents (0.242), being run over (0.218), motorcycle accidents (0.136) and maritime accidents (0.135). The FISS, on the other hand, had the highest average values for car accidents (7.00), maritime accidents (6.70), motorcycle accidents (5.25) and being run over (4.39), with the lowest values for accidents involving cycling (3.00) and animal transport (2.75) (Table 3).

In the boxplot of Fig. 1, the TRISS SpO_2 variable has a high concentration of values and a median well below the FISS variable, indicating a significant difference between them that was confirmed with the t-test (Table 4). In addition, it is possible to observe a high number of outliers in the two variables.

The boxplot in Fig. 2 follows the same pattern, indicating a significant difference between the TRISS SpO_2 and FISS in all age groups, the greatest difference between the scales being in the age group of 0–4 years.

After normalization of the scales, the observed averages of the TRISS SpO_2 and FISS variables are 0.1460 and 0.2431, respectively. When looking at age groups, the following averages were obtained for the TRISS SpO_2 and FISS, respectively: 0–4 years, 0.1070 and 0.4140; 5–9 years, 0.1471 and 0.3967; 10–14 years, 0.1274 and 0.2728; and 15–19 years, 0.1511 and 0.2393 (Fig. 2).

The average days of hospitalization showed a relationship with the FISS and TRISS SpO_2: the higher the mean value of the FISS and

Table 2
Number of fracture variables (%).

Fracture variables	Gender		Age (years)								Total
	Male	Female	0–04		05–09		10–14		15–19		
			Male	Female	Male	Female	Male	Female	Male	Female	
Number of fractures	740 (79.65)	189 (20.34)	19 (2.04)	13 (1.40)	30 (3.23)	5 (1.52)	47 (5.06)	26 (2.80)	644 (69.32)	145 (15.61)	929 (100)
Zygomatic	159 (17.12)	39 (4,20)	3 (0,32)	1 (0,11)	7 (0.75)	–	16 (1.72)	6 (0.65)	133 (14.32)	32 (3.44)	198 (21.31)
Mandible	218 (23.47)	58 (6,24)	10 (1,08)	6 (0,65)	10 (1.08)	3(0.32)	11 (1.18)	13 (3,94)	187 (20,13)	36 (3.88)	276 (29.71)
Maxilla	117 (12.59)	25 (2,69)	–	2 (0,22)	2(0.22)	1 (0.11)	4 (0.43)	1 (0,11)	111 (11,95)	21 (2.26)	142 (15.29)
Nasal	49 (5.27)	14 (1.51)	1 (0.11)	1 (0.11)	1 (0.11)	1 (0.11)	4 (0.43)	3 (0.32)	43 (4.63)	9 (0.97)	63 (6.78)
Orbit	75 (8.07)	17 (1.83)	2 (0.22)	1 (011)	4 (0.43)	–	4 (0.43)	2 (0.22)	65 (7.00)	14 (1.51)	92 (9.90)
Naso-orbital-ethmoidal	48 (5.17)	12 (1.29)	2 (0.22)	1 (0.11)	3 (0.32)	–	1 (0.11)	–	42 (4.52)	11 (1.18)	60 (6.46)
Frontal	59 (6.35)	17 (1.83)	1 (0.11)	1 (0.11)	2 (0.22)	–	5 (1.52)	–	51 (5.49)	16 (1.72)	76 (8.18)
Dentoalveolar	15 (1.61%)	7 (0.75%)	–	–	1 (0.11%)	–	2 (0.22%)	1 (0.11%)	12 (1.29%)	6 (0.65%)	22 (2.37%)

Table 3
Study average TRISS SpO2 and FISS in aetiology of traffic accidents.

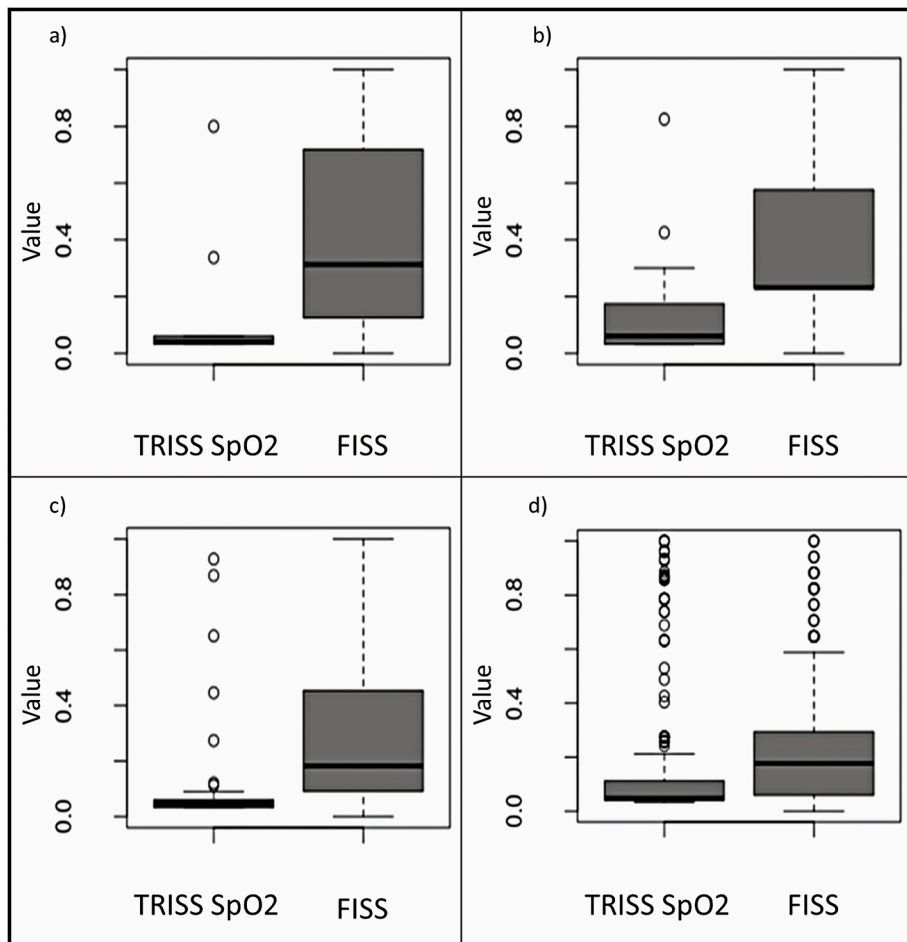| TRISS SpO2 and FISS variables	Gender		Age (years)								Total
	Male	Female	0–4		05–09		10–14		15–19		
			Male	Female	Male	Female	Male	Female	Male	Female	
TRISS SpO2 average											
Score average	0.148	0.160	0.086	0.592	0.178	0.177	0.121	0.200	0.152	0.127	0.151
Motocicle	0.149	0.132	0.031	0.032	0.039	0.060	0.075	0.335	0.155	0.123	0.136
Pedestrian	0.172	0.300	0.137	0.946	0.179	0.236	0.308	0.265	0.077	0.208	0.218
Maritime	0.179	0.069	0.047	–	0.091	–	0.060	0.032	0.393	0.082	0.135
Car	0.173	0.799	0.424	0.799	0.825	–	0.051	–	0.091	–	0.242
Cycling	0.056	0.065	–	–	0.047	–	0.042	0.037	0.068	0.150	0.059
Animal riding	0.058	–	0.047	–	–	–	–	–	0.068	–	0.058
FISS variables											
Score average	5.20	4.96	3.88	8.66	5.18	2.33	3.69	3.54	5.41	5.18	5.14
Motocicle	5.32	4.94	2.00	5.00	2.50	3.00	4.75	5.66	5.40	4.94	5.25
Pedestrian	4.85	3.54	5.00	4.00	4.8	2.00	2.8	2.75	6.5	5.00	4.39
Maritime	6.33	7.25	4.00	–	11.00	–	6.00	5.00	3.00	8.00	6.70
Car	5.75	17.00	4.00	17.00	2.00	–	2.00	–	7.60	–	7.00
Cycling	2.62	3.75	–	–	4.00	–	1.00	2.00	3.50	9.00	3.00
Animal riding	2.75	–	2.50	–	–	–	–	–	3.00	–	2.75
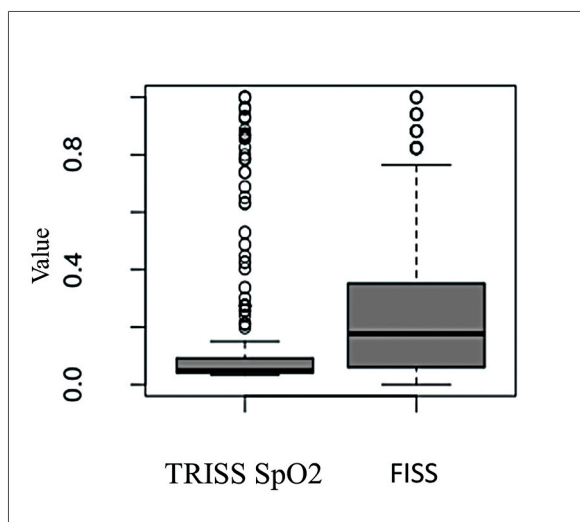
Fig. 1. Boxplot of TRISS SpO$_2$ and FISS variables between 0 and 19 years of age after normalization.

Table 4
t-test for the age variable in a traffic accident.

Age (Years group)	Means		t	p_Valor
	TRISS	FISS		
0–4	0,1070	0,4140	−2998	0,006
5–9	0,1471	0,3967	−3051	0,005
10–14	0,1274	0,2728	−2469	0,016
15–19	0,1511	0,2393	−4193	0,000
0–19	0,1460	0,2431	−5272	0,000

TRISS SpO$_2$, the greater the mean number of days of hospitalization. It can be observed that when the score in the scales is lower, the average number of days of hospitalization is 10.32 days, whereas a maximum score leads to an average of 29.50 days of hospitalization.

Fig. 2. Boxplots of TRISS SpO$_2$ and FISS variables after normalization. a) Boxplots to 0–04 years of age; b) Boxplots to 05–09 years of age; c) Boxplots to 10–14 years of age; d) Boxplots to 15–19 years of age.

4. Discussion

Traffic accidents in children are accepted as one of the leading causes of maxillofacial fractures and a major cause of mortality and disability worldwide [29]. Scoring systems to determine severity in paediatric trauma depend on age and mechanism of injury, as there are significant differences in the physiology of infants, children and adolescents, and their responses to injuries are not the same as in adults [24].

In this study, we showed that the number of facial fractures substantially increased with the age group. We support the view that adolescents' lifestyle is closer to the adult lifestyle, whereas children are less involved in dangerous activities because they are usually under supervision [20,21]. In addition, paediatric craniofacial bone has unique characteristics to protect the facial bones from trauma, being more stable due to the greater elasticity of the bone, the nature of the adipose tissue and the lack of pneumatization of the sinuses, with the unerupted permanent dentition giving additional strength to the jaw bones [29]. Even with a higher number of fractures in the 15–19-year age group of this study, there was no proportionally higher statistical significance for the severity of body trauma with the TRISS SpO2 and facial fracture with the FISS in relation to the other age groups. Among the aetiologies, there is a prevalence of traumas in motorcycle accidents but no absolute prevalence of statistical significance in relation to the other aetiologies.

Our data are also in accord with the very recent evidence supporting males as presenting more fractures than females [20,30] [–] [32]. This may be related to several factors: male participate in activities that are more physical and often are more aggressive than female, involving themselves in a greater number of aetiologies, whereas female are more associated with aetiologies that have less trauma exposure [20,33]. Previous literature has reported that the mean severity of general and maxillofacial trauma is higher in male patients; however, this factor was not observed in our study, where similar means were observed in both males and females on the FISS and TRISS SpO$_2$ scales [34,35].

Studies indicate that injuries to different parts of the body act to increase or decrease the severity of trauma in young people [35]. The present study compared the FISS and TRISS SpO$_2$ scales to verify whether there is a relationship between the severity of trauma on the face and injuries in other regions of the body. In this context, when analyzing severity through two scales – general (TRISS SpO$_2$)

and specific (FISS) – better accuracy and precision can be obtained. This measure makes it possible to verify whether the general significance level of severity is related to local values of severity in a given population, as in the case of the age groups of children and young people.

In this study, a statistically significant difference was observed between the median values of the FISS and TRISS SpO$_2$ severities. Regarding age group, the greatest significant discrepancy was found in children aged 0–4 years, with high local severity significance (FISS) and low overall severity value (TRISS SpO$_2$). This demonstrates that even with a high value observed on a local scale, a high general value will not necessarily be obtained, requiring a more accurate assessment of this relationship.

In this study, mandibular fractures were the most frequently encountered facial fractures in all age groups and this agrees with previously published studies [20,21,36,37]. Condyle and mandibular angle fractures are the most prevalent in the bones of the lower third of the face, mainly in the group aged 0–4 years [21,36,38]. However, orbital fractures involving the walls and floor are more common in patients older than 7 years of age [39].

The aetiology of facial fractures varies depending on social, cultural and environmental factors [40]. Traffic accidents, which are high-energy impacts, are reported as aetiologies with high severity in general and maxillofacial trauma and can be graded within the TRISS SpO$_2$ and FISS scales [35,40,41]. In this study, among the traffic accidents there is a prevalence of motorcycle accidents. The high percentage of male victims aged 15–19 years is noteworthy. There is currently a consensus in the literature that the vast majority of maxillofacial trauma is associated with this aetiology [30] [–] [32]. Children using motorcycles, either as drivers or pillion riders, is a reality in many Brazilian cities and infants are often carried on motorcycles by the driver or another passenger. This makes children and adolescents vulnerable to accidents. Furthermore, many of these individuals do not use crash helmets.

A lack of public transport in the metropolitan area of the city forces the population, especially young people, to use motorcycles and bicycles as a means of public transport, often with little or no safety equipment [28,42,43]. Accidents involving pedestrians are also very common and have a high rate of morbidity due to the relatively small mass of a pedestrian compared to a car, thus offering little resistance and absorbing the energy of the impact [42] The data on aetiology were significantly related to being run over, car accidents and motorcycle accidents in the TRISS SpO$_2$ and to motorcycle and cycling accidents in the FISS, showing a variety of significance within the severity of the trauma according to the means of transport (two- or four-wheel vehicles).

In the countries of Asia, 14.28% of maxillofacial traumas are associated with falls due to animal riding. In these countries, horse breeding is prevalent and is the oldest traditional branch of livestock in Asia [44]. Regarding maritime traffic, in some places this form of transport is commonly used due to the large network of waterways found or used in sporting activities, as in the region of this study. Although accidents are not so common, the absence of safety equipment can lead to an emergency in most cases [45]. In our research, we found significant data on maritime accidents for the TRISS SpO$_2$ in male aged 15–19 years and for the FISS in male aged 5–9 and 10–14 years, showing the great severity of this aetiology.

As with previous studies [7], in traffic accidents the middle third of the face is more affected by facial fractures in children and adolescents, with the zygomatic complex mostly affected [29,46]. In other studies, even the results indicating the same prevalence in relation to age showed a greater number of fractures in the lower third of the face, in contrast to the results of this study. Another point is that the authors report the lower third of the face as more accessible during trauma, but in many cases the victim assumes a defensive position, lowering the chin before facial trauma and making the middle of the face more susceptible to injuries or fractures [19,21,47, 48]. As in this study, other research indicated that more than one-third of the face can be involved in facial trauma, with one or more bone fractures [49].

Considering our study, the severity of maxillofacial trauma according to the FISS in paediatric patients has higher statistical significance than injuries in the rest of the body if we consider the TRISS SpO$_2$ [40]. Regarding severity, greater severity was observed in multiple facial trauma patients, which corroborates with other findings in the literature [31,49]. In this study, mandible fractures had the most numerical significant data, with emphasis on males aged 15–19 years.

Our study corroborates the literature, where patients with the highest means of the TRISS SpO2 and FISS scores also had the highest mean days of hospitalization for treatment [43].

5. Conclusion

We conclude that there is a statistically significant difference in the relationship between the FISS and TRISS SpO$_2$ with general age and between groups of child and adolescents in the aetiology of traffic accidents with facial trauma.

However, this relationship corroborated with more efficiency, amplitude and precision in determining the severity and mortality of these patients.

Author contribution

TBX: literature search, study design, data collection and writing.; CLSM: data collection, writing and data interpretation.; JGRL: data collection, literature search and writing.; LLS: study design, data analysis and data interpretation.; DPF: data collection and writing.; DVM: data collection and data analysis.; MSM: data collection and critical review.; NCN: data collection and critical review.; HARP: study design, writing and critical review

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