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Original Article

Risk factors and patterns of traumatic dental injuries among Indian adolescents

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Abstract *Background/purpose:* Dental injuries in children have functional, esthetic, and psychological effects, with consequences for the child, parent, and dentist. This study assessed the pattern of traumatic dental injuries and their relationship with predisposing factors among 12- and 15-year-old school children in Kanpur, India.
Materials and methods: A cross-sectional study was conducted on 1100 boys and girls aged 12 or 15 years. Anterior permanent teeth were examined based on the modified Ellis classification. Type of damage, size of incisal overjet, and adequacy of lip coverage were also recorded. Chi-square tests and multiple regression analysis were used for statistical analysis.
Results: The prevalence of traumatic dental injuries to anterior teeth was 10.9%. Age and gender distribution indicated that most injuries occurred in 15-year-old age group (11.3%) and among boys (11.5%). The gender-related difference was statistically significant ($p < 0.024$). Maxillary central incisors (83.7%) were frequently involved. The predominant injury type was enamel fracture (68.3%) mainly due to falls (52.5%). Increased overjet, inadequate lip coverage, type of school, and gender were significant contributing factors for traumatic dental injuries.
Conclusion: Study reveals the frequency and cause of traumatic injuries to anterior teeth, which assists in identifying risk groups and treatment needs in order to establish effective preventive strategies.

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Introduction

When a condition is predominant, significantly affects the individual, involves considerable social expenses, and is preventable,[1] it should be considered as a public health concern. Traumatic dental injuries (TDIs) fit these criteria. Their prevalence has increased over the last few decades, and thus there is a need to gain insight into the causes, preventions, and effective treatments of these injuries.[2,3]

Most dental injuries involving the anterior teeth result from simple falls, accidents, sports activities, or childish pranks, which were not intended to cause harm.[2–4] Dental injuries can cause esthetic, psychological, social, functional, and therapeutic problems, both at the time of the mishap, as well as later during treatment.[5] Children with TDIs can experience emotional stress, teasing, and distress, influencing their self-image.[6–8] Moreover, there is a relationship between dental issues and scholastic accomplishment and learning in children.[9]

The prevalence of TDIs to the anterior teeth among schoolchildren has been found to vary greatly across different regions. It has been reported that 4%—58% of individuals experience TDIs during childhood or adolescence.[3,4] This variability may have various causes, including the type of study, trauma classification, strategy, study size and population, geographical area, and contrasts in cultural behavior.[4] Additionally, an increase in recorded violence also contributes to the escalating prevalence of TDIs.[4]

Nevertheless, most previous investigations of the epidemiology of TDIs have not provided adequate details of the causes of TDI that would allow prioritization of the causal factors in terms of prevention. In most previous studies, increased overjet, incompetent lip coverage, and maxillary incisor protrusion have been considered to have a relationship with the occurrence of TDIs.[10–12] There are complex interactions of these oral risk factors with environmental factors and individual practices, which together explain the multifaceted nature of the etiology of dental trauma.

Although epidemiological data on TDI have been gathered in many countries, no information on this problem is available for Kanpur population in India. Variations in prevalence rates both between and within countries imply information obtained elsewhere cannot be generalized to this region. Given the negative impact of TDI, it is important to elucidate the causes and risk factors of TDI, so as to prevent its occurrence. Therefore, the present investigation set out to obtain detailed insights into the pattern and risk factors associated with TDI in Kanpur, India.

Materials and methods

Study population

This cross-sectional descriptive study surveyed 1100 adolescents, aged 12 and 15 years, from July 2016 to October 2016. Subjects willing to participate, who were permanent residents of Kanpur, India, and who lacked any obvious dental or facial anomalies were included in the study. Children with permanent anterior teeth lost due to caries or causes other than trauma, or with partial or complete anodontia involving permanent anterior teeth, were excluded. Medically compromised children, children with physical impediments, and/or mental disability were also excluded from the study.

Ethical approval

The survey procedure was approved by the relevant institutional ethics committee. Before the start of the investigation, a list of all senior secondary schools of Kanpur city was obtained from the District Education Office (DEO), Kanpur. Permission for performing the study was also obtained from the respective Heads of the selected schools. Subjects who individually assented to take part also had their parents sign a consent form.

Calculation of sample size

A required sample size of 1046 was estimated, based on a prevalence of TDI of around 10—15% reported in earlier Indian studies and at a confidence level of 95%, with a 2% allowable error. To compensate for potential refusals, the sample size was increased, resulting in a final sample of 1100 children. The study population was enrolled by a two-stage stratified random sampling procedure. In the first stage, Kanpur city was randomly divided into four topographical areas, and five schools from each area were arbitrarily chosen from a list of 93 senior secondary schools. In the second stage, eligible schoolchildren were stratified by age and gender and by using a computer-generated random number table based on the admission registration number of each student in the school, subjects were randomly chosen in order to obtain the final sample size.

Data collection

Data were gathered on a standardized form, which consisted of two sections. The first segment was utilized to gather information on sociodemographic data, while the later section was used to record clinical examination data

and incorporated information obtained via interview regarding the details of the injury event, such as the cause and place of injury. A trained and calibrated clinician, with the help of a recording assistant, examined the children at school, under natural daylight, for TDI to anterior permanent teeth, using the modified version of the Ellis classification (Table 1).[13] This is a simplified classification for recording dental trauma, as injuries to the alveolar socket and fractures of the jaws or laceration of the gingival or oral mucosa were not evaluated. Children were verbally asked to state the cause of the injury, which was recorded under the categories of fall, collision, traffic incident, violence, unknown, and miscellaneous. The miscellaneous category included biting on hard objects, for example, pencil, pen, etc., and improper use of teeth, such as opening of bobby pins and soft drink tins.

Lip coverage was recorded according to the criteria adopted by Burden.[14] If the lip covered the upper incisors in the rest position, lip coverage was rated as adequate. If the greater part of upper incisors was exposed or lip strain was evident upon closure, lip coverage was rated as inadequate. Maxillary overjet was estimated with the teeth in centric occlusion; the distance from the labio-incisal edge of the most prominent maxillary incisor to the labial surface of the corresponding mandibular incisor was measured using the Community Periodontal Index (CPI) probe, as described in the 2013 WHO Basic Oral Health Survey guidelines.[15] The overjet findings were dichotomized into ≤ 5.5 mm and >5.5 mm. Approximately 10% of children were re-examined; the intra-examiner variability was satisfactory (kappa = 0.78).

Statistical analysis

The documented information was collated in a computer spreadsheet. A master file was created and transferred to data editor of SPSS version 21.0 (SPSS Inc., Chicago, Illinois, USA) for data analysis. The data acquired were deemed appropriate for using parametric tests, since the results were normally distributed. Chi-square tests were used to evaluate any difference in the distribution of TDIs according to the children's age and gender. Stepwise multiple regression analysis was executed to estimate the potential risk factors for TDI. For all tests, confidence intervals and p values were established at 95% and <0.05 respectively.

Results

A total of 1100 school children, 572 (52%) boys and 528 (48%) girls, were examined and those affected were personally interviewed regarding TDI. One-hundred-and-twenty children showed signs of previous TDI, equating to a prevalence of 10.9%. Age distribution analysis indicated that these injuries were more common in 15-year-olds (11.3%) than in 12-year-olds (10.6%) children, but the difference was not statistically significant ($p = 0.065$). Similarly, TDIs were more common among boys (11.5%) than girls (10.2%); this difference was statistically significant ($p < 0.024$). Boys were 1.24 times (95% CI = 0.94, 1.54) more prone to TDI than girls. In comparing the schools, the prevalence of TDI was significantly higher in private (12.8%) than in government (8.8%) schools ($p = 0.042$). Children with inadequate lip coverage had 4.64 times greater chance of suffering trauma to permanent teeth than those with adequate lip coverage (odd's ratio, OR = 4.64; 95% CI = 3.92, 5.36; $p = 0.023$). In terms of overjet (>5.5 mm vs ≤ 5.5 mm), 27.3% and 7.8% showed TDI to the anterior teeth, respectively (Table 2) which was statistically significant ($p = 0.040$).

The present study demonstrated that children representing from the upper socioeconomic echelons had higher rates of TDI (11.8%), followed by those from the middle and lower socioeconomic echelons (7.1%); this difference was found to be statistically significant ($p = 0.035$) (Table 3).

Among boys and girls, TDIs were reported among 55% and 45%, respectively. Type 1 (enamel) fracture (68.3%) was the most common type of tooth fracture (Table 4), followed by Type 2 (enamel and dentin) fracture (21.7%), and Type 3 (enamel and dentin with pulp) fractures (3.3%). Type 1 fractures were significantly ($p = 0.041$) more common among girls (72.2%) than boys (65.2%). Non-vital teeth and tooth loss (3% each) were more often reported among boys and were statistically not significant. A few girls (3.7%) had fractures and restorations indicating that they had undergone treatment.

The total number of affected teeth among TDI-positive children was 141 (Table 5). Boys (58.2%) more often had

Table 1 The modified Ellis classification criteria for scoring traumatic dental injuries.

Code	Criteria	Description
0	No Trauma	
1	Enamel fracture	Simple fracture of crown, enamel only; involving little or no dentine
2	Enamel and dentine fracture	Extensive fracture of the crown involving considerable dentine but with no pulp involvement
3	Enamel and dentine fracture with pulp	Extensive fracture of the crown involving considerable dentine and exposing dental pulp
4	Non- vital tooth with discoloration	Traumatized tooth that is non-vital, and is discolored, with or without loss of crown structure
5	Displacement	Extrusion, intrusion, or lateral displacement
6	Total tooth loss	Absence of tooth due to complete ex-articulation
7	Fracture and restoration	Restored tooth with composite or crown following fracture of the crown

Table 2 Distribution of traumatic dental injuries in the study population.

Variables	Children examined n (%)	Traumatic Dental Injury		OR (95% CI)	p—value
		Absent n (%)	Present n (%)		
Age (years)					
12	594 (54.0)	531 (89.4)	63 (10.6)	1.12 (0.76, 1.48)	0.065
15	506 (46.0)	449 (88.7)	57 (11.3)		
Gender					
Boys	572 (52.0)	506 (88.5)	66 (11.5)	1.24 (0.94, 1.54)	0.024*
Girls	528 (48.0)	474 (89.8)	54 (10.2)		
Type of school					
Government	520 (47.3)	474 (91.2)	46 (8.8)	1.48 (1.26, 1.70)	0.042*
Private	580 (52.7)	506 (87.2)	74 (12.8)		
Lip coverage					
Adequate	981 (89.2)	891 (90.8)	90 (9.2)	4.64 (3.92, 5.36)	0.023*
Inadequate	119 (10.8)	89 (74.8)	30 (25.2)		
Overjet					
$\leq$5.5 mm	924 (84.0)	852 (92.2)	72 (7.8)	2.98 (2.65, 3.31)	0.040*
$>$5.5 mm	176 (16.0)	128 (72.7)	48 (27.3)		
Total	**1100 (100)**	**980 (89.1)**	**120 (10.9)**		

OR - Odds Ratio, CI- Confidence Interval,
* $p<0.05$ Statistically significant.

Table 3 Distribution of traumatic dental injuries according to socio economic status.

Socio economic status	Children examined n (%)	Traumatic Dental Injuries		p—value
		Absent n (%)	Present n (%)	
Upper (I)	339 (30.8)	299 (88.2)	40 (11.8)	0.035*
Upper Middle (II)	371 (33.7)	331 (89.2)	40 (10.8)	
Lower Middle (III)	258 (23.5)	230 (89.1)	28 (10.9)	
Upper Lower (IV)	104 (9.5)	94 (90.4)	10 (9.6)	
Lower (V)	28 (2.5)	26 (92.9)	02 (7.1)	
Total	1100 (100)	980 (89.1)	120 (10.9)	

* $p<0.05$ Statistically significant.

Table 4 Distribution of different types of traumatic dental injury (TDI) according to gender.

Types of TDI	Boys n (%)	Girls n (%)	Total n (%)	χ value	p—value
1	43 (65.2)	39 (72.2)	82 (68.3)	7.241	0.041*
2	16 (24.2)	10 (18.5)	26 (21.7)	4.321	0.050*
3	3 (4.5)	1 (1.9)	4 (3.3)	1.324	0.082
4	2 (3.0)	1 (1.9)	3 (2.5)	1.265	0.067
5	0 (0)	0 (0)	0 (0)	—	—
6	2 (3.0)	1 (1.9)	3 (2.5)	1.201	0.084
7	0 (0)	2 (3.7)	2 (1.7)	—	—
Total	**66 (55)**	**54 (45)**	**120 (100)**	**10.201**	**0.035***

* $p<0.05$ Statistically significant.

numerous teeth affected than girls (41.8%) which was statistically significantly ($p = 0.023$). Maxillary central incisors were the most frequently affected teeth (83.7%), followed by maxillary lateral incisors (14.9%) and mandibular central incisors (1.4%). The type of tooth/teeth involved did not demonstrate any significance between the gender.

The most common cause of TDI was falling (52.5%) and sports (19.2%); both of these were statistically significantly more common causes of TDI (Table 6). This was followed by collisions (16.7%) and traffic accidents (5%). Three children could not remember the cause of the TDI. The least reported cause was miscellaneous (holding pen/pencil in their mouth, opening a soft drink tin with their teeth, etc.).

Stepwise multiple linear regression analysis was performed to evaluate the relationship between TDI, as dependent variable, and other independent variables

Table 5 Type of teeth involved in traumatic dental injuries according to gender.

Type of teeth	Boys n (%)	Girls n (%)	Total n (%)	χ value	p−value
Maxillary Central incisors	67 (81.7)	51 (86.4)	118 (83.7)	3.258	0.083
Maxillary Lateral incisors	13 (15.9)	8 (13.6)	21 (14.9)	0.053	0.214
Mandibular Central incisors	2 (2.4)	0 (0)	02 (1.4)	–	–
Mandibular Lateral incisors	0 (0)	0 (0)	0 (0)	–	–
Others (Maxillary and Mandibular canines)	0 (0)	0 (0)	0 (0)	–	–
Total	**82 (58.2)**	**59 (41.8)**	**141 (100)**	**7.012**	**0.023***

* $p<0.05$ Statistically significant.

Table 6 Causes of traumatic dental injuries according to gender.

Variables	Boys n (%)	Girls n (%)	Total n (%)	χ value	p−value
Falls	32 (48.5)	31 (57.4)	63 (52.5)	4.367	0.041*
Collision	11 (16.7)	9 (16.7)	20 (16.7)	1.254	0.245
Traffic incident	3 (4.5)	3 (5.6)	06 (5.0)	0.054	0.324
Sports	13 (19.7)	10 (18.5)	23 (19.2)	4.896	0.032*
Violence	3 (4.5)	0 (0)	03 (2.5)	–	–
Unknown	2 (3.0)	1 (1.9)	03 (2.5)	1.201	0.634
Miscellaneous	2 (3.0)	0 (0)	02 (1.6)	–	–
Total	**66 (55)**	**54 (45)**	**120 (100)**	**5.012**	**0.005***

* $p<0.05$ Statistically significant.

(Table 7). As risk factors for TDI, lip coverage, followed by overjet, type of school, and gender were identified. The amount of variance obtained for these risk factors was 3.5%, 7.3%, 9.1%, and 10.3% respectively. Based on the F and p-values, all the above predictors were found to be statistically significant.

Discussion

For the present investigation, the WHO index age groups of 12 and 15 years was chosen, as there is maximum physiological growth and development during this period and children are typically actively involved in many outdoor activities. In various epidemiological studies, the prevalence of TDI has been found to differ considerably, ranging from 4% to 58%.[4] In the present study, the prevalence of TDI to anterior permanent teeth was 10.9% in 12- and 15-year-old school children in Kanpur. This proportion was somewhat lower than the 13.8% reported by Gupta et al.,[16] 14.5% reported by Dua and Sharma,[17] 14.9% reported by Baldava and Anup,[18] and 15.1% reported by Ravishankar et al.[19] among children of a similar age, at different locations in India. Soriano et al.[20] reported a prevalence of 23.3%. A low prevalence of 4.1% and 4.15% were reported in the studies conducted by Nik-Hussein[21] and Gupta et al.[22] respectively, 8.79% was reported by Patel and Sujan,[11] and 9.3% was reported by Ain et al.[23] These variations in prevalence may be related to the study design, sample size, sampling procedure, diagnostic criteria, limited age-groups, and geographical and behavioral differences between the study locations.[10]

Studies have consistently shown that male individuals have a higher chance of TDI than female individuals.[11,24,25] Similarly, the prevalence of TDI was higher in boys than in girls in the present study. Typically, boys are more active and perform physical activities requiring more strength, such as contact sports, fights, and rough play, and use toys and equipment with a higher risk potential and without adequate protection. The distinction might be because of the restricted behavior of girls, enforced by conservative parents due to cultural and social conditions in India. In addition, the fact that pubertal development is postponed in boys, so that girls are more mature in nature at an earlier age than boys, could also be a factor.[11,19] This dissimilarity might be reduced or may even disappear due to the societal changes with greater participation of girls in contact sports and play, which was previously typical of boys.

Table 7 Stepwise multiple linear regression analysis with traumatic dental injury (TDI) as dependent variable.

Model	R	R^2	F− value	p−value
TDI				
1	0.187[a]	0.035	15.748	0.001[a]
2	0.270[b]	0.073	14.646	0.001[b]
3	0.301[c]	0.091	12.015	0.001[c]
4	0.320[d]	0.103	11.354	0.001[d]

R = Correlation coefficient, R^2 = Coefficient of determination.
[a] Predictors: (Constant), lip coverage.
[b] Predictors: (Constant), lip coverage, overjet.
[c] Predictors: (Constant), lip coverage, overjet, type of school.
[d] Predictors: (Constant), lip coverage, overjet, type of school, gender.

The prevalence of TDI increased with increasing age, as shown in the present study with most injuries occurring in children aged 15 years. The possible explanation for this is that, as the child grows older, the number of injuries increase due to the accumulated impacts from sports, violence, collision, and biting on hard objects. Some other previous studies showed similar results.[26–28]

In the present study population, the prevalence of dental trauma was 8.8% and 12.8% among children in government and private schools, respectively. In a sample analyzed in Brasília, the prevalence was 14.63% in public schools and 23.4% in private schools.[29] These values were relatively high as compared with those in the present study involving the same type of population and age group.

Inadequate lip coverage has been considered as the most critical, independent risk factor for the occurrence of TDIs to the anterior teeth.[2,30] The present study revealed similar results, since students with inadequate lip coverage had a 4.64 times greater risk of having trauma to permanent teeth than those with adequate lip coverage. Competent lips provide a cushioning effect, whereas lip incompetence decreases incisor protection, and thus leaves the incisors more vulnerable to trauma.[31]

The cause of injury may vary according to gender, age, climate, and socioeconomic status of the children. The most frequent causes for TDI in the present study were falls, sports, and collisions. The results are in accordance with a study conducted by Rai and Munshi[32] and also with the study conducted by Dua and Sharma;[17] these studies found "fall" to be the most common cause of TDI. Comparable results were reported in previous investigations in other countries.[33–35] However, the cause of TDI could not be identified in 2.5% of the TDI children. This percentage of unknown causes may be related to unreported violence, especially domestic violence.[34] Violence has also been suggested as a reason for the greater number of TDIs among boys. On numerous occasions, children were hesitant to reveal the cause of the injury, suggesting that the proportion due to violence may be underestimated. Additionally, some children were simply not able to recall the history of the injury, and this was particularly true when the fractures were not so severe and involved only the enamel. This finding was in accordance with a previous study of Chopra et al.[36]

This study showed that maxillary teeth were more frequently traumatized than mandibular teeth; this is also commonly reported in the existing literature.[1,21,26] The most frequently affected teeth are maxillary central incisors. This probably relates to the vulnerable position of these teeth. A blow to the maxillary incisors is also more often damaging than a blow to the mandibular incisors, as the force of the latter is dissipated due to the non-rigid connection of the mandible to the cranial base.[11] In addition, these teeth frequently protrude and may have insufficient coverage by the lips.

In the present investigation the most common TDI type was enamel fracture. This finding corroborated those of previous studies,[16,21,37–39] but differed from that of Rajab et al.[40] where the most common type of crown injury was enamel and dentin fracture. No cases of displacement were encountered in the present study. The difference between the types of fractures observed in this investigation and those observed in previous studies might be due to the distinctive criteria utilized and the examination locale, i.e., in the hospital or in the field.[4]

Treatment for trauma was received by a mere 1.7% of the children, which demonstrated a high and unmet need for treatment. Lack of adequate knowledge and valid motivation, exacerbated by financial limitations, could clarify the high level of untreated injuries.

The connection between overjet with TDI has been explored broadly by different authors and has yielded conflicting results. In this study, children with overjet more prominent than 5 mm exhibited a significant association with and higher risk of TDIs than those with typical overjet. Other studies have also demonstrated this relationship.[41–44] Patel and Sujan[11] have observed an average 3.5-fold increased risk of sustaining trauma to the anterior teeth among individuals with an overjet exceeding 3.5 mm. Petti et al.[45] reported that individuals with overjet exceeding 3 mm had a 2.5-fold higher risk of TDI than individuals who had a normal overjet. Stokes et al.[46] also found a significant difference in the mean overjet sizes between a TDI group and a control group. The varied results might be a due to the different populations, sample sizes, available resources, intraexaminer consistency, reliability, etc., among studies. Traebert et al.[47] did not find any relationship between inadequate lip coverage and TDI in their investigation. Glendor revealed that these varying outcomes might be because of the interplay between oral predisposing factors and environmental and behavioral factors.[12]

In the present study, socioeconomic stratification was performed based on Kuppuswamy's Socio-Economic Status Scale (revised in 2018). As Kuppuswamy's socioeconomic status is determined by a summation of education, occupation, and income, the value system for a particular level of education and occupation can be predicted. An updated version of the Kuppuswamy Scale was utilized because of the increase in the consumer price index.[48] Socioeconomic status has been associated with several oral diseases and conditions, such as dental caries, periodontal diseases, tooth loss, and oral cancer. Nevertheless, the association between TDI and socio-economic indicators remains unclear.[34,42,49] Although some researchers have reported that schoolchildren with lower socioeconomic status are more likely to suffer TDIs,[11,20,42,50] others have shown an inverse correlation, with children of higher socio-economic status having a higher risk of TDIs.[20] This is explained by the fact that a higher socioeconomic level is associated with greater access to leisure goods and equipment, such as bicycles, skates, swimming pools, etc., which, when used without safety precaution, may lead to an increased prevalence of TDIs.

The present study had some limitations. The investigation used a cross-sectional design and a retrospective gathering of data on TDIs. Thus, the accuracy of history recalls by the participants, particularly given that they were children, may not be ideal. Nevertheless, cross-sectional investigations are critical devices for identifying risk factors that can be incorporated into further longitudinal evaluations. To comprehend the complexities of dental trauma epidemiology, additional prospective studies are required in representative populations, which can

facilitate implementation of preventive strategies to reduce the frequency of dental trauma.

The results of this study were in accordance with those of many previous studies, which have also emphasized the importance of such data for health policy makers seeking to establish prevention strategies to reduce traumatic facial injuries. The prevalence of TDIs can be reduced if the potential risk factors are identified in time and strategies are directed at behavioral, environmental, and societal changes and are implemented by the health policy makers.

Conflicts of interest

None.

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