REVIEW ARTICLE

Prevalence, Trends, and Associated Risk Factors of Traumatic Dental Injury among Children and Adolescents in India: A Systematic Review and Meta-analysis

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Abstract

Aim and objective: Traumatic dental injury (TDI) is a significant public health concern. This study aimed to perform a systematic review on the prevalence, trends, and possible risk factors of dental trauma in permanent teeth among children and adolescents in India.

Materials and methods: Literature search was carried out, in PubMed, EMBASE, Web of Science, Cochrane, Google scholar, and Gray literature (MDS dissertation, manuscripts) database up to October 5, 2020, reporting on dental trauma prevalence in India. Meta-analyses were done using random effects model. Pooled estimates were calculated with a confidence interval of 95% (95% CI) both for prevalence and odds ratios (OR). Trend analysis was performed for the included studies. Quality assessment of the included studies was done using the Hoy checklist for prevalence studies. Qualitative synthesis was done for predictors in which meta-analysis could not be performed.

Results: This online searching strategy collected and listed 2,491 articles on this topic. After evaluating their titles and abstracts, only 59 were finally selected for complete review and data collection. All studies had been performed in children and adolescents. The pooled prevalence of dental trauma in permanent teeth was 11%. Positive summary association of dental trauma with male gender (pooled OR = 1.52; 95% CI: 1.37–1.70), inadequate lip coverage (pooled OR = 4.76; 95% CI: 3.18–7.11), and increased overjet of >3.5mm (pooled OR = 4.84; 95% CI: 2.86–8.19) and >5.5 mm (pooled OR = 4.93; 95% CI: 4.32–5.63) was observed. Prevalence of dental trauma showed an increasing trend with time. All of the studies were having moderate–high risk of bias.

Conclusion: Approximately 9–13% of the children and adolescents in India presented some type of TDI in permanent teeth, with an increasing trend. Boys, children, and adolescents presenting inadequate lip coverage, or an increased overjet greater than 3.5 and 5.5 mm are more likely to have traumatic dental injuries.

Clinical significance: Future population-based analytical studies on TDI in India are recommended.

Keywords: Adolescent, Children, Dental trauma, Inadequate lip coverage, Overjet, Permanent teeth, Systematic review.

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Introduction

Traumatic dental injury (TDI) is a significant public health concern. It is presumed to be the fifth most prevalent dental disease in the world and around 20% of people suffer from trauma to teeth at some point in their life. A meta-analysis of the worldwide global burden of TDI reported a prevalence of 15.2% in permanent dentition alone.[1] A 12-year review of literature stated that approximately two-thirds of all diagnosed TDIs occurred in children and adolescents.[2] Various population-based studies have been conducted in different states of India to quantify TDI and the prevalence ranged from 2.05[3] to 50%.[4] There has been an increase in the number of observational studies carried out on TDI over the past decade.

Previous studies have shown that, as a consequence of dental tissue trauma, bacterial invasion in the exposed dentinal tubules could lead to pulpal inflammation and subsequent necrosis, resulting in discoloration or sometimes even loss of the tooth. Undoubtedly, TDI can thus negatively affect the psychological development in children and adolescents. Moreover, the treatment is expensive and time-consuming.[5]

TDI is not a disease but a consequence of several unavoidable risk factors in life.[6] Published literature has reported host factors like male gender, increased overjet, inadequate lip coverage, along with environmental factors, such as unsafe playgrounds, risk-taking behavior, and violence, to be mostly associated with TDI.[1,2,6–12] Some studies have observed obesity and socioeconomic factors to be associated with higher incidence and prevalence of TDI in permanent teeth.[10,13]

A previous systematic review included studies for TDI in both primary and permanent dentition, before April 2019 in India.[14] The review has concluded that there is high degree of variability followed by heterogeneity in the data from primary studies. Also, there is a lack of empirical evidence on the measures of trends over the years and other associated factors, such as obesity and socioeconomic status for TDI across urban and rural India. Such major gaps ultimately hinder careful planning, better decision-making, and the development of an effective intervention

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for the prevention and management of TDI. Therefore, the present systematic review and meta-analysis of published literature made an attempt to provide a precise pooled estimate by including a greater number of recent studies and comprehensive assessment of TDI prevalence in permanent dentition, trends, and reliable association of various risk factors among Indian children and adolescents.

Materials and Methods

Study Design and Search Strategy

The present systematic review and meta-analysis were undertaken in accordance with the guidelines of the COSMOS-E: Guidance on conducting systematic reviews and meta-analyses of observational studies of etiology.[15] A comprehensive literature research of online databases, PubMed Medline, Web of Science, Cochrane Central, EMBASE, and Gray literature (MDS dissertation, manuscripts) from inception to October 5, 2020, was conducted. In addition to these electronic searches, the reference lists of key publications or further material were manually searched. Further articles were manually hand-searched from the citation list of the published literature. The studies from these databases were then imported to Mendeley reference manager software for the removal of duplicate titles.

Keywords Included in the Search Strategy for all Six Databases (Title, Abstract, and MeSH Terms of Papers) (Table 1)

(Prevalence OR incidence OR survey OR epidemiology OR "cross sectional" OR Etiology) AND (dental OR teeth OR tooth) AND (trauma OR injury OR fracture OR avulsion OR dislocation OR luxation) AND (child OR children OR adolescents OR young OR school) AND (India).

Study Eligibility Criteria

Population-based observational studies that evaluated the prevalence of TDI in permanent dentition were eligible. The results from conference proceedings, editorials, letters, reviews, and meta-analysis and publications with incomplete data which could not be obtained from the authors were not included. Studies pertaining to primary dentition as well as those reported from nonrepresentative population (athletes, visually impaired or special needs group, studies done exclusively on male and female population) were also excluded from the present meta-analysis.

Study Selection and Data Collection Process

Two independent reviewers (SPN and RHK) screened all the titles of retrieved records from the databases, followed by a screening of abstracts of relevant titles (Kappa score = 0.81). Abstracts were selected if they fulfilled the selection criteria. Any disagreements about selection were discussed with a third reviewer (HR) for resolution. All duplicates were removed after verifying the most recent and complete version. Full-text studies were retrieved for the selected abstracts and additionally reference lists of these studies were searched. The retrieved full-text studies were assessed further to ensure they satisfied the inclusion criteria.

Assessment of Quality in Included Studies

After the full-text screening, all the articles were subjected to risk of bias assessment using a 10-item checklist adapted from Hoy et al. (2012).[16] The selected articles were thus assessed for the representation of the population, sampling, random selection, nonresponse bias, data collected directly from subjects, case definition, reliability and validity of the method used, mode of data collection, and length of shortest prevalence period. Based on the assessment, studies were identified as high, moderate, or low risk.

Data Collection and Extraction

A data collection form was designed in Microsoft Excel to extract and enter the relevant data fields from the selected full-text studies. Data extraction was performed by the two reviewers independently and in duplicate. When needed, authors were contacted to gather missing information. The excel sheet was saved as a comma-separated-values (.csv) file. The data for each included study were then tabulated (Table 2).

Statistical Analysis

Statistical analysis for pooled prevalence and to obtain a forest plot to demonstrate the degree of heterogeneity among the selected articles was performed using R (version 3.0.2) software after extracting data in an excel sheet. Subgroup analyses were further conducted to estimate and verify the influence of studies, by groups, on the pooled results.

Review Manager (Review Manager v. 5.3, The Cochrane Collaboration; Copenhagen, Denmark) was used to obtain forest plots and odds ratio (OR) for associated factors with TDI. The software uses Chi-square, I^2, and Tau^2 to study heterogeneity. The

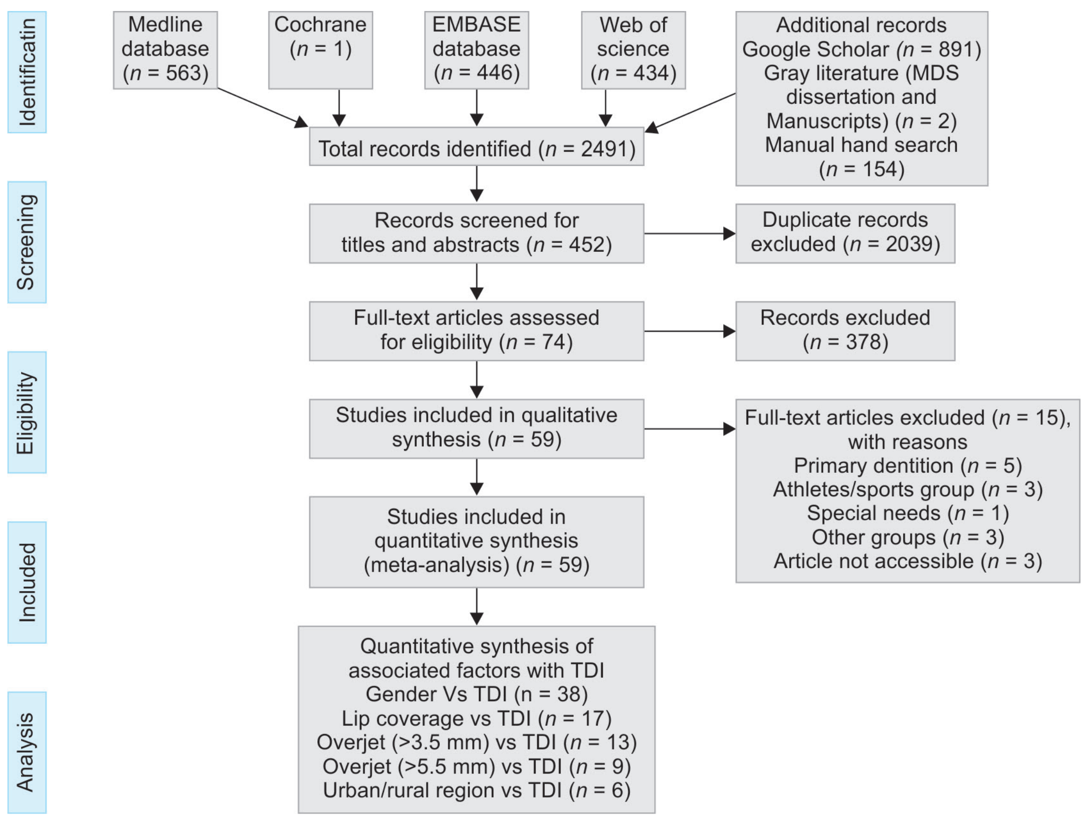
Table 1: Search strategy based on population, exposure, comparison, outcome, and study design (PECOS) criteria

Study design (AND)	*TDI (AND)*	*Associated factors (AND)*	*Population (AND)*
Prevalence	Traumatized teeth	Etiology	School child
Cross-sectional study	Dentoalveolar trauma	Etiology	Child
Epidemiology	Oral trauma	Caus (cause, causation,	Adolescent
Survey	Traumatized incisors	causative factors)	Young
Point estimate	Permanent anterior	Malocclusion	Minor
Cohort analysis	Tooth trauma	Incisor overjet	Young child
Cross sectional analysis	Teeth trauma	Anterior overjet	School students
Observational analysis	Tooth fractures	Risk factors	School
Disease frequency	Teeth fractures	Associated factors	
Cohort Study	Teeth injuries		
Cross-sectional studies	Tooth injuries		
Epidemiologic study Incidence	Traumatic dental injuries		
Longitudinal study	Dental trauma		
Observational study			
Population study			
Prospective study			
Retrospective study			

Table 2: Details of categories under which data were extracted from the included studies

Demographic details	*Study methods*	*TDI prevalence and tooth type*	*Place of occurrence of TDI*	*Cause of TDI*	*Associated factors*
Author last name	Type of study	TDI number	Home	Fall	Gender
Year of publication	Calculated sample size	TDI percentage	Street	Violence	Lip competency
Region of the study	Total sample size taken	Tooth type affected: Number and percentages	Playground	Collision	Overjet
State where the study was conducted	Sampling strategy	Type of Trauma-based on the classification	School	Biting hard	BMI
Journal in which it was published	Evaluation period		School type (Government school/Private school)	Road traffic accidents	Molar relation
	Age-group			Sports	Urban/Rural region
	TDI classification			Cannot remember and others	Socioeconomic status

Flowchart 1: Flow diagram of literature search according to PRISMA statement



p-value was set at <0.05 for the results to be significant. Meta-analysis was performed by using a random effects model due to the variation between the studies.

Trend analysis was done in Microsoft Excel. The Statistical analysis for the given dataset was performed using the "Data analysis toolpak" toolbox from Excel in the "Data" section.

Results

Study Selection

Flowchart 1 shows a flowchart outlining the number of articles identified at each step of the literature search. The searches resulted in 2,491 references in total. The articles were checked for duplicates using the Mendeley reference manager and 2,039 references were excluded in the process. The titles and abstracts of 452 studies were then screened against the inclusion criteria, independently and in duplicate, discarding 378 studies. Additionally, 15 more studies were excluded after quality assessment. Therefore, 59 records met the inclusion criteria for this review.

Study Characteristics

A total of 59 studies (58 cross-sectional studies and 1 case–control study) were included in the final analysis. A total of 162,997 participants provided data for the included studies. All the included studies involved the children and adolescent population. The study characteristics extracted from the included observational studies are described in Table 3.

Quality Assessment

The risk of bias assessment was carried out using the Hoy et al. scale for 59 studies, out of which 47% were at moderate risk and the remaining 53% were at high risk of bias. Low scores were mainly due to lack of representativeness of the sample and proper definition or criteria for TDI. Furthermore, the adjusted odds ratio for associated factors has not been reported adequately. Scores for individual studies are mentioned in Table 4.

Pooled Prevalence of TDI in Permanent Teeth in India

The result of the meta-analysis for pooling the proportion of TDI is graphically represented in Figure 1A. Forest plot of meta-analysis of

Table 3: Study characteristics of the included studies

Author	*Year*	*Region*	*State*	*Age*	*Sample size*	*Study design*	*Sampling strategy*	*Classification*
Gauba[17]	1967	NA	NA	NA	4,296	CS	NA	NA
Rai and Munshi[18]	1998	South Kanara	Karnataka	NA	4,500	CS	NA	NA
Gupta et al.[19]	2002	South Kanara	Karnataka	8–14	2,100	CS	Random sampling	Hargreaves and Craig
Jose and Joseph[20]	2003	Vadavucode	Kerala	12–15	1,068	CS	NA	Clinical examination
Tangade[21]	2007	Belgaum	Karnataka	12–15	3,621	CS	Simple random sampling	WHO
David et al.[22]	2009	Trivandrum	Kerala	12	838	CS	Stratified two stage random cluster sampling	O'Brien
Bharadwaj[23]	2009	Coorg	Karnataka	7–15	4,036	CS	Stratified random sampling	Garcia Godoy
Ravishankar et al.[24]	2010	Davangere	Karnataka	12	1,020	CS	Random sampling	WHO
Gupta et al.[25]	2010	Baddi-barotiwala	Himachal Pradesh	4–15	1,059	CS	Simple random sampling	Modified Ellis and Davies
Ingle et al.[26]	2010	Chennai	Tamil Nadu	11–13	687	CS	Random sampling	Ellis and Davies
Kumar et al.[27]	2011	Ambala	Haryana	NA	963	CS	NA	NA
Naveen et al.[28]	2011	Tandoor	Andhra Pradesh	12	1,020	CS	NA	WHO
Patel and Sujan[29]	2012	Vadodara	Gujarat	8–13	3,708	CS	Multistage sampling technique	Andreason
Govindarajan et al.[30]	2012	Chidambaram	Tamil Nadu	3–13	3,200	CS	Simple random sampling	Ellis and Davies
Ankola et al.[31]	2012	Belgaum	Karnataka	6–11	13,200	CS	Random sampling	WHO
Sharma and Dua[32]	2012	Dera bassi	Punjab	7–12	880	CS	NA	Ellis and Davies
Rajesh et al.[33]	2012	4 states	South India	4–16	30,000	CS	Multistage cluster sampling	Modified Ellis and Davies
Dhingra et al.[34]	2012	Faridabad	Haryana	12–15	1,090	CS	Multistage sampling	Ellis and Davies
Vijaykumar et al.[35]	2013	Bengaluru	Karnataka	10–12	858	CS	Simple random sampling	Clinical examination
Basavaraj et al.[36]	2013	Modinagar	Uttar Pradesh	12–15	900	cs	Two stage cluster sampling	WHO
Chopra et al.[37]	2014	Panchkula	Haryana	12–15	810	CS	Multi stage sampling technique	Ellis mod Holland
Bansode et al.[38]	2014	Aurangabad	Maharashtra	>10	1,000	CS	NA	NA
Krishna murthy et al.[39]	2014	Bengaluru	Karnataka	5–16	2,132	CS	Multistage random sampling	Ellis and Davies
Prasad et al.[40]	2014	Gurgaon	Haryana	12–15	671	CS	Multistage sampling technique	Ellis and Davies
Chandra[41]	2014	Greater Noida	New Delhi	NA	9,074	CS	NA	NA
Vashisth et al.[42]	2014	Kangra	Himachal Pradesh	11–14	1,041	CS	NA	Modified Ellis and Davies

(Contd...)

Table 3: *(Contd...)*

Author	*Year*	*Region*	*State*	*Age*	*Sample size*	*Study design*	*Sampling strategy*	*Classification*
Gojanur et al.[3]	2015	Mathura	Uttar Pradesh	5–8	1,657	CS	Stratified cluster random sampling	Ellis and Davies
Mathur et al.[13]	2015	NCT	New Delhi	12–15	1,386	CS	Multistage sampling technique	Modified O' Brien
Basha et al.[43]	2015	Davangere	Karnataka	6–13	1,550	Nested CS	NA	Andreason
Hegde and Sajnani[44]	2015	Mangaluru	Karnataka	14–70	2,000	CS	NA	WHO
Kirthiga et al.[45]	2015	Davangere	Karnataka	11–16	2,000	CS	Two stage random sampling	Ellis and Davies
Ramaiah and Maraiah[46]	2015	Shivamoga	Karnataka	9–14	1,450	CS	Random sampling	WHO
Singh et al.[47]	2015	Lucknow	Uttar Pradesh	3–17	1,112	CS	NA	Ellis and Davies
Yadav et al.[4]	2015	Bhopal	Madhya Pradesh	12–15	200	CS	Snowball sampling	NA
Ain et al.[48]	2016	NA	Kashmir	12	1,600	CS	Multistage sampling technique	Ellis and Davies
Gupta et al.[49]	2016	Bhopal	Madhya Pradesh	11–15	1,518	CS	Stratified cluster sampling	Andreason and WHO codes
Prasad et al.[50]	2016	West Godavari	Andhra Pradesh	NA	5,203	CS	Simple random sampling	NA
Hegde and Agrawal[51]	2017	Kharagpur-Belapur	Navi Mumbai	9–14	3,012	CS	Stratified random sampling	Andreason
Garg et al.[52]	2017	NA	Delhi	7–14	3,000	CS	Multistage random sampling	Andreason and WHO
Goyal et al.[53]	2017	Dhanganagar	Rajasthan	10–17	3,002	case control	Multistage sampling technique	Ellis and Davies
Shashikiran et al.[54]	2017	Bhopal	Madhya Pradesh	6–12	1,204	CS	Random sampling	WHO
Sharva et al.[55]	2017	Bhopal	Madhya Pradesh	12–15	1,100	CS	Three stage sampling	WHO
Shah and Jeevanandan[56]	2018	Chennai	Tamil Nadu	6–15	108	CS	NA	Clinical examination
Khandelwal et al.[57]	2018	Indore	Madhya Pradesh	3–17	5,000	CS	Random sampling	Ellis and Davies
Saraswathi and Kumar Rathinavelu[58]	2018	Rohtak	Haryana	12	2,000	CS	NA	Ellis and Davies
Juneja et al.[59]	2018	Indore	Madhya Pradesh	8–15	4,000	CS	Multistage random sampling	Modified Ellis and Davies
Bhagat and Singh[60]	2018	Ghaziabad	Uttar Pradesh	12–19	1,819	CS	NA	WHO
Gupta et al.[61]	2018	Jabalpur	Madhya Pradesh	6–15	2,671	CS	Stratified cluster sampling	WHO
Peter and Narayan[62]	2018	Kottayam	Kerala	15–18	930	CS	Multistage sampling	WHO
Dharmani et al.[63]	2019	Patiala	Punjab	8–12	3,000	CS	Simple random sampling	Ellis and Davies
Priyadarshini et al.[64]	2019	Chennai	Tamil Nadu	11–13	825	CS	Simple random sampling	Ellis and Davies
Prasanna et al.[65]	2019	Bengaluru	Karnataka	7–14	3,363	CS	Simple random sampling	WHO TDI
Nagarajappa et al.[66]	2019	Kanpur	Uttar Pradesh	12–15	1,100	CS	Two stage stratified random sampling	Ellis and Davies
Das et al.[67]	2019	Lucknow	Uttar Pradesh	5–16	500	CS	Simple random sampling	Clinical examination
Prakash and Kumari[68]	2019	Patna	Bihar	7–14	2,820	CS	NA	WHO
Shakuntala and Kalpavriksha[69]	2019	Bengaluru	Karnataka	9–14	500	CS	Simple random sampling	Andreason with WHO
Ramachandran et al.[70]	2019	Chettinad	Tamil Nadu	20–73	1,562	CS	NA	WHO
Basak et al.[71]	2020	Siliguri	West Bengal	0–14	780	CS	Cluster sampling	WHO
Lakshmi et al.[72]	2020	Chennai	Tamil Nadu	8–15	7,247	CS	Stratified random sampling	Ellis and Davies

Table 4: Ascertainment of risk of bias in the included studies according to Hoy checklist

Author	*Risk of bias score*
Gojanur et al.[3]	6
Yadav et al.[4]	7
Mathur et al.[13]	5
Ramachandran et al.[70]	7
Prakash and Kumari[68]	7
Das et al.[67]	7
Tangade[21]	6
Khandelwal et al.[57]	5
Garg et al.[52]	7
Gupta et al.[49]	6
Prasad et al.[40]	7
Chopra et al.[37]	6
Basak et al.[71]	6
Patel and Sujan[29]	6
Krishna Murthy et al.[39]	7
Ravishankar et al.[24]	6
Lakshmi et al.[72]	6
Gupta et al.[19]	6
Sharma and Dua[32]	8
Nagarajappa et al.[66]	7
Juneja et al.[59]	6
Shashikiran et al.[54]	8
Bharadwaj[23]	7
Peter and Narayan[62]	7
Basavaraj et al.[36]	7
Sharva et al.[55]	6
Priyadarshini et al.[64]	7
Dhingra et al.[34]	6
Gupta et al.[61]	7
Kirthiga et al.[45]	7
Dharmani et al.[63]	6
Basha et al.[43]	6
Govindarajan et al.[30]	8
Hegde and Agrawal[51]	6
Ain et al.[48]	6
Goyal et al.[73]	7
Saraswathi and Kumar Rathinavelu[58]	7
Ankola et al.[31]	6
Gupta et al.[25]	6
Ramaiah and Maraiah[46]	7
Shakuntala and Kalpavriksha[69]	7
Anegundi et al.[60]	6
Bhagat and Singh[60]	6
Singh et al.[47]	7
David et al.[22]	6
Vijaykumar et al.[35]	6
Prasanna et al.[74]	6
Hegde and Sajnani[44]	7
Shah and Jeevanandan[56]	6
Gauba[17]	8
Rai and Munshi[18]	8
Jose and Joseph[20]	7
Ingle et al.[26]	6
Kumar et al.[27]	7
Naveen et al.[28]	8
Bansode et al.[38]	6
Chandra[41]	8
Vashisth et al.[42]	7
Prasad et al.[50]	7

studies in the prevalence of traumatic dental injuries in permanent teeth (all studies included $n = 59$) revealed a pooled prevalence of 11% with 95% CI of 9–13% using random effect model.

Sensitivity Analysis for the Pooled Prevalence of TDI in Permanent Teeth in India

The result of the meta-analysis for pooling the proportion of TDI by removal of outlier studies[4,67,68,70] on visual inspection of the forest plot is graphically represented in Figure 1B. No significant change in the heterogeneity was observed after excluding four outlier studies.

Subgroup Analysis

Subgroup analysis was performed based on various study level covariates contributing to clinical and methodological heterogeneity. Probable covariates were identified before analysis. The subgroup analysis was conducted by the state where the study was carried out as well as by the criteria used to classify TDI.

- **Subgroup analysis based on the state where the study was conducted:** Figure 2A depicts subgroup analysis by state with Karnataka subgroup including 14 studies and non-Karnataka including 45 studies. The forest plot revealed a nonsignificant effect of the moderator using mixed model analysis (random effects model within subgroups and fixed effects model between subgroups) suggesting that the study state does not modify the prevalence of TDI.
- **Subgroup analysis based on the criteria used to classify TDI:** Subgroup analysis by criteria used to classify TDI has been projected in Figure 2B. The forest plot revealed a nonsignificant effect of the moderator using mixed model analysis (random effects model within subgroups and fixed effects model between subgroups) implying that classification does not modify the prevalence of TDI.

Meta-regression of the Study Level Covariates

Among the study level covariates considered for meta-regression, both sample size and year of publication significantly explain the percentage of heterogeneity variation (18.15 and 4.89%) found on the prevalence proportion (Table 5).

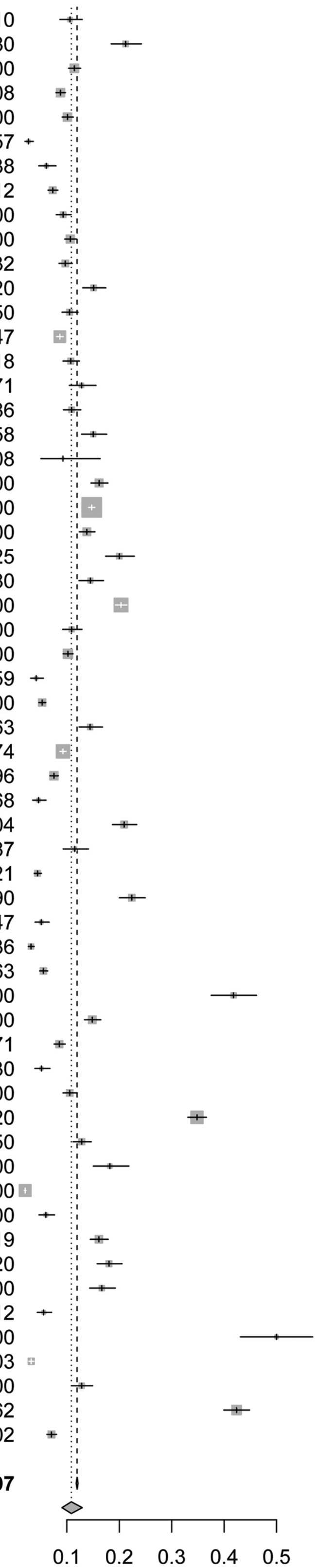
Predictors

Association between Gender and TDI in Permanent Teeth

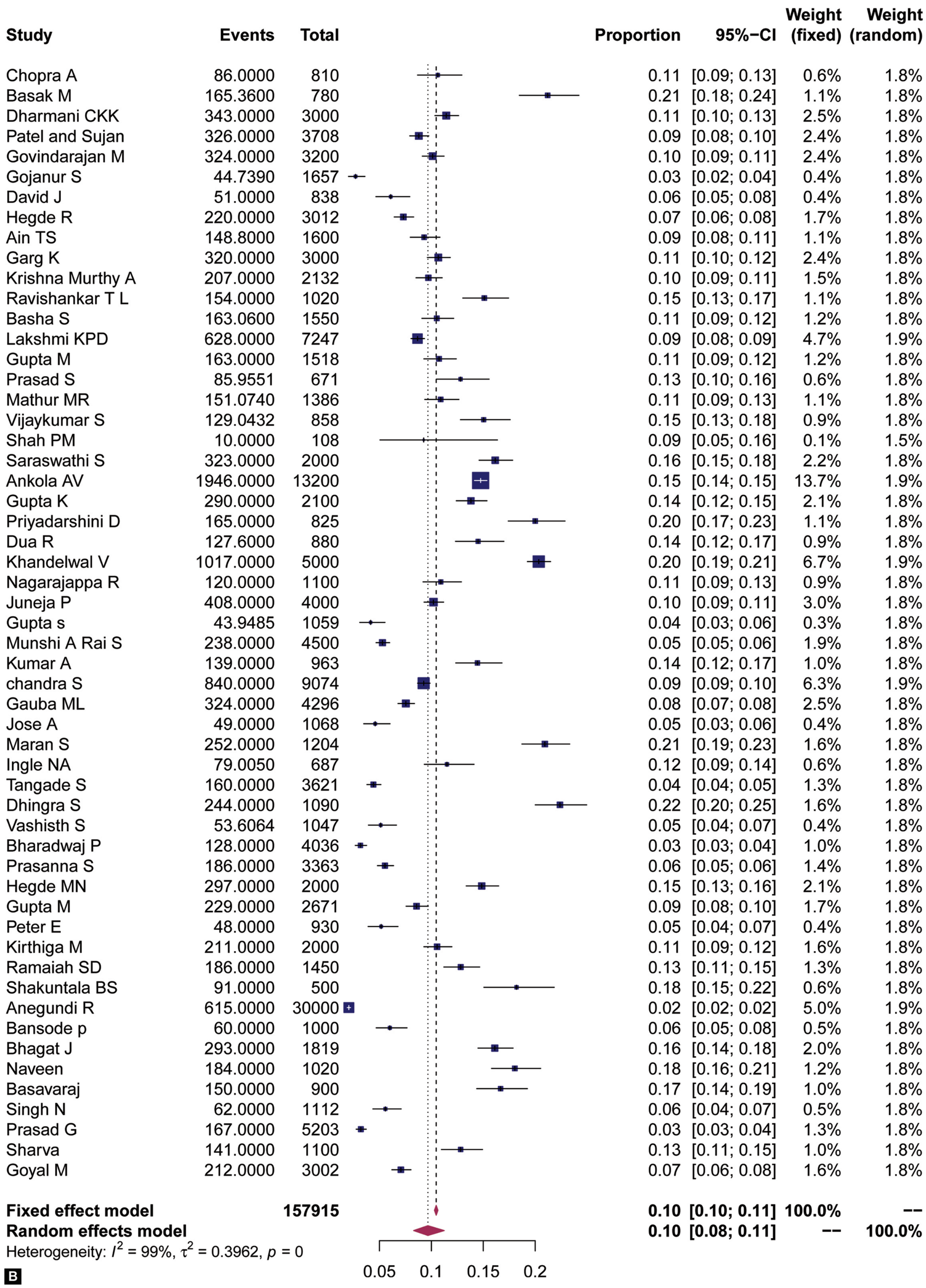
Figure 3A is a forest plot of 38 studies reporting the association between gender and traumatic dental injuries in permanent teeth. The study-specific odds ratio was 1.52 and summary effect estimates

Study	Events	Total	Proportion	95%−CI	Weight (fixed)	Weight (random)
Chopra A	86.0000	810	0.11	[0.09; 0.13]	0.6%	1.7%
Basak M	165.3600	780	0.21	[0.18; 0.24]	1.0%	1.7%
Dharmani CKK	343.0000	3000	0.11	[0.10; 0.13]	2.3%	1.7%
Patel and Sujan	326.0000	3708	0.09	[0.08; 0.10]	2.2%	1.7%
Govindarajan M	324.0000	3200	0.10	[0.09; 0.11]	2.2%	1.7%
Gojanur S	44.7390	1657	0.03	[0.02; 0.04]	0.3%	1.7%
David J	51.0000	838	0.06	[0.05; 0.08]	0.4%	1.7%
Hegde R	220.0000	3012	0.07	[0.06; 0.08]	1.5%	1.7%
Ain TS	148.8000	1600	0.09	[0.08; 0.11]	1.0%	1.7%
Garg K	320.0000	3000	0.11	[0.10; 0.12]	2.1%	1.7%
Krishna Murthy A	207.0000	2132	0.10	[0.09; 0.11]	1.4%	1.7%
Ravishankar T L	154.0000	1020	0.15	[0.13; 0.17]	1.0%	1.7%
Basha S	163.0600	1550	0.11	[0.09; 0.12]	1.1%	1.7%
Lakshmi KPD	628.0000	7247	0.09	[0.08; 0.09]	4.3%	1.7%
Gupta M	163.0000	1518	0.11	[0.09; 0.12]	1.1%	1.7%
Prasad S	85.9551	671	0.13	[0.10; 0.16]	0.6%	1.7%
Mathur MR	151.0740	1386	0.11	[0.09; 0.13]	1.0%	1.7%
Vijaykumar S	129.0432	858	0.15	[0.13; 0.18]	0.8%	1.7%
Shah PM	10.0000	108	0.09	[0.05; 0.16]	0.1%	1.5%
Saraswathi S	323.0000	2000	0.16	[0.15; 0.18]	2.0%	1.7%
Ankola AV	1946.0000	13200	0.15	[0.14; 0.15]	12.4%	1.7%
Gupta K	290.0000	2100	0.14	[0.12; 0.15]	1.9%	1.7%
Priyadarshini D	165.0000	825	0.20	[0.17; 0.23]	1.0%	1.7%
Dua R	127.6000	880	0.14	[0.12; 0.17]	0.8%	1.7%
Khandelwal V	1017.0000	5000	0.20	[0.19; 0.21]	6.1%	1.7%
Nagarajappa R	120.0000	1100	0.11	[0.09; 0.13]	0.8%	1.7%
Juneja P	408.0000	4000	0.10	[0.09; 0.11]	2.7%	1.7%
Gupta s	43.9485	1059	0.04	[0.03; 0.06]	0.3%	1.7%
Munshi A Rai S	238.0000	4500	0.05	[0.05; 0.06]	1.7%	1.7%
Kumar A	139.0000	963	0.14	[0.12; 0.17]	0.9%	1.7%
chandra S	840.0000	9074	0.09	[0.09; 0.10]	5.7%	1.7%
Gauba ML	324.0000	4296	0.08	[0.07; 0.08]	2.2%	1.7%
Jose A	49.0000	1068	0.05	[0.03; 0.06]	0.4%	1.7%
Maran S	252.0000	1204	0.21	[0.19; 0.23]	1.5%	1.7%
Ingle NA	79.0050	687	0.12	[0.09; 0.14]	0.5%	1.7%
Tangade S	160.0000	3621	0.04	[0.04; 0.05]	1.1%	1.7%
Dhingra S	244.0000	1090	0.22	[0.20; 0.25]	1.4%	1.7%
Vashisth S	53.6064	1047	0.05	[0.04; 0.07]	0.4%	1.7%
Bharadwaj P	128.0000	4036	0.03	[0.03; 0.04]	0.9%	1.7%
Prasanna S	186.0000	3363	0.06	[0.05; 0.06]	1.3%	1.7%
Das N	209.0000	500	0.42	[0.38; 0.46]	0.9%	1.7%
Hegde MN	297.0000	2000	0.15	[0.13; 0.16]	1.9%	1.7%
Gupta M	229.0000	2671	0.09	[0.08; 0.10]	1.6%	1.7%
Peter E	48.0000	930	0.05	[0.04; 0.07]	0.3%	1.7%
Kirthiga M	211.0000	2000	0.11	[0.09; 0.12]	1.4%	1.7%
Prakash J	982.0000	2820	0.35	[0.33; 0.37]	4.8%	1.7%
Ramaiah SD	186.0000	1450	0.13	[0.11; 0.15]	1.2%	1.7%
Shakuntala BS	91.0000	500	0.18	[0.15; 0.22]	0.6%	1.7%
Anegundi R	615.0000	30000	0.02	[0.02; 0.02]	4.5%	1.7%
Bansode p	60.0000	1000	0.06	[0.05; 0.08]	0.4%	1.7%
Bhagat J	293.0000	1819	0.16	[0.14; 0.18]	1.8%	1.7%
Naveen	184.0000	1020	0.18	[0.16; 0.21]	1.1%	1.7%
Basavaraj	150.0000	900	0.17	[0.14; 0.19]	0.9%	1.7%
Singh N	62.0000	1112	0.06	[0.04; 0.07]	0.4%	1.7%
Yadav	100.0000	200	0.50	[0.43; 0.57]	0.4%	1.7%
Prasad G	167.0000	5203	0.03	[0.03; 0.04]	1.2%	1.7%
Sharva	141.0000	1100	0.13	[0.11; 0.15]	0.9%	1.7%
Ramachandran A	662.0000	1562	0.42	[0.40; 0.45]	2.9%	1.7%
Goyal M	212.0000	3002	0.07	[0.06; 0.08]	1.5%	1.7%
Fixed effect model		**162997**	**0.12**	**[0.12; 0.12]**	**100.0%**	**--**
Random effects model			**0.11**	**[0.09; 0.13]**	**--**	**100.0%**

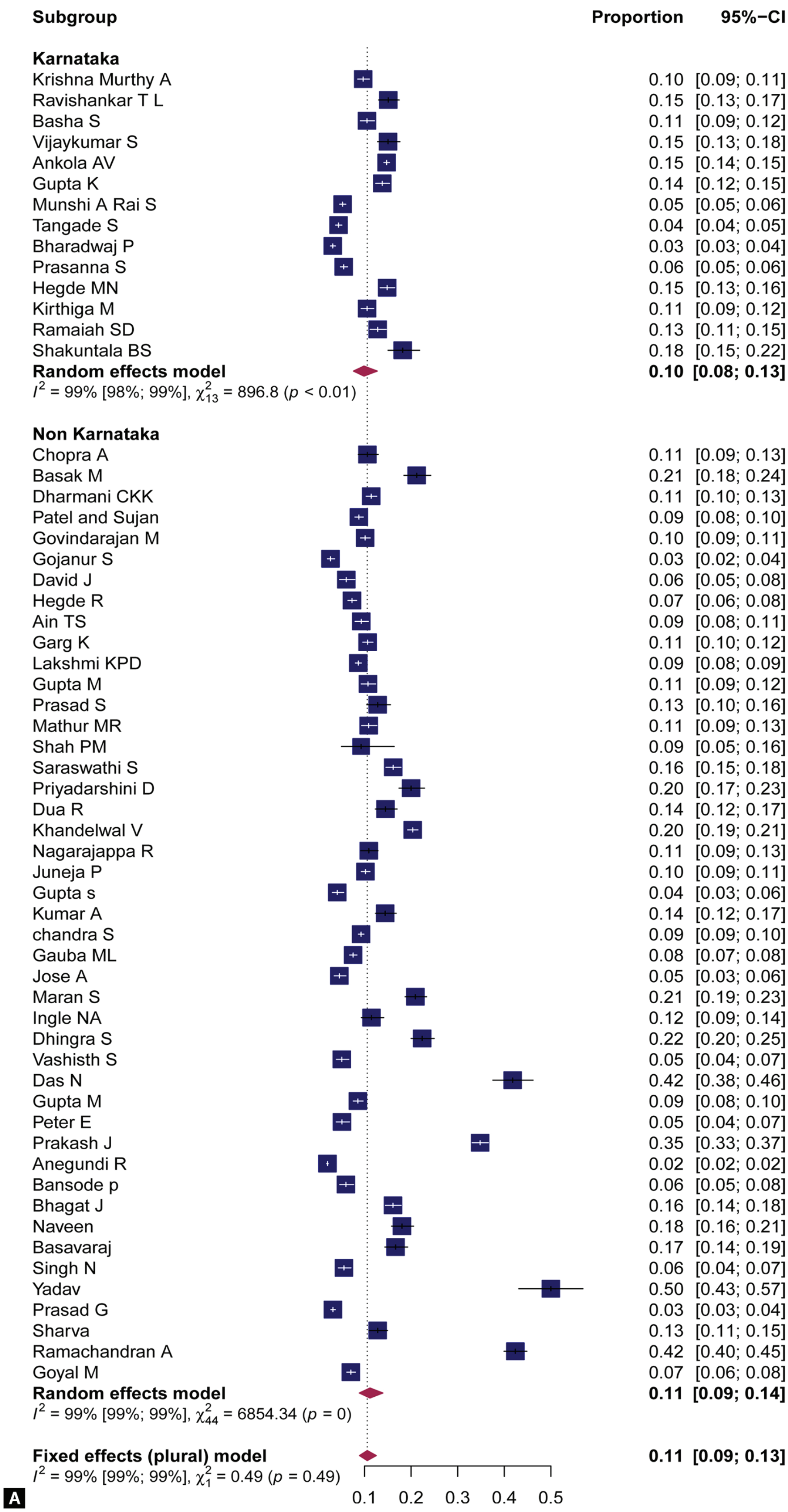
Heterogeneity: $I^2 = 99\%$, $\tau^2 = 0.6006$, $p = 0$

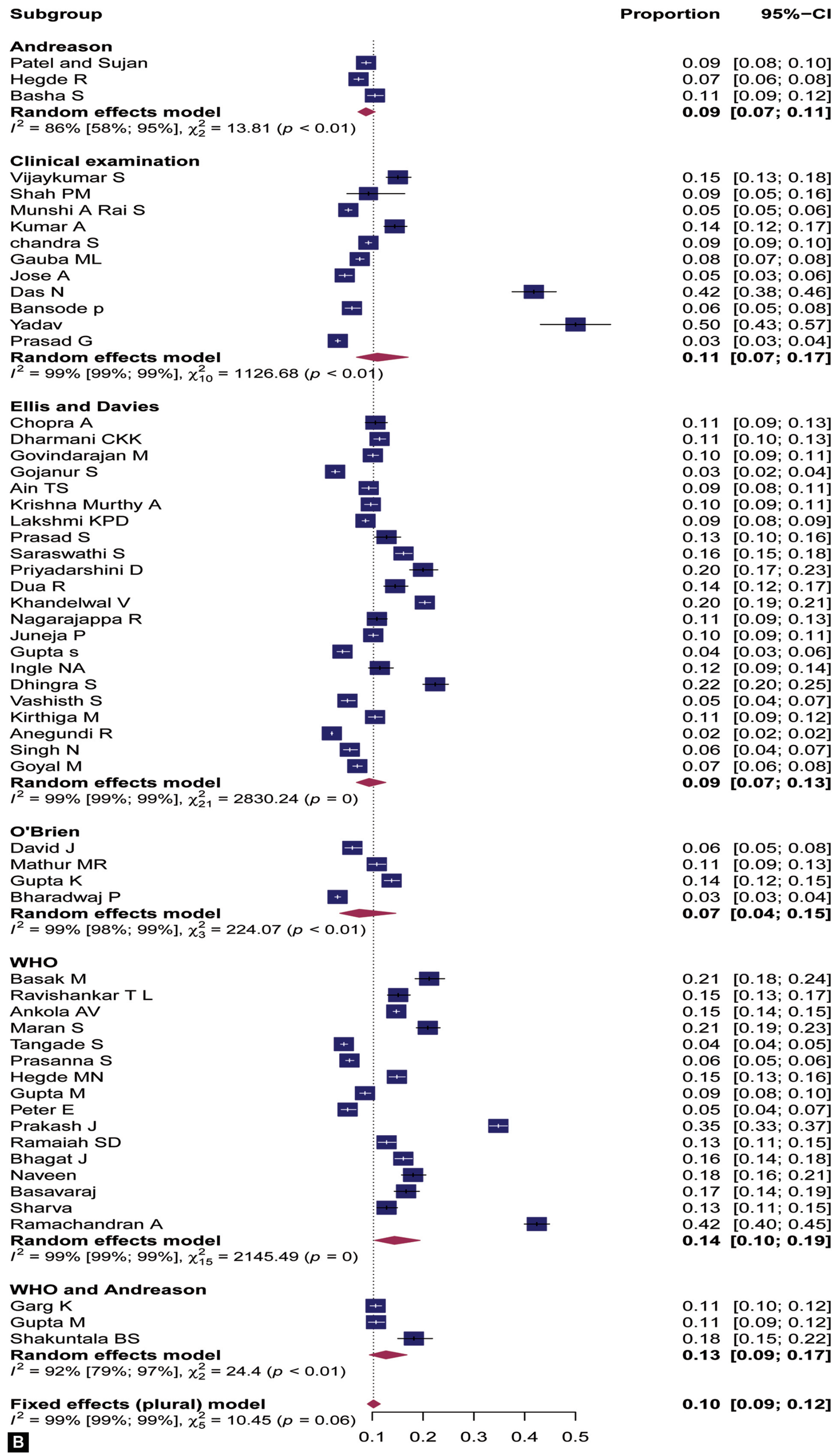


A



Figs 1A and B: (A) Forest plot of meta-analysis of studies in prevalence of traumatic dental injuries in permanent teeth (all studies included $n = 59$). Study-specific and summary effect estimates 0.11 (0.09–0.13) (heterogeneity—$I^2 = 99\%$; Tau$^2 = 0.6005$; $p < 0.001$); (B) Forest plot for sensitivity analysis of meta-analysis of studies in prevalence of traumatic dental injuries in permanent teeth after excluding outliers studies (all studies included $n = 55$). Study-specific and summary effect estimates 0.10 (0.08–0.11) (heterogeneity—$I^2 = 99\%$; Tau$^2 = 0.3963$ $p < 0.001$)


Subgroup
Proportion
95%−CI
Karnataka
Krishna Murthy A 0.10 [0.09; 0.11]
Ravishankar T L 0.15 [0.13; 0.17]
Basha S 0.11 [0.09; 0.12]
Vijaykumar S 0.15 [0.13; 0.18]
Ankola AV 0.15 [0.14; 0.15]
Gupta K 0.14 [0.12; 0.15]
Munshi A Rai S 0.05 [0.05; 0.06]
Tangade S 0.04 [0.04; 0.05]
Bharadwaj P 0.03 [0.03; 0.04]
Prasanna S 0.06 [0.05; 0.06]
Hegde MN 0.15 [0.13; 0.16]
Kirthiga M 0.11 [0.09; 0.12]
Ramaiah SD 0.13 [0.11; 0.15]
Shakuntala BS 0.18 [0.15; 0.22]
Random effects model 0.10 [0.08; 0.13]
I^2 = 99% [98%; 99%], χ^2_{13} = 896.8 (p < 0.01)
Non Karnataka
Chopra A 0.11 [0.09; 0.13]
Basak M 0.21 [0.18; 0.24]
Dharmani CKK 0.11 [0.10; 0.13]
Patel and Sujan 0.09 [0.08; 0.10]
Govindarajan M 0.10 [0.09; 0.11]
Gojanur S 0.03 [0.02; 0.04]
David J 0.06 [0.05; 0.08]
Hegde R 0.07 [0.06; 0.08]
Ain TS 0.09 [0.08; 0.11]
Garg K 0.11 [0.10; 0.12]
Lakshmi KPD 0.09 [0.08; 0.09]
Gupta M 0.11 [0.09; 0.12]
Prasad S 0.13 [0.10; 0.16]
Mathur MR 0.11 [0.09; 0.13]
Shah PM 0.09 [0.05; 0.16]
Saraswathi S 0.16 [0.15; 0.18]
Priyadarshini D 0.20 [0.17; 0.23]
Dua R 0.14 [0.12; 0.17]
Khandelwal V 0.20 [0.19; 0.21]
Nagarajappa R 0.11 [0.09; 0.13]
Juneja P 0.10 [0.09; 0.11]
Gupta s 0.04 [0.03; 0.06]
Kumar A 0.14 [0.12; 0.17]
chandra S 0.09 [0.09; 0.10]
Gauba ML 0.08 [0.07; 0.08]
Jose A 0.05 [0.03; 0.06]
Maran S 0.21 [0.19; 0.23]
Ingle NA 0.12 [0.09; 0.14]
Dhingra S 0.22 [0.20; 0.25]
Vashisth S 0.05 [0.04; 0.07]
Das N 0.42 [0.38; 0.46]
Gupta M 0.09 [0.08; 0.10]
Peter E 0.05 [0.04; 0.07]
Prakash J 0.35 [0.33; 0.37]
Anegundi R 0.02 [0.02; 0.02]
Bansode p 0.06 [0.05; 0.08]
Bhagat J 0.16 [0.14; 0.18]
Naveen 0.18 [0.16; 0.21]
Basavaraj 0.17 [0.14; 0.19]
Singh N 0.06 [0.04; 0.07]
Yadav 0.50 [0.43; 0.57]
Prasad G 0.03 [0.03; 0.04]
Sharva 0.13 [0.11; 0.15]
Ramachandran A 0.42 [0.40; 0.45]
Goyal M 0.07 [0.06; 0.08]
Random effects model 0.11 [0.09; 0.14]
I^2 = 99% [99%; 99%], χ^2_{44} = 6854.34 (p = 0)
Fixed effects (plural) model 0.11 [0.09; 0.13]
I^2 = 99% [99%; 99%], χ^2_{1} = 0.49 (p = 0.49)
A
0.1
0.2
0.3
0.4
0.5



Figs 2A and B: (A) Forest plot for subgroup analysis of studies in Karnataka (14 studies included) and non-Karnataka state (45 studies included); (B) Forest plot for subgroup analysis of studies by classification criteria used for assessing TDI

Table 5: Meta-regression of the study level covariates

Study level covariate	*β coefficient*	R^2	*p value*
Sample size	−0.0001	18.15%	0.0033
Risk of bias	0.0545	0.01%	0.6906
Year of publication	0.0253	4.89%	0.0534

of 1.37–1.70. There are 1.52 times increased odds of experiencing traumatic dental injury among males as compared to females.

Association between Inadequate Lip Coverage and TDI in Permanent Teeth

Figure 3B depicts that the overall effect estimate of 17 studies was 4.76 (3.18–7.11), thus indicating that there are 4.76 times increased odds of experiencing traumatic dental injury among those with inadequate lip coverage as compared to those with adequate lip coverage.

Association between Geographic Area and TDI in Permanent Teeth

As explained in Figure 3C, the overall effect estimate of six studies was 1.30 (0.88–1.91) indicating that there are 1.30 times increased odds of experiencing traumatic dental injury among those from the rural area as compared to those from the urban region. However, this finding was not statistically significant.

Association between Increased Overjet of >3.5 mm, >5.5 mm with TDI in Permanent Teeth

Figure 3D illustrates that the overall effect estimate from 13 studies was 4.84 (2.86–8.19), thus indicating that there are 4.84 times increased odds of experiencing traumatic dental injury among those with increased overjet (>3.5 mm) as compared to those with normal overjet. Figure 3E shows the overall effect estimate of nine studies as 4.93 (4.32–5.63), thus indicating that there are 4.84 times increased odds of experiencing traumatic dental injury among those with increased overjet (>5.5 mm) as compared to those with normal overjet.

Trends

Trends in Prevalence of Dental Trauma in Permanent Teeth in India

Figure 4A depicts the trends of prevalence for TDI in the percentage of the studies included over the years. The first study was conducted in 1967. Out of the 59 mentioned studies, the maximum number of prevalence studies ($n = 32$) has been done in the last 6 years. Figure 4B depicts the trend line of TDI prevalence in permanent teeth in India which denotes an upward trend. Figure 4C reveals the forecast of prevalence for TDI by average for the next 10 years that suggests an increasing pattern over the coming years. An estimate of the prevalence percentage for the corresponding year can be deduced. Figure 4D depicts the forecast of prevalence for TDI by average for the next 10 years broadly based on studies classified under the three most commonly used classifications that suggest a steeper pattern of TDI% when using clinical examination compared to WHO[75] and Ellis and Davies classification.[76]

Assessment of Publication Bias

The funnel plot (Fig. 5) for the current review is a simple scatter plot of the intervention effect estimates from individual studies against each study's precision (standard error) that is depicting considerable asymmetry with scattered studies depicting heterogeneity.

Qualitative Synthesis of Other Factors in Which Meta-analysis Could Not Be Performed

Out of 59 included studies, 50 studies[10–13,44–78,79] could provide data for causes of trauma. The most common cause mentioned was falls.[10–13,19,22,24,25,27,31–36,43–47,49,51,54,55,58–64,66,69,73,74,77–79] Twenty-five[11,19,24,30,32,34,36,37,39,43,45,49,52,54,55,57,59,61–66,72,77] studies provided information about the geographical place where the TDI occurred. The most common places mentioned were home (12 studies)[11,24,36,43,49,52,54,57,63,64,66,72,77] followed by the school (six studies).[39,43,55,62,63,72] Eight studies[13,24,43,49,57,62,66,69] evaluated socioeconomic status that was categorized to upper, middle, and lower socioeconomic status. Three studies[13,57,72] mentioned that participant of middle socioeconomic status experienced greater TDI. In the other five studies,[43,49,62,66,69] lower socioeconomic status groups experienced greater TDI. BMI was categorized as overweight/obese, normal, and underweight. There were four[35,52,63,77] studies that could be included in this analysis. A greater prevalence of TDI in overweight or obese participants was reported in three studies.[35,63,77] In one study, underweight participants were associated with TDI.[52] A total of six studies[48,49,51,57,59,63] assessed molar relations and all of them reported greater TDI prevalence among participants with class 2 molar relation. The affected tooth type was mentioned in 20[13,23,24,31,32,36,43,47,48,51,56,58,59,62,64,66,77,80–82] studies. In 19 studies, maxillary central incisors were most commonly affected teeth. Out of the 24[7,11,13,22,24,30,31–33,35,37,43,45,47-49,51,55,57,63,66,78,81] studies that reported the nature of the injury, enamel fracture was the most common findings in 18 studies.[7,11,13,30,31,33,35,37,43,45,47–49,51,55,57,66]

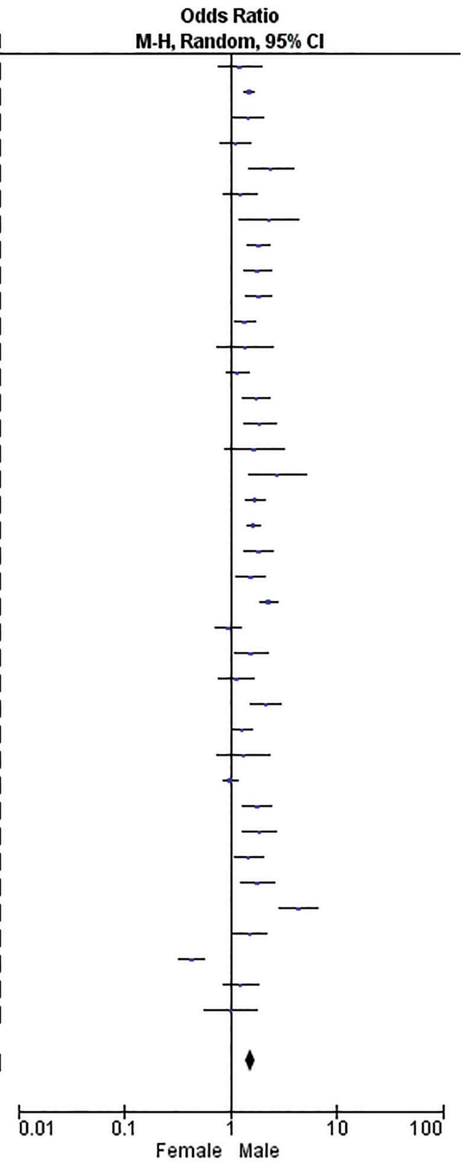
Discussion

The present systematic review was undertaken to evaluate the prevalence, trends, and associated factors of TDI in permanent teeth of children and adolescents in India. The overall prevalence of TDI from a total of 59 studies meeting the inclusion criteria in permanent teeth was 11% (0.11) (95% CI 0.09–0.13) with high heterogeneity among studies conducted in different geographic areas in India using the random effects model. A previous systematic review has reported 13% overall prevalence of TDI in India for 48 included studies.[14] The difference may be due to inclusion of studies pertaining to primary dentition and high-risk groups such as athletes. The systematic reviews conducted in different countries reported a pooled prevalence of 18.6%[9] in Latin American and Caribbean countries and 17.5%[7] in Iran. This difference may be because of variation in the actual prevalence in the different study populations from different countries. By visual inspection, four outlier studies[4,67,68,70] was noted indicating the varying prevalence of TDI in the studies conducted. Sensitivity analysis was done removing the outlier studies; however, no significant changes in the pooled result were observed.

There is a high degree of heterogeneity between studies, which can likely be explained by clinical, methodological, and statistical reasons. Although the study population included children and adolescents, factors that contributed to clinical heterogeneity include participants in the studies who differed in their age, gender, risk factors assessed, evaluation period, definition, and criteria used for TDI. There was considerable variability in the region where studies were conducted. Out of the 59 studies, 17 were done in

Study or Subgroup	Male Events	Male Total	Female Events	Female Total	Weight	Odds Ratio M-H, Random, 95% CI
Ain TS	39	767	35	833	2.2%	1.22 [0.77, 1.95]
Ankola AV	1124	6512	822	6688	3.5%	1.49 [1.35, 1.64]
Basak M	91	372	74	408	2.6%	1.46 [1.03, 2.06]
Basha S	88	798	75	752	2.7%	1.12 [0.81, 1.55]
Chopra A	60	415	26	395	2.1%	2.40 [1.48, 3.89]
Das N	130	296	79	204	2.6%	1.24 [0.86, 1.78]
David	38	479	13	359	1.6%	2.29 [1.20, 4.37]
Dharmamani CKK	217	1500	126	1500	3.1%	1.84 [1.46, 2.33]
Dhingra S	154	569	90	521	2.9%	1.78 [1.33, 2.38]
Dua R	285	495	163	385	2.9%	1.85 [1.41, 2.42]
Garg K	201	1683	119	1317	3.1%	1.37 [1.07, 1.73]
Gojanur S	29	935	16	696	1.7%	1.36 [0.73, 2.52]
Govindarajan M	202	1890	122	1310	3.1%	1.17 [0.92, 1.48]
Gupta m	158	1520	71	1151	2.9%	1.76 [1.32, 2.36]
Gupta M	115	871	48	647	2.6%	1.90 [1.33, 2.70]
Gupta S	29	573	15	485	1.6%	1.67 [0.88, 3.15]
Jose A	34	490	15	570	1.7%	2.76 [1.48, 5.13]
Juneja P	279	2058	129	1534	3.1%	1.71 [1.37, 2.13]
Khandelwal V	686	2907	331	2093	3.4%	1.64 [1.42, 1.90]
Krishnamurthy	132	1074	75	1058	2.8%	1.84 [1.36, 2.47]
Krithiga M	143	1173	68	827	2.8%	1.55 [1.14, 2.10]
Laxmi KPD	490	4527	138	2720	3.2%	2.27 [1.87, 2.76]
Maran S	144	697	108	507	2.9%	0.96 [0.73, 1.27]
Mathur MR	93	736	55	650	2.6%	1.56 [1.10, 2.22]
Nagarajappa R	66	572	54	528	2.5%	1.14 [0.78, 1.68]
Naveen	121	515	63	505	2.7%	2.15 [1.54, 3.01]
Patel & Sujan	183	1867	143	1841	3.1%	1.29 [1.03, 1.62]
Peter E	22	366	26	564	1.8%	1.32 [0.74, 2.37]
Prakash J	540	1551	442	1269	3.4%	1.00 [0.86, 1.17]
Prasad G	102	2464	65	2739	2.8%	1.78 [1.30, 2.44]
Priyadarshini D	112	462	53	363	2.6%	1.87 [1.30, 2.68]
Ramaiah SD	118	800	68	650	2.8%	1.48 [1.08, 2.04]
Ravishankar TL	97	519	57	501	2.6%	1.79 [1.26, 2.55]
Sharva	110	538	31	562	2.4%	4.40 [2.90, 6.69]
Tangade S	120	2418	40	1203	2.6%	1.52 [1.05, 2.19]
Vashisth S	353	726	216	315	2.9%	0.43 [0.33, 0.57]
Vijaykumar S	74	452	55	406	2.5%	1.25 [0.86, 1.82]
Yadav	60	120	40	80	1.8%	1.00 [0.57, 1.76]
Total (95% CI)		**46707**		**39136**	**100.0%**	**1.52 [1.37, 1.70]**
Total events	7039		4166			

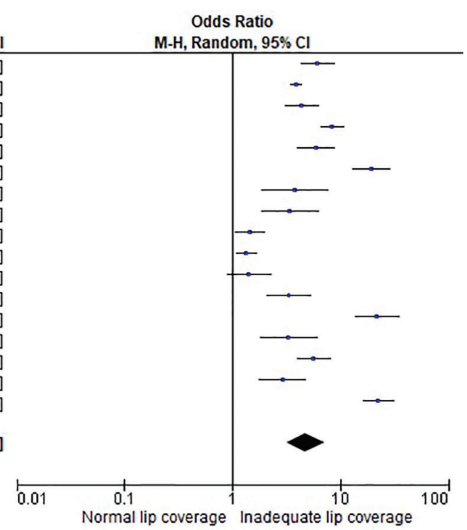
Heterogeneity: Tau² = 0.09; Chi² = 202.48, df = 37 (P < 0.00001); I² = 82%
Test for overall effect: Z = 7.58 (P < 0.00001)



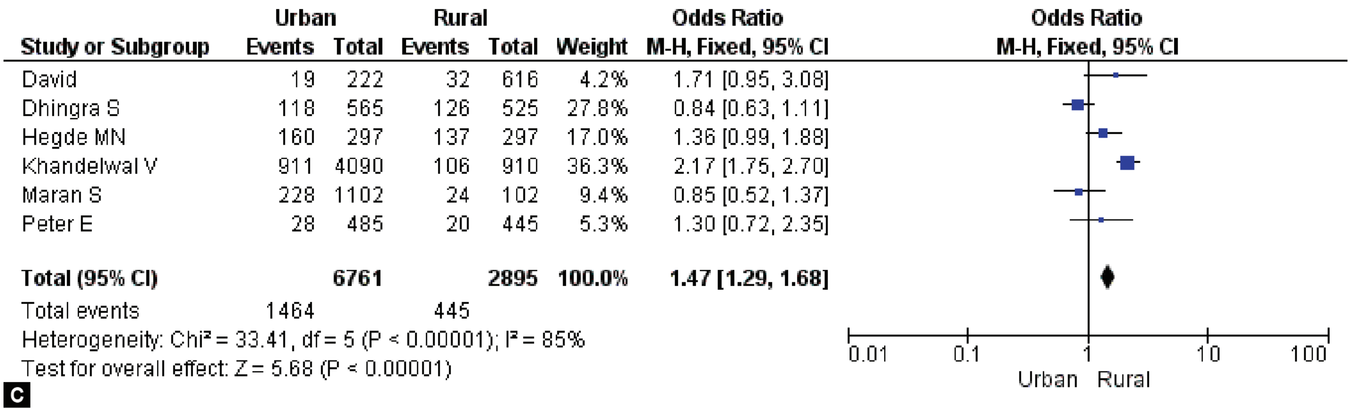
A

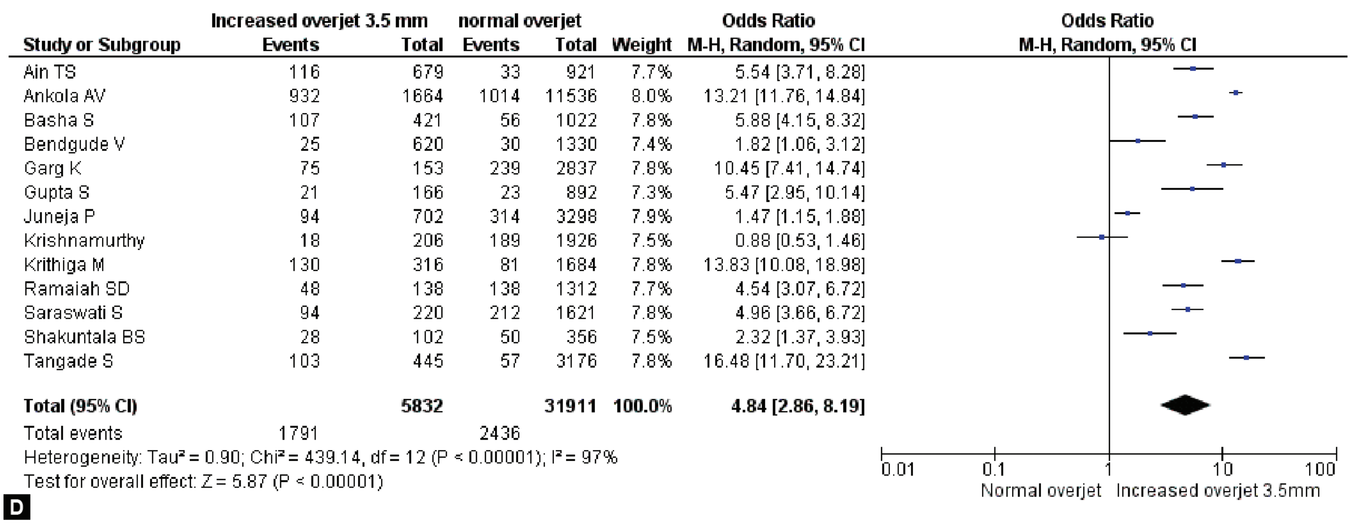
Study or Subgroup	Inadequate lip coverage Events	Inadequate lip coverage Total	Normal lip coverage Events	Normal lip coverage Total	Weight	Odds Ratio M-H, Random, 95% CI
Ain TS	78	299	71	1301	6.0%	6.11 [4.30, 8.69]
Ankola AV	634	1892	1312	11308	6.3%	3.84 [3.43, 4.29]
Basha S	98	500	55	1050	6.0%	4.41 [3.11, 6.26]
Dharmamani CKK	173	462	170	2538	6.1%	8.34 [6.53, 10.65]
Garg K	42	109	278	2891	5.9%	5.89 [3.93, 8.83]
Gupta m	69	122	160	2549	5.9%	19.44 [13.13, 28.77]
Gupta M	11	42	121	1407	5.3%	3.77 [1.85, 7.69]
Gupta S	25	307	19	751	5.5%	3.42 [1.85, 6.30]
Juneja P	49	359	359	3641	6.1%	1.45 [1.05, 1.99]
Khandelwal V	121	485	896	4515	6.2%	1.34 [1.08, 1.67]
Krishnamurthy	24	187	183	1945	5.8%	1.42 [0.90, 2.23]
Nagarajappa R	30	119	90	981	5.8%	3.34 [2.09, 5.32]
Naveen	82	112	102	908	5.8%	21.60 [13.55, 34.43]
Peter E	18	153	30	777	5.5%	3.32 [1.80, 6.13]
Ramaiah SD	76	214	110	1236	6.0%	5.64 [4.01, 7.93]
Ravishankar TL	27	86	127	934	5.8%	2.91 [1.78, 4.76]
Saraswati S	169	247	154	1753	6.1%	22.50 [16.42, 30.83]
Total (95% CI)		**5695**		**40485**	**100.0%**	**4.76 [3.18, 7.11]**
Total events	1726		4237			

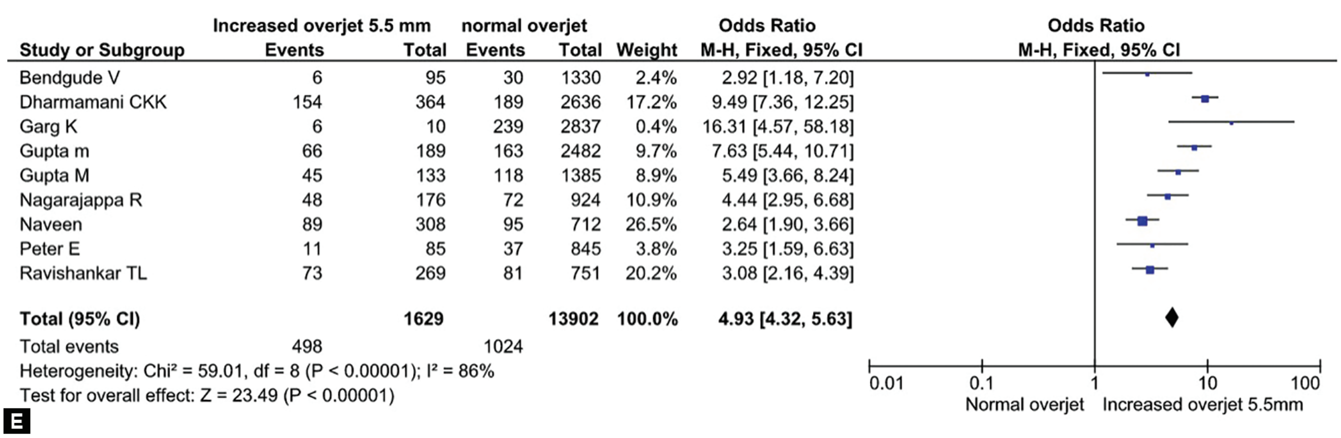
Heterogeneity: Tau² = 0.67; Chi² = 432.95, df = 16 (P < 0.00001); I² = 96%
Test for overall effect: Z = 7.60 (P < 0.00001)



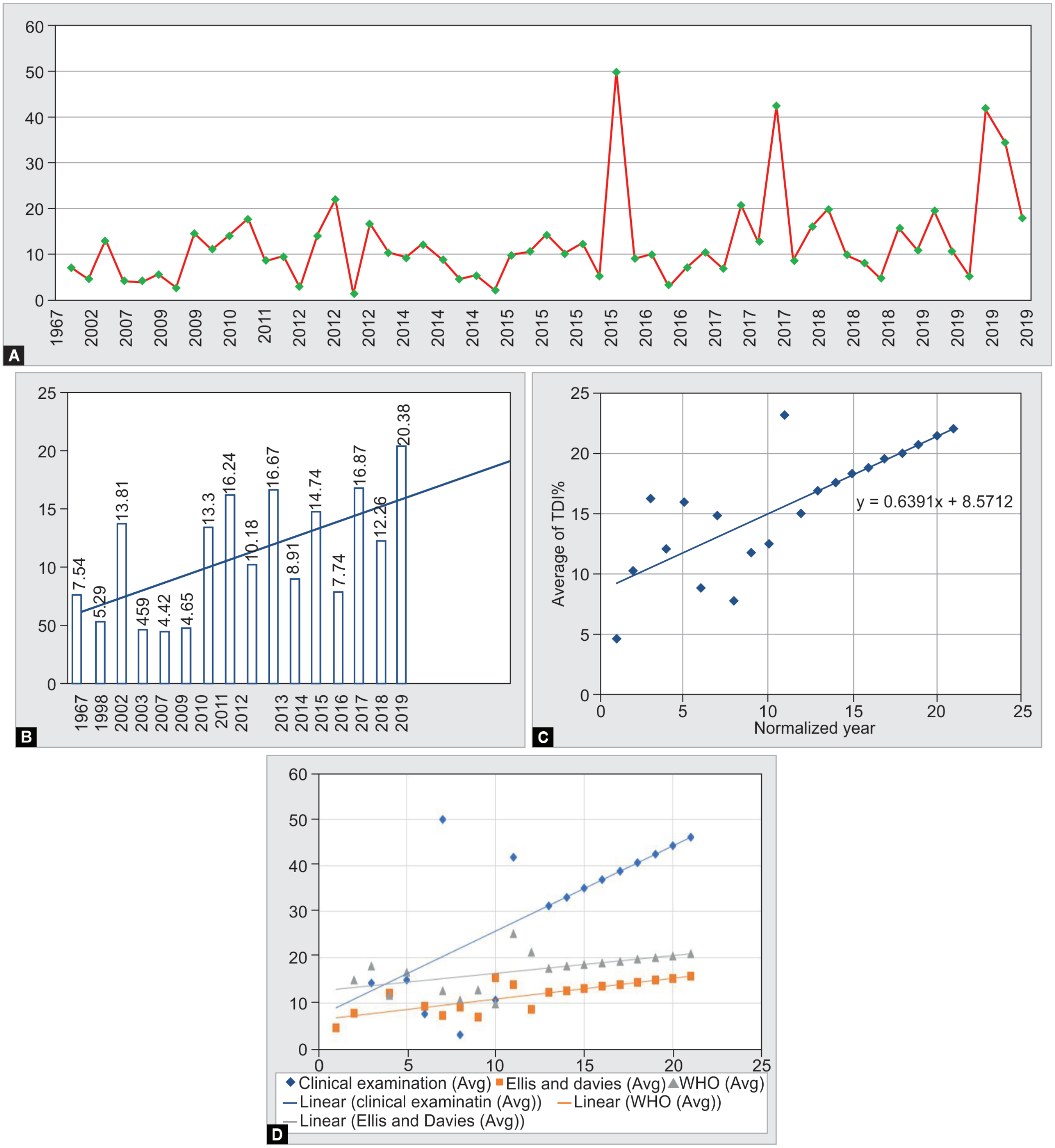
B







Figs 3A to E: (A) Forest plot of studies showing association between gender and traumatic dental injuries in permanent teeth (n = 38). Study-specific and summary effect estimates 1.52 (1.37–1.70) [odds ratio (OR) and 95% confidence interval (CI)]/(heterogeneity—I^2 = 82%; p <0.001); (B) Forest plot of studies showing association between inadequate lip coverage and traumatic dental injuries in permanent teeth (n = 17). Study-specific and summary effect estimates 4.76 (3.18–7.11) (heterogeneity—I^2 = 96%; p <0.001); (C) Forest plot of studies showing association between geographic area and traumatic dental injuries in permanent teeth (n = 6). Study-specific and summary effect estimates 1.30 (0.88–1.91) (heterogeneity—I^2 = 85%; p <0.001); (D) Forest plot of studies showing association between increased overjet (>3.5 mm) and traumatic dental injuries in permanent teeth (n = 13). Study-specific and summary effect estimates 4.84 (2.86–8.19) (heterogeneity—I^2 = 97%; p <0.001); (E) Forest plot of studies showing association between increased overjet (>5.5 mm) and traumatic dental injuries in permanent teeth (n = 9). Study-specific and summary effect estimates 4.93 (4.32–5.63) (heterogeneity—I^2 = 86%; p <0.001)



Figs 4A to D: (A) Trends in prevalence of TDI in permanent teeth ($n = 59$); (B) Trend line of TDI prevalence in permanent teeth by reported average for each year; (C) Forecast of prevalence of TDI in permanent teeth by average for next 10 years; (D) Forecast of prevalence of TDI in permanent teeth by average for next 10 years based on classification

the Southern state of Karnataka. Hence, a subgroup analysis was performed based on Karnataka and non-Karnataka studies. The moderator effect was not statistically significant as there were a varying number of studies in each group. No subgroup analysis was able to explain the heterogeneity.

The commonly used criteria were WHO classification.[75] The WHO classification of oral trauma describes injuries to the internal structures of the mouth. Luxation injuries are grouped as one and not divided into intrusive, extrusive, and lateral luxation. Injuries to the alveolar socket and fractures of the mandible or maxilla are not

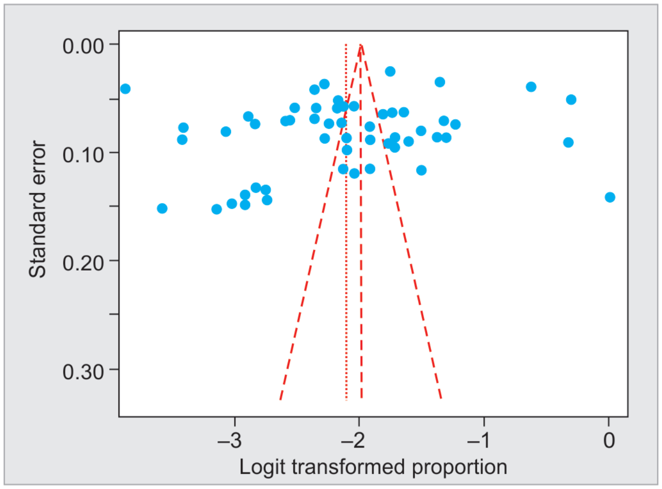


Fig. 5: Funnel plot for pooled prevalence of TDI in permanent teeth

grouped under oral injuries, but rather are classified separately as fractures of facial bones.

The Ellis classification[76] is a modification of the WHO system which has been used most commonly by various authors for recording dental trauma. This system is a simplified classification which groups many injuries and allows for subjective interpretation by including broad terms such as "simple" or "extensive" fractures. However, injuries to the alveolar socket and fractures of the mandible and maxilla have not been classified here, which can underestimate the actual prevalence percentage. Unlike the WHO classification, Andreasens[80] is a more comprehensive system having 19 groups including injuries to the teeth, supporting structures, gingiva, and oral mucosa that allows for minimal subjective interpretations. Nevertheless, this is the least commonly used criterion in Indian studies. Although the best option to evaluate TDI could not be narrowed down, a universal classification can be used to facilitate further comparisons between survey results. Subgroup analysis based on classification used could not prove heterogeneity statistically.

Methodologically the included studies varied in the sampling technique, sample size, and geographic location. Qualitative appraisal of the studies revealed that 42 studies reported sampling method and only 22 studies reported the evaluation period and sample size calculation. The sample size included in the meta-analysis ranged from 108[56] to 30,000.[33] There were also differences in the quality of the studies with the majority of them having moderate-to-high risk of bias. Both methodological and clinical sources of heterogeneity contribute to the occurrence and magnitude of statistical heterogeneity.[81]

When gender was assessed as a risk factor for TDI, boys were reported to have about two times greater odds of TDI compared to girls (OR = 1.52; 95% CI: 1.37–1.70). This finding was compatible with reports from similar systematic reviews in other countries like the Latin America and Caribbean countries[9] and Iran.[7] A possible explanation for this finding might be due to boys engaging more actively in sports, fights, and outdoor activities than girls.

The meta-analysis from the forest plot could not deduce a significant association of the rural population with TDI (OR = 1.30; 95% CI: 0.88–1.91). A possible explanation could be that only six studies had assessed this variable. Individuals raised in rural areas are exposed to considerably different environmental risk factors than those living in urban regions such as household and school setting, play area, and lifestyle behaviors, which have all been implicated as potential environmental risk factors for TDI.[57]

The studies that evaluated socioeconomic status reported the greatest prevalence of TDI among adolescents in lower socioeconomic status. Meta-analysis could not be conducted because the data was not extractable. This was in contrast to a systematic review which proved that the scientific evidence indicates no association between socioeconomic indicators and TDI.[82] Socioeconomic differences in the prevalence of TDI in adolescents are likely due to differential exposure to environmental factors of the neighborhood, parental education level and employment status, and the level of social capital in the community.[13,43] This difference could be partly explained by the fact that there is no single measure of socioeconomic status, and the studies for the systematic review did not include observations from the Indian population. The standardization of a measure, particularly in the Indian scenario which is a lower-middle-income country, is needed for the acquisition of scientific evidence of such an association.

The association between obesity and the occurrence of TDI in the present systematic review was doubtful. Although results suggest that there was an increased chance of TDI among overweight/obese individuals,[35,63,77] inconsistencies exist among the four studies[35,52,63,77] reported. In a systematic review by Gottems et al.,[10] the evidence favors no significant association between dental trauma and physical activity and nutritional status. However, the authors were inconclusive of the results due to the relatively low level of current evidence especially because of obesity. Consequently, prospective cohort studies are needed to address this issue further.

The current systematic review indicates that fall injuries were most commonly associated with dental trauma followed by sports and collision. This was a common finding in other reviews as well.[7,8] Besides the present systematic review also suggested that TDI most frequently occurs at home than in school, street, or playgrounds. Previous studies with similar findings suggested that this could be because the children and adolescents spend more time at home and the parents are unaware of preventing TDI.[2,6,7,11]

In the present review, overjet was classified as studies reporting an overjet of >3.5mm (OR = 4.84; 95% CI: 2.86–8.19) and >5.5mm (OR = 4.84; 95% CI: 4.32–5.63). In both cases, a positive association of as much as five times greater with TDI than normal overjet was found in the meta-analysis. An Australian systematic review conducted by Arraj[82] reported that an increased overjet was significantly associated with higher odds of developing trauma in all dentition stages and age-groups. A similar study by Soriano EP in Brazil also suggested that an overjet size greater than 5 mm and inadequate lip coverage were predisposing factors related to the occurrence of traumatic dental injuries.[83] Increased overjet due to the proclination of anterior teeth leaves them vulnerable and less protected by lips. Thus, when the lips do not cover the entire tooth, they do not absorb any impact and all force is applied to the tooth.

The present review showed that participants with inadequate lip coverage were three times as likely to be associated with TDI compared to those without TDI (OR = 4.76; 95% CI: 3.18–7.11). The finding was in accordance with other systematic reviews as well.[7–9,12] Even before orthodontic treatment is started, such patients should be periodically monitored and educated about TDI prevention. The use of mouthguards should also be promoted in these groups.[2]

In addition, increased association of Angle's class 2 malocclusion (particularly division 1 molar relation) with TDI is inferred from the qualitative synthesis. It has been well documented that malocclusion is associated with less masticatory efficiency and a poorer quality of life. As such, clinical factors of malocclusion associated with a higher chance of suffering TDI (such as greater overjet, inadequate lip sealing, class II division I molar relation) should be prevented and treated not only because of their association with TDI but also due to their impact on children and adolescents.[8]

Based on the qualitative synthesis of the studies, maxillary central incisors account for most of the TDI followed by maxillary lateral incisors, which was in agreement with other studies.[2,7] This could be partly explained by the fact that the anterior teeth are more prone to injures due to their obvious placement in the arch and also maxillary central incisors are positioned to receive the maximum impact during a fall or collision. The nature of injury involved maximum enamel fracture followed by enamel and dentine fractures. This finding was supported by other review articles as well.[6,7,11]

There is noticeable fluctuation in the trends of TDI prevalence over the years. An increasing pattern for trend line with a positive slope can be observed suggesting that TDI could pose a significant dental public health issue in permanent dentition. In addition to the trend line, a forecast plot for the next 10 years based on different classifications used was generated to further understand the variation in the prevalence of TDI. All the three most commonly used classification indicated an increasing pattern with a positive slope. A steep gradient was observed in the case of TDI classified by mere clinical examination and a considerably moderate rise in the case of Ellis and Davies and WHO criteria. A possible explanation for the overestimation of TDI by clinical examination could be inability to follow a specific set of standard criteria. Inconsistencies of outcome assessment by different examiners can thus add more to the reason why the observations were more scattered resulting in a steep forecast line. As for Ellis and Davies and WHO criteria, most of the observations were almost in line with the forecast trend suggesting a proper estimation for TDI. Nevertheless, it is worth to state that this trend analysis does not reflect exact data from all regions of India. Further studies should be conducted to map possible different scenarios nationwide considering different geographic locations for more prediction.

Considerable asymmetry was observed in the funnel plot for the present systematic review. This may be due to several reasons, including true heterogeneity (i.e., smaller studies differ from larger ones in terms of the study population, exposure levels of risk factors, etc.), selection bias and bias in design or analysis, or chance.

There were several limitations in this systematic review. It should be noted that the data for Indian studies are weighted toward Southern and Northern India with only 1 of the 59 studies reporting data from West Bengal. Therefore, the data presented should be interpreted as pertaining mainly to some regions of India. Moreover, the literature search was restricted to studies published in permanent teeth, which may have introduced bias into the study. However, there were only a few studies that were excluded for this reason. Meta-analysis could not be performed for several predictors as data were not extractable for each study level covariate. Subgroup analysis could not be relied upon because of the high disparity in the number of studies under each subgroup. Varying criteria for assessing TDI as well as lack of longitudinal studies could have underestimated the actual prevalence.

Despite these limitations, this systematic review provides a comprehensive overview of prevalence, associated risk factors of TDI across time and geography compared to other published review in India without any language restriction in the included studies. The burden of TDI varies by geography and appears to be increasing over time. Definitive reasons for the increasing incidence rates of TDI are largely unknown and may be attributed to a greater number of studies being conducted in the last 5 years. Despite several Indian surveys conducted for TDI in the literature, the present systematic review highlights the need for incidence and prevalence data in many regions of India, particularly from the Eastern and North Eastern and Western regions. Future studies in these regions are required for additional insight into the geographic patterns and time trends of TDI that will provide important perceptions into the etiology and may well serve as a foundation for the formulation of an objective universal classification for TDI that would facilitate judging the actual prevalence.

Public Health Significance and Recommendation

This review will help researchers estimate the public health burden of TDI and assist policymakers in the allocation of appropriate healthcare resources and research in specific geographic regions. Simple measures such as identifying high-risk groups and prompting them for orthodontic treatment can curb the incidence of TDI. Parents, teachers, and supervisors must be educated particularly about the potential risk factors of TDI and safeguarding home by padding sharp furniture or corners, carpeting the play area or hall so that the children can be careful at home when left unattended. Further, they must be made aware of consequences of deleterious oral habits, such as chewing on hard objects like pencils or pens that can be preventable. Children and adolescents, especially males, should be informed about risk-taking behavior and to watch out for possible obstruction while playing so that they do not trip down. Also, they must be advised to practice safe and responsible playing without pushing or knocking each other with heavy objects. Maintenance of certain harmonized movement measures in the school classrooms, corridors, or staircases where the children are more likely to get injured due to collision and falls can prevent sudden impact injuries to the teeth. The play area of the schools should be preferably covered with grass and children involved in sports activities should be informed about using mouthguards. Therefore, the results of this study should be considered in the adoption of public health policies and inform further research to the same end preferably with a universal classification for assessing TDI.

Conclusion

The present systematic review reported that the prevalence of dental trauma in permanent teeth among children and adolescents in India was 11% (0.11) (95% CI 0.09–0.13), with a high degree of heterogeneity among studies. Most of the studies presented a moderate–high risk of bias. Male gender, increased overjet, and inadequate lip coverage were observed to be significantly associated with TDI. Also, a qualitative synthesis revealed a positive association of sociodemographic factors, such as rural population, low socioeconomic status, and environmental factors, like place of occurrence and cause of TDI, with TDI. However, the data could not be pooled under the criteria required for meta-analysis. Trends for TDI seem to be increasing with years among children and adolescent population in India. To advance the understanding of the key determinants of TDI, future population-based analytical studies should focus on reporting the incidence and/or prevalence of TDI among marginalized communities.

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