

# Study of Risk Factors, Clinical Spectrum, and Outcome for Head Injury in Pediatric Age Group in Western India

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## Abstract

**Aim:** To study various risk factors which leads to head injury, severity of head injury and to compare survival as predicted by the Revised Trauma Score (RTS) and Pediatric Trauma Score (PTS) in pediatric patients admitted in a tertiary care hospital. **Methods:** 300 consecutive pediatric patients below 12 years of age with head injury admitted in our institute were analysed as per a set proforma. Data pertaining to patient's demographic details, mode of injury, computed tomography (CT) findings, type of management, severity of head injury, and outcome were recorded. The results were tabulated and analyzed. RTS and PTS scores were calculated to predict the survival of an individual patient. **Results:** The most commonly affected age group was 1–5 years. Boys outnumbered girls in the incidence. Fall was the most common injury, with road traffic accident being the most common cause of mortality. Skull fracture was the most common CT scan finding. Most of the patients presented with mild head injury (Glasgow Coma Scale 13–15), and they improved with conservative management only. RTS and PTS scores were calculated and were equally effective in predicting the outcome for a particular patient. **Conclusion:** Head injury occurs more commonly in 1–5 years' age group due to fall from unprotected roof tops. The overall prognosis in majority of the cases is excellent. However, road traffic accident shows the highest mortality and hence, we propose to include mode of injury as a variable for designing future predictive outcome models.

**Keywords:** Accidents, child, head injury, trauma severity indices, wounds and injuries/mortality

## INTRODUCTION

In 2013, Centers for Disease Control and Prevention has classified Trauma as a disease.<sup>[1]</sup> As per the World Health Organization, more than nine people die every minute from injuries or violence and 5.8 million people of all ages and economic groups die every year from unintentional injuries and violence.

Trauma ranks as the 4<sup>th</sup> most common cause of death in India, next only to deaths due to cardiac causes, malignant neoplasms, and lower respiratory diseases.<sup>[1,2]</sup>

Trauma affects all age groups; however, it is the leading cause of death and disability in the first four decades of life.<sup>[3]</sup> This age group includes the future generation and major family income providers. It is thus the leading cause of years of productive life loss.<sup>[4]</sup>

Trauma is the second most common cause of mortality and morbidity in children. It is responsible for more deaths than

all diseases combined in pediatric age group. World over the incidence of pediatric head trauma is as high as 50%. However, in India due to sparse studies on this topic and poor logistics issue the exact incidence is not known.<sup>[5]</sup>

Trauma audit involves collection of data and analysing it according to the anatomical region of trauma, severity of trauma and the outcome in terms of survival. Proper evaluation at onset helps in triaging the patients to guide further management and predicting mortality. At every step, vital signs become the guiding parameters to medical and paramedical professionals to determine survival status and outcome of emergency medical care.

With the help of such parameters, medical fraternity all over the world has attempted on devising some form of scoring system that would help in identifying survival outcome.

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Specialists have formulated various scoring systems which are classified as anatomical scoring systems, physiological scoring systems and combined anatomical and physiological scoring systems. The present study is restricted to study based on Revised Trauma Score (RTS) which is a physiological scoring system and Pediatric Trauma Score (PTS) which is a combined anatomical and physiological scoring system. In our study we aim to study the various clinical parameters and compare outcomes of these predictive models as regards to pediatric trauma.

## METHODS

It is an unicentric prospective observational study carried out in our institute. 300 children below the age of 12 years (including neonates) admitted during the period of 2 years (2014-2016), having a history of isolated head injury, are included in the study. Patients treated on outpatient basis or with polytrauma were excluded.

Depending on time and the mode of injury, as per Advanced Trauma Life support (ATLS) protocol following evaluations and interventions were carried out:

1. Primary survey with primary resuscitation
2. Secondary survey
3. Definitive management.

Patient vital parameters and Glasgow Coma Scale (GCS) scores were recorded on admission. X rays were done to rule out cervical spine fracture and other bony injuries. Baseline hematological work up was carried out as routine. The criteria for Computed Tomography Scan (CT scan) was followed as per NICE guidelines. CT scan was performed within 1 hour of the admission.<sup>[6]</sup> A neurosurgery consultation was taken in

all cases and treatment was modified accordingly. Patients requiring cranial exploration were transferred to neurosurgery department and the rest were managed in our department. The cases were followed up till the time of discharge or death after admission. All 300 patients were evaluated by RTS and PTS scoring systems.

To calculate the RTS, the three indicators, including the GCS, systolic blood pressure (SBP), and respiratory rate (RR), were measured, with each divided into four categories and a value between 0 (worst) and 4 (best) was allocated. Codes from Table 1 were multiplied with each index (GCS = 0.9368, SBP = 0.7328, and RR = 0.2908), and the product of the multiplication determined the final value for RTS. The logistic regression used to predict and analyze the outcomes of injury and the probability of survival was calculated based on the standard of RTS.

The PTS was calculated as the sum of individual scores, and its total values varied from -6 to +12. A score of  $\leq 8$  is an indication at prehospital triage to manage patient at dedicated trauma centre, rest were transferred to ward admissions [Table 2].

The means, standard deviations, median, and ranges were calculated for continuous variables. For the categorical variables, proportions were calculated.

Independent t test was used to compare the differences of RTS and PTS outcome mean. The Pearson's correlation coefficient gave us the relationship between the RTS and PTS scores. Receiver operating characteristic (ROC) curve provided the cutoff value for the mortality of each scoring model. Statistical analysis was performed to compare "P" value and  $P < 0.05$  was considered statistically significant.

**Table 1: Revised Trauma Score**

GCS	SBP	RR	Coded value
13-15	>89	10-29	4
9-12	76-89	>29	3
6-8	50-75	6-9	2
4-5	1-49	1-5	1
3	0	0	0

SBP: Systolic blood pressure, RR: Respiratory rate, GCS: Glasgow Coma Scale

**Table 2: Pediatric Trauma Score**

Assessment component	+2	+1	-1
Weight	Weight >20 kg (44lb)	10-20 kg (22-44lb)	<10 kg (<22lb)
Airway	Normal	Oral or nasal airway, Oxygen	Intubated, Circothyroidotomy, or Tracheostomy
Systolic Blood Pressure	>90 mm Hg, good peripheral pulses and perfusion	50-90 mm Hg, Carotid/Femoral pulses palpable	<50 mm Hg, Weak or no pluses
Level of Consciousness	Awake	Obtunded or any loss of consciousness	Coma, Unresponsive
Fracture	None seen or suspected	Single, closed	Open, Multiple
Cutaneous	None visible	Contusion, Abrasion, Laceration <7cm not through fascia	Tissue loss, any gunshot wound or stab wound through fascia

## RESULTS

### Age and sex distribution

The mean age of the study group was 5.02 years with age ranging from the youngest (0.2 years) to the oldest (12 years).

Age group-related survival mortality is shown in Figure 1.

According to Figure 1, head trauma was seen more in the age group of 1-5 years. However, the survival was also better in

the same age group. Mortality was highest in 11–12 years' age group.

According to Figure 2, of the total 300 cases, 182 (60.67%) were boys whereas 118 (39.33%) were girls. It was observed that boys had 1.5 times higher risk of getting head trauma than girls in our study.

**Mode of injury**

This study revealed that fall from height was the most common mode of injury, accounting for 73% of the study cases. Road traffic accidents (17%) was second most common mode of head trauma and this was followed by other causes.

On analysing the mortality data from our study, fall as mode of head injury had better survival than road traffic accident cases [Table 3].

**Computed tomography findings**

Positive CT scan findings were observed in 210 cases of the total 300 cases. Six patients could not undergo a CT scan examination as they were hemodynamically unstable [Figure 3].

The most common CT scan finding in our study was skull fractures followed by hemorrhagic contusion, subdural hematoma (SDH), and extradural hematoma (EDH) in that order.

**Management**

Most of the patients were managed conservatively. Only 15 patients required surgical intervention [Table 4].

**Severity of head injury**

It was seen that most of the head injuries in the pediatric age group have mild head injury (55.33%), which are usually managed conservatively and do not show morbidities on discharge. Only 8% of the patients in the present study had severe head injury [Table 5].

**Final outcome**

In the present study, the final outcome of patients in terms of survival was compared. It was realized that 7% of the patients expired, whereas 93% of the patients survived [Table 6].

**RTS and mortality (in percentage) relationship**

It was observed that RTS and mortality have inverse relationship i.e. as RTS increases, mortality decreases. Nearly 6.3% of the patients showed 100% mortality with a score of 4 and below. The score of 7 and 8 had zero mortality. [Figure 4].

Majority of the patients (92%) had a score of 6 and above and the cumulative mortality in these patients was only 1%.

**PTS and mortality (in percentage) relationship**

PTS score of -3, -1, and 3 showed 100% mortality. At the score of 2, a dip in graph is noticed [Figure 5]. This may be because of two clinical parameters included in PTS i.e. airway and CNS status which are comparatively subjective measures and can differ amongst different examiners.<sup>[6]</sup> None of the patients in our study had a score of -2, 1, 0, and 1. A decreasing trend in mortality is observed as the PTS score increases. For the PTS

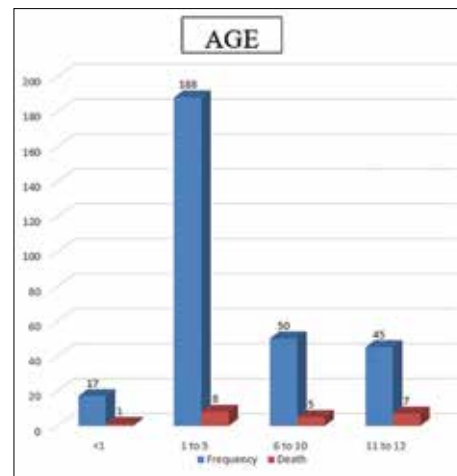


Figure 1: Age distribution

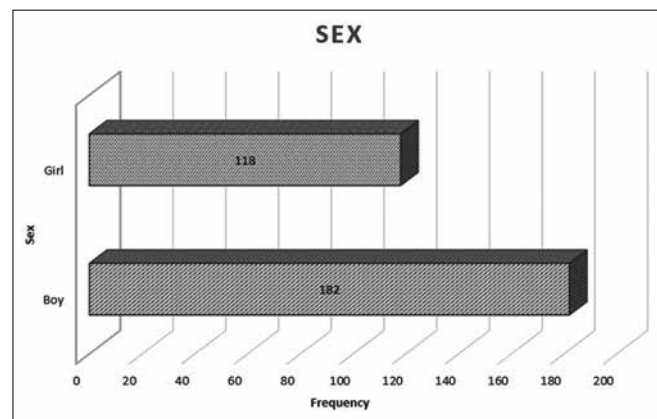


Figure 2: Sex distribution

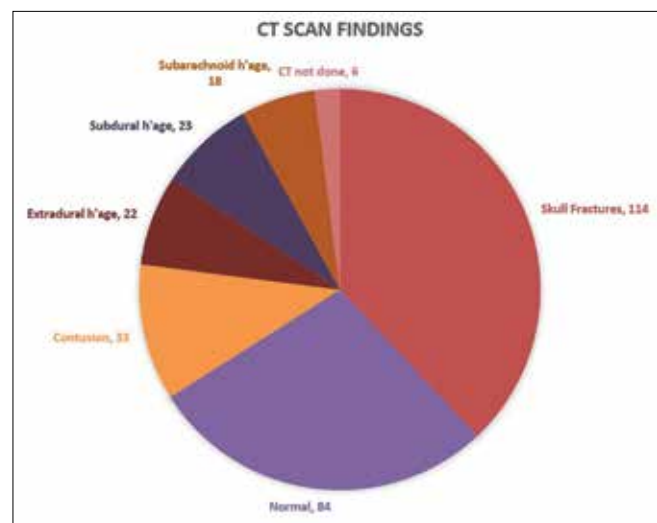


Figure 3: Computed tomography scan findings

score of 7 and above, the mortality was zero. Comparable to our findings with RTS, majority of the patients (92.6%) were found with the score of 6 and above and the cumulative mortality in these patients was only 1%.

Mode of injury	Frequency (%)	Mortality	Percentage of mortality
Fall from height	219 (73)	9	4.11
Road traffic accident	51 (17)	9	17.65
Others	30 (10)	3	10
Total	300 (100)	21	7

Management	Number of patients (%)
Surgery	15 (5)
Conservative	285 (95)
Total	300 (100)

Severity of head injury	GCS	Frequency (%)
Mild	13-15	166 (55.33)
Moderate	9-12	110 (36.67)
Severe	3-8	24 (8)

GCS: Glasgow Coma Scale

Final outcome	Frequency (%)
Survived	279 (93)
Expired	21 (7)
Total	300 (100)

Outcome	N	Mean	Std Deviation	Std Error of Mean	
RTS	Discharge	279	7.29	0.722	0.043
	Death	21	3.19	1.209	0.264
PTS	Discharge	279	9.70	1.614	0.097
	Death	21	2.52	2.272	0.496

**T-test**

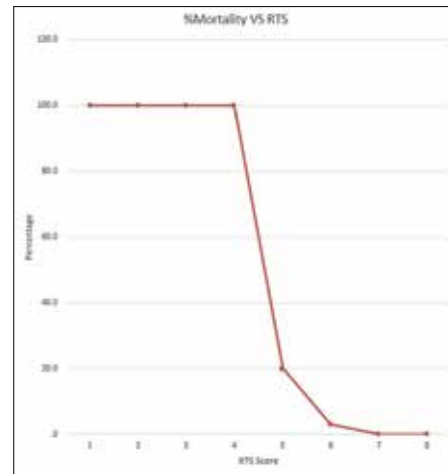
As shown in Tables 7 and 8, RTS and PTS scores when compared with the help of independent t test, shows that these scoring systems are comparable for prediction of mortality and prognosis which is statistically significant. This implies that RTS and PTS model can equally predict the mortality of a patient when used independently.

**Correlations**

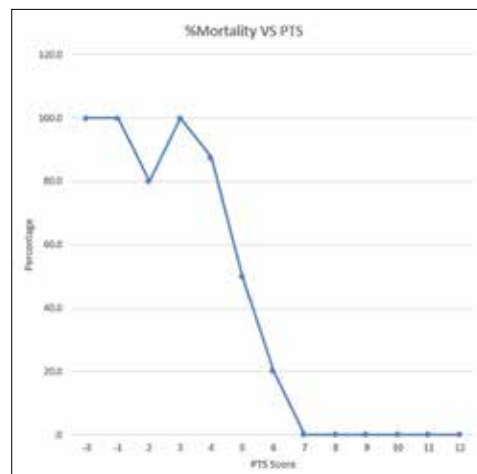
As shown in Tables 9 and 10 with the use of Pearson’s correlation analysis, irrespective of the outcome whether discharge or mortality, RTS and PTS scores showed statistically significant positive correlation.

**Receiver operating characteristic curve**

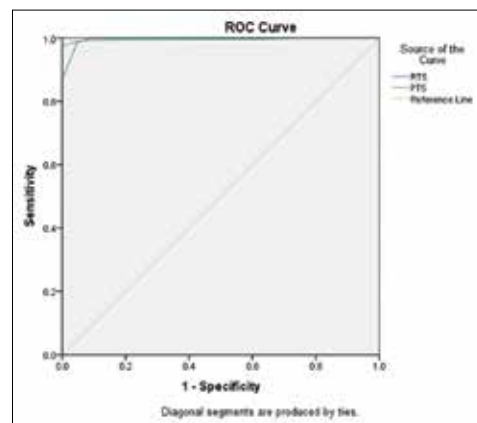
When plotted on a ROC curve, area under the curve for RTS and PTS are equal, which indicates that both the scores are



**Figure 4:** Revised trauma score versus percent mortality



**Figure 5:** Pediatric trauma score versus percent mortality



**Figure 6:** Area under the curve using Receiver operating characteristic (ROC) curve

equally sensitive and specific in predicting the mortality for a patient [Figure 6 and Table 11].

**Receiver operating characteristic cutoff value**

ROC cutoff value in Table 12 shows that for both RTS and PTS, if the scores is <5.5, the risk of mortality increases

**Table 8: 't' test for equality of means**

		t	Df	p-value	Mean Difference	Std Error Difference	Interval of the	
							Lower	Upper
RTS	Equal variance assumed	23.670	298	0.000	4.096	0.173	3.756	4.437
	Equal variance not assumed	15.321	21.088	<0.001	4.096	0.267	3.540	4.652
PTS	Equal variance assumed	19.037	298	<0.001	7.179	0.377	6.437	7.921
	Equal variance not assumed	14.212	21.546	0.000	7.179	0.505	6.130	8.228

**Table 9: Pearson Correlation analysis between RTS and PTS**

		RTS	PTS
RTS	Pearson Correlation (r)	1	0.809*
	P-value		<0.001
	N	300	300
PTS	Pearson Correlation @	0.809*	1
	P-value	<0.001	
	N	300	300

\*Correlation is significant at the 0.01 level

**Table 10: Pearson Correlation analysis for outcome using RTS and PTS**

Outcome			RTS	PTS
Discharge	RTS	Pearson Correlation	1	0.518*
		P-value		<0.001
		N	279	279
	PTS	Pearson Correlation	0.518*	1
		P-value	<0.001	
		N	279	279
Death	RTS	Pearson Correlation	1	0.617*
		P-value		0.003
		N	21	21
	PTS	Pearson Correlation	0.617*	1
		P-value	0.003	
		N	21	21

\*Correlation is significant at the 0.01 level

**Table 11: Analysis to calculate area under the curve using ROC curve**

Test Results Variable (s)	Area	Std Error	Asymptotic Sig.	Asymptotic 95% Confidence Interval	
				Lower	Upper
RTS	0.996	0.004	0.000	0.989	1.000
PTS	0.996	0.003	0.000	0.990	1.000

tremendously. It also explains that ~92% of the patients had a score of 6 and above in both these predictive models which shows cumulative mortality of only 1% amongst them.

## DISCUSSION

In India, children between 1 and 15 years of age constitute about 35% of the total population.<sup>[7]</sup> Head injury in infancy and childhood has been documented as the single most common

cause of death.<sup>[8]</sup> Moreover, the modes of injury, the mechanisms of damage and the management of specific problems in pediatric population differ significantly with that of an adult. Globally, traumatic brain injury (TBI) is a burning issue with an annual incidence of about 200 per 1 lakh per year and a mortality of 20 per 1 lakh per year. In India, Gururaj G. *et al.* (2002) reported the incidence, mortality, and case fatality rates due to TBI as 150 in 1 lakh, 20 in 1 lakh, and 10%, respectively.<sup>[9]</sup> While assessing children with TBI, depth and duration of impaired consciousness, presence of diffuse cerebral edema, cerebral hypoperfusion, brain infarction, and degree of parenchymal injury are the determinants for poor outcome.<sup>[8,10,11]</sup>

In current study sample, the mean age of children with head injury is 5.02 years. This is comparable to the findings of various other Indian studies.<sup>[5,12]</sup>

Age group of 1-5 years was commonly affected in our study. This is similar to a study done by Vikrant<sup>[12]</sup> and Bhargava *et al.*,<sup>[13]</sup> which reflects the fact that because the children in this age group are very active without the fear of consequences, even small amount of carelessness on the part of the caretaker can lead to an injury. However, this finding differs from other studies which shows that age group of 6–12 years is most commonly affected.<sup>[5,14-16]</sup>

Our study shows that age group of 11–12 years had the highest percentage of mortality which is similar to prior literature.<sup>[17]</sup> Whereas other studies show higher mortality in the age group of 1–3 years.<sup>[5]</sup>

As far as our study is concerned, the incidence of head injury in boys (60.67%) is more than that of girls (39.33%). It is observed that boys had 1.5 (1.5:1) times higher risk of getting head trauma than girls, which is comparable to most of the studies conducted except in a study by Vikrant, which showed girls being more affected than boys.<sup>[5,17,12]</sup> Sambasivan has reported an equal incidence in boys and girls in his series on pediatric head injury.

Chiaretti *et al.* hypothesized that the higher incidence of TBI in boys might be due to larger head circumference and more muscular and physical activities in comparison to girls, which we believe is true and might have contributed in our study as well.<sup>[18]</sup>

Fall from height is the most important cause of pediatric head injury, which is seen in comparable literature available.<sup>[13,12,19,20]</sup> However, Osmond *et al.* found a higher incidence of road traffic accident while reviewing severe pediatric head injury

**Table 12: Co-ordinates of the Curve**

Test Results Variables (s)	Positive if Greater Than or Equal to	Sensitivity	1 - Specificity	Specificity
RTS	0.00	1.000	1.000	0.000
	1.50	1.000	0.952	0.048
	2.50	1.000	0.667	0.333
	3.50	1.000	0.429	0.571
	4.50	1.000	0.095	0.905
	5.50	0.986	0.048	0.952
	6.50	0.871	0.000	1.000
	7.50	0.430	0.000	1.000
	9.00	0.000	0.000	1.000
PTS	-4.00	1.000	1.000	0.000
	-2.00	1.000	0.952	0.048
	0.50	1.000	0.810	0.190
	2.50	0.996	0.619	0.381
	3.50	0.996	0.429	0.571
	4.50	0.993	0.095	0.905
	5.50	0.989	0.048	0.952
	6.50	0.975	0.000	1.000
	7.50	0.885	0.000	1.000
	8.50	0.774	0.000	1.000
	9.50	0.642	0.000	1.000
	10.50	0.366	0.000	1.000
	11.50	0.086	0.000	1.000
13.00	0.000	0.000	1.000	

over a period of 4 years.<sup>[21]</sup> Similarly, Satapathy *et al.* found road traffic accident as the most common mode of head injury in the Indian pediatric population. It is noticed that majority of the children in their study belonged to age group of 10-15 years and this age group shows passion for bicycling and bike riding leading to more road traffic accidents.<sup>[17,19]</sup>

In our study, the most common mode of injury was fall from height (73% of patients), followed by road traffic accident (being hit by a moving vehicle – 17% of patients). These results are similar to the studies conducted in developing countries.<sup>[5,15]</sup>

Whereas in developed countries road traffic accident is most common cause of injury and mortality, along with several other cases of gunshot injuries.<sup>[22]</sup> Likewise road traffic accidents had maximum mortality amongst our cases also.

To put in a nutshell, fall from height is associated with mild head injury and road traffic accidents cause grave head injuries often leading to mortality. Hence more than often mode of injury can predict outcome in a case of pediatric head injury and we highly recommend that mode of injury should also be included as a parameter in future predictive outcome models.

The most common CT scan finding in children was skull fracture, accounting to 38% followed by contusion (11%) SDH (7.7%), and EDH (7.3%). The study by Vikrant<sup>[12]</sup> showed similar findings, with skull fractures being the most common CT findings. In few studies, EDH was the most common CT scan finding, whereas other studies reported contusion as the most common finding.<sup>[13,17,19]</sup> A normal CT scan finding was

seen in 28% cases in our study, 16.3% by Satapathy *et al.*, and 13.48% by Mahapatra *et al.*<sup>[17,19]</sup>

An overwhelming majority of patients recovered well with conservative management, indicating a good prognosis in mild-to-moderate head injury in children <12 years. GCS for children at presentation is generally good as they have open fontanels and better ability to cope with head trauma as the intra-cranial pressure does not rise with mild to moderate head trauma.<sup>[12]</sup>

In our study, conservative management (95%) far exceeds craniotomies (5%), owing to a large number of cases (55.33%) of mild head injury (GCS 13–15). We achieved a good recovery in majority of cases which is comparable to other studies.<sup>[13,17,20]</sup>

In terms of final outcome, mortality was low (7%), and 93% of children survived the head injury and were discharged. The severity of head injury was directly related to mortality and inversely related to a better outcome.<sup>[13,20]</sup> A mortality of 20%–50% has been reported for severe head injury.<sup>[19]</sup>

Our institute being a tertiary care centre, mortality is observed due to delayed presentation of patients after being referred from primary health centres and private hospitals where facilities to manage such cases are not present. Also, low socioeconomic status, illiterate parents finding difficult to take important decisions and unpreparedness for the surgery in time contributed to mortality.

It was observed that RTS and mortality have inverse relationship. Nearly 6.3% of the patients showed 100% mortality with a

score of 4 and below. The score of 7 and 8 had zero mortality. Majority of the patients (92%) had a score of 6 and above and the cumulative mortality in these patients is only 1%.

Similarly, there was a decreasing trend in mortality as with increasing PTS score. There was 100% mortality for PTS scores -3, -1, and 3 whereas for score of 7 and above, the mortality was zero.

Moreover, like RTS score, 92.6% of the patients were found to have a score of 6 and above in the PTS score and amongst them, there is only 1% of cumulative mortality.

This shows that both RTS and PTS scoring systems can be used independently in predicting outcome.

RTS and PTS scoring system also show positive correlation. To summarize if RTS predicts mortality for a patient, there are high chances that PTS will also predict mortality for that particular patient. This has been shown in our study by Pearson's correlation.

A ROC curve when charted also shows that the area under the curve is equal for both the scoring systems, that is both the scores are equally sensitive and specific in predicting the outcome for a particular patient.

Similar results were found in a study conducted by Eichelberger *et al.*,<sup>[23]</sup> which states that RTS and PTS are equally sensitive and specific indicators for pediatric prehospital triage.

Except for this study, we were unable to find any literature comparing these two scoring systems. The uniqueness of our study is that we have attempted to correlate both the scoring systems in a developing country like India with a large pediatric population living in low socio-economic condition.

## CONCLUSION

Trauma is one of the most common causes of mortality in children and fall from height is a very common mode of injury. Boys are more commonly the victims than girls. The prognosis in most of the cases of mild-to-moderate head trauma cases is excellent if referred early to a tertiary care center. The individual can be subsequently treated on the basis of the primary lesion with the objective to prevent the ongoing biomechanical, physiological, and pathological sequels owing to head injury. Timely investigation to establish intracranial pathology and early surgical intervention can lead to a good outcome. Fall from height is the most common mode of injury in the pediatric age group followed by road traffic accident, but percentage of mortality is seen more in road traffic accidents. This indicates that mode of injury should also be included as a parameter to predict the outcome of pediatric head injury. Even within the immature brain, there seems to be time-dependent responses following TBI in children. Most of these injuries are preventable by having a proper housing systems with grills and by ensuring proper education and vigilance by the parents and the caretaker. Both RTS and PTS scores are good prognostic evaluators of survival. Thus, both the scoring systems can be used independently to predict the final outcome.

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## Conflicts of interest

There are no conflicts of interest.

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