

Prevalence of Tooth Mortality among Adults in India: A Systematic Review and Meta-Analysis

Abstract

Tooth loss remains a significant deterrent to oral health and adversely affects the dietary intake and nutritional status of individuals compromising their general health. It is a debilitating and irreversible condition and is considered as the “final marker of disease burden for oral health.” The prevalence of tooth mortality and its causes has been studied for many years through point prevalence studies; however, there is a need to generate a national representative data. This study aimed to systematically review the available literature measuring the prevalence of tooth mortality in India. We searched the following databases for studies that had assessed the prevalence of tooth mortality in India: PubMed/Medline, PubMed Central, and Scopus. This yielded 36 studies, of which 16 eligible cross-sectional studies assessing the prevalence among those 18 years and above were included. Meta-analyses using the random-effects model were conducted for tooth mortality outcomes which stratified for different covariates such as age groups, gender, geographic region, population group, type of index, and reason for loss using MetaXL Version 5.3 Software, Netherlands developed by Dr Jan J Barendregt. Pooled prevalence was used to estimate the overall effect, with 95% confidence intervals (CI). A total of 13,662 adults participated in the 16 studies. We found that the overall prevalence of complete tooth mortality (loss of 32 teeth) was 10.7% (95% CI: 10.2%–11.2%, 16 studies, $n = 2249$) and partial tooth mortality (having one or more teeth) was 58.8% (95% CI: 57.9%–59.6%, 16 studies, $n = 7526$). Rural area adults showed twice 61% (60.5%, 95% CI: 58.9–62.1, 7 studies) than urban adults. Females had higher partial tooth mortality (48.2%), whereas males higher complete tooth mortality (20.2%). There was higher methodological heterogeneity of included studies. Nearly 35% of adults have complete or partial tooth mortality. Greater tooth mortality indicates the burden of the prosthetic needs.

Keywords: *Edentulousness, prevalence, tooth mortality*

Introduction

Tooth loss remains a significant deterrent to oral health and adversely affects the dietary intake and nutritional status of individuals compromising their general health. In adults, the number of tooth loss can be viewed as an index of lifetime accumulation of poor oral health which mainly stems from untreated dental caries and periodontal disease. Moreover, evidence from observational studies shows that tooth loss may be associated with multiple adverse health effects, including epilepsy, cognitive impairment, ischemic heart disease, heart failure, stroke, peripheral vascular diseases, and cancer. The determination of the specific causes of tooth loss as examined by the previous studies shows tooth loss is an eventual

complication of the two most common dental diseases namely dental caries and periodontal disease. It is a debilitating and irreversible condition and is considered as the “final marker of disease burden for oral health.”^[1] Edentulism has a significant effect on quality of life outlined by the contribution of more than a third to oral disorder disability burden globally (7.6 million DALY's).^[2] While edentulism primarily affects normal day to day functions such as mastication and speech, it eventually leads to systemic effects such as nutrition, diabetes, and cardiovascular complications. Being a consequence of dental caries and periodontal disease, the prevalence of edentulism is also shown to vary with demographic factors such as age, gender, geographical region, and social status. Edentulism can be broadly divided into partial and complete edentulism. It represents a state of disability that the

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person carries for life unless prosthetically rehabilitated.^[3] Due to its high prevalence and its effect on general health, edentulism qualifies itself as a public health problem. Thus, a reduction in the number of edentulous patients is proposed as one of the Global Oral Health Goals of 2020.^[4] The past few decades have seen a decline in the prevalence of edentulism globally. This decrease could be attributed mainly to the estimates from high-income countries, whereas low- and middle-income countries show an increasing trend corresponding to the rise in periodontal disease and dental caries. The World Health Organization (WHO's) The World Health Organization's (WHO) Study on global AGEing and adult health (SAGE) Wave 1 conducted in 2012 pegs the prevalence of rate of edentulism in India at 16.3%.^[5] Data from the sole national-level survey in India report a prevalence of 0.8% among 35–44 years old and 29.3% among 65–74 years old patients.^[6] The WHO recommends surveillance of oral disease every 5 years.^[7] Unfortunately, such a system of data collection and monitoring does not exist in India. This deficit substantiates the need to identify alternate sources of data, which includes point prevalence studies conducted to measure the burden of edentulism in selected population groups or geographical regions across the country, to estimate a pooled prevalence of edentulism in the country. Hence, this systematic review was designed to generate nationally representative data on the burden of edentulism among the adult population in India from previously published point prevalence studies.

Materials and Methods

The review protocol was registered in PROSPERO data with reference number CRD42020128403 (Registration was delayed due to COVID-19 Pandemic Situation). The Preferred Reporting Items for Systematic Reviews and Meta-analyses^[8] statement and the patient, intervention, comparison, and outcomes method was followed in this systematic review. The details are as below:

- Patient: Adult's ≥ 18 years
- Intervention = Not applicable
- Comparison: Prevalence
- Outcomes: Tooth mortality.

Focused question

What is the prevalence of tooth mortality among adults in India?

Eligibility criteria

This systematic review was limited to cross-sectional studies. The studies which assessed the prevalence and oral health status of tooth mortality among adult's ≥ 18 years were included, that is.

- Population-based or community-based cross-sectional studies conducted on Indian adults (>18 years) to assess the prevalence of tooth mortality
- Studies conducted to assess the oral health status of a

population in which assessment is done as per eligible indices

- Studies done to compare tooth mortality of immigrants and native population-the data of native people will be eligible.

Information sources and search

The electronic search was performed using PubMed/Medline, PubMed Central, Scopus, databases, with a platform-specific search strategy consisting of combinations of controlled terms (MeSH) and text words. The studies published from January 1, 2010 to August 2019 in the adult population were selected. The search strategy included the usage of MeSH terms, with "edentul*" (All Fields) AND "prevalence" (All Fields) AND "India" (All Fields) "toothloss" AND (All Fields) "reason for toothloss" AND (All Fields) "partially edentulous*" AND (All Fields) "completely edentulous" and key words such as oral health status or decay missing filling teeth index, with no language restrictions. In addition to, 230 articles were found by Google Scholar, hand search, and bibliographies of retrieved articles with the usage of search strategy using Mesh terms as described previously. Two authors (MV and CJ) independently eliminated any duplicate from the gathered results and examined the remaining articles by title and abstract. Any disagreement was adjudicated with a third reviewer (RV). Subsequently, the full texts were obtained and analyzed for further inclusion/exclusion criteria. Studies that did not meet the inclusion criteria were excluded. Full text of articles identified from title and abstract screenings were reviewed thereafter.

Data collection process and data items

The following details were recorded by two reviewers (MV and CJ) from all the included studies, using a Microsoft Excel spreadsheet: Year of publication, language, demographic characteristics of participants, authors, place of the study, sample size and sampling technique used, the sample size in terms of gender, age range of the studied population, overall age, and gender-wise prevalence, and status of the prevalence of tooth loss. The weighted-proportions differences were calculated for the outcomes (measured by different scales/indices) of each study. Random-effects models were used to calculate a pooled estimate of tooth loss and its 95% confidence intervals (CIs). The authors were contacted in the event of any missing data.

Quality assessment

All included studies were assessed independently and in duplicate by two review authors (MV and CJ) for study design characteristics and features of internal validity. An instrument was used (adapted from Hoy *et al.*)^[9] to assess the quality of the eligible studies. Each study was assessed in terms of study settings, sampling strategy, measurement

tools, analysis method and generalizability of findings. The sum of the points awarded to each question was assessed by the scoring (low risk – 0 and high risk – 1). The overall quality of each study was then assessed by ranking the studies. Score of 0–3, 4–6, and 7–9, were considered as low, moderate, and high quality, respectively [Table 1]. Review authors were not blinded to author and source institution. Any disagreement was resolved by discussion or by third party adjudication.

Synthesis of findings

The absence of significant clinical heterogeneity in terms of patient demographic characteristics and the measures used to record tooth loss, along with the quality of the studies led to the decision to pool the study data. We performed an evaluation of the heterogeneity of the data using the Q statistic, a Chi-square test, with a threshold $P < 0.10$. The consistency was assessed visually using the I^2 statistic. An I^2 value above 75% was indicative of high heterogeneity. The I^2 statistic describes the proportion of variation in point estimates attributable to heterogeneity rather than sampling error. Subgroup analyses were performed for age, gender, place of the study. Meta-analysis was performed using Meta XL software developed for use with Microsoft Excel. Meta-analysis was undertaken using a random-effects model (to account for heterogeneity). Pooled prevalence was calculated with 95% CI based on the total sample size and number of affected participants. The following variable was considered for subgroup analysis: Gender (males and females), age group (35 years, 35–65 years, and 65 years), population sub-group (general, rural, urban, and others), and region (North and South India).

Results

Study selection

Electronic searches from all sources retrieved 547 citations [Figure 1]. After the removal of duplicates, 167 records were screened further. Titles and abstracts were screened to yield 36 studies (131 were excluded). Of these

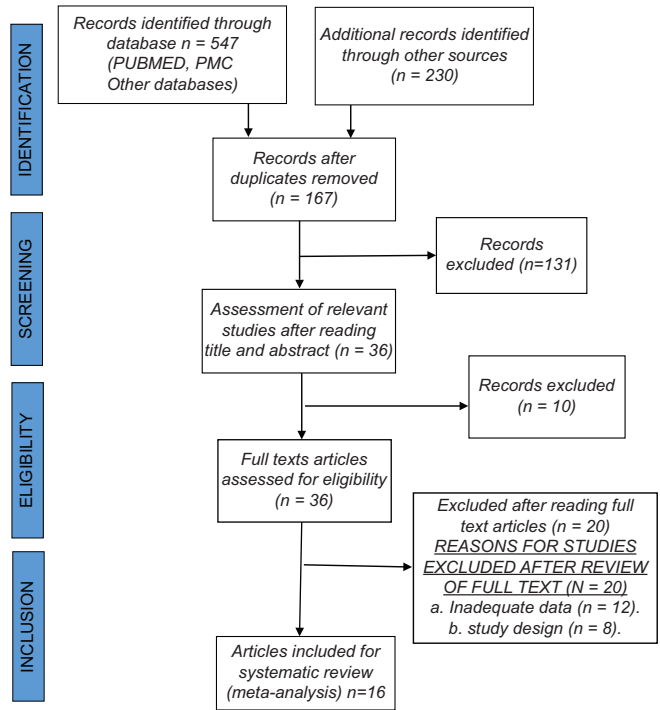


Figure 1: Flow chart to illustrate the process by which articles were selected or rejected for inclusion in the study

Table 1: Characteristics of included studies

First author	Year of survey	Geographic zone	Location of survey	Target population	Total sample size	Age group (years)	Index used to measure tooth mortality	QA score
Bushranaaz	2011	S	Karnataka	Urban and rural	1293	35-74	DMF	2
Pradeep	2006	S	Kerala	General	1791	15-24 35-44 55-64	DSTN	2
Nagaraj	2009	S	Karnataka	General	1000	40-70	DSTN	2
Pradeep S	2009	N	Madhya Pradesh	General	1170	14>	DMF	3
Shah	2003	N	Delhi	Urban and rural	1240	60+	DSTN	2
Kamal	2008	S	Karnataka	General	365	16-84	DSTN	3
Suneel	2015	S	Karnataka	General	384	18-35	DSTN	5
Vishal	2006	S	Karnataka	Others	614	18-67	DSTN	1
Manimaran	2019	S	Tamilnadu	Rural	1000	30-60	DSTN	1
Vikram	2007	N	Haryana	Others	1393	18-80	DSTN	1
Abdurahiman	2013	S	Kerala	General	500	18-25	DMF	2
Ramya	2008	S	Karnataka	Urban	1223	18-65	DMF	2
Sesha	2014	S	Andhra Pradesh	General	150	18+	DMF	3
Vidhi	2018	N	Uttar Pradesh	General	1044	20-40 40-60	DSTN	5
Shabana	2015	S	Andhra Pradesh	General	450	35-74	DSTN	1
Deepa	2019	N	Uttar Pradesh	Urban and rural	1200	35-74	DMF	2

Low risk: 0-3, Moderate risk: 4-6. DSTN: Dentition status and treatment needs, DMF: Decay missing and filled teeth

36 studies, 20 studies did not meet the inclusion criteria as they had missing values of outcome (studies were not cross-sectional [8 studies] and 12 studies did not mention the dentate status namely complete or partially edentulous value). There have been no responses for communication to authors through E-mail for additional data. A total of 16 studies were eventually included in the systematic review.

Study description

Selected characteristics of the included studies are shown in Table 1. Sixteen studies were included for the systematic review and comprising of 27,324 adults were included for the meta-analysis. The pooled estimate of completely edentulous and partially edentulous status is from 16 (13,622 participants) and 16 studies (13,622 participants), respectively, are enumerated in Table 2. The Decayed, Missing, and Filled (DMF) teeth was used to assess tooth mortality in 6 studies, while the rest 10 studies followed the Dentition status and treatment need (DSTN) index. Only eight studies were conducted before the year 2010. Sixteen studies each represented the northern and southern part of India. The target population was specified as the general population in nine studies, whereas 3 studies assessed the prevalence in the rural and urban populations. Furthermore, 1 study assessed specifically in rural, while another 1 study assessed in the urban population.

Synthesis of results

Overall, the prevalence of tooth mortality was 34.6% (95% CI: 34.1%–35.2%, 16 studies, 27,324 participants) [Table 2]. Females had a higher proportion (80.1%) (95% CI: 78.6%–81.4%) of tooth loss than males (76.4%) (95% CI: 75.2%–77.5%, 11 studies, 5516 participants) [Figure 2]. Compared to other age groups, those aged ≥65 years had a higher prevalence (99.8%, 95% CI: 99.3%–100%, 4 studies), while participants were aged 35–65 years and 0–35 years had a prevalence 91.5%, (95% CI: 90.6%–92.4%, 8 studies), 90.6% (95% CI: 89.5%–91.7%, 7 studies) are, respectively. Rural population had a higher burden of tooth mortality (47.5%, 95% CI: 46.2%–48.7%, 10 studies), while compared among urban participants (31.3%, 95%

CI: 30.2%–32.5%, 9 studies). Dental caries had higher prevalence 93.9% (95% CI: 92.0%–95.6%, 4 studies) of reason for the loss of tooth compared to periodontal disease 65.5% (95%CI: 61.9%–69.0%, 4 studies). The publication bias of the included studies is described in funnel plot [Figure 3].

Subgroup analysis

The outcomes of the subgroup analysis of the pooled estimate of tooth mortality prevalence (according to its dentate status) are described in Tables 3 and 4. Nearly 59% participants had partially edentulous (58.8%, 95% CI: 57.9%–59.6%, 16 studies), while completely edentulous was reported in 10.7% (95% CI: 10.2%–11.2%, 16 studies). When the pooled prevalence of partially edentulous and completely edentulous was stratified by age, sex, type of population, the reason for loss, and geographical region, females had a higher proportion of (48.2%, 95% CI: 46.4%–50.0%, 10 studies) partially edentulous than males in the completely edentulous state (20.2%, 95% CI: 19.1%–21.2%, 11 studies). Individuals aged between 0 and 35 years had a higher prevalence (88.9%, 95% CI: 87.7%–90.0%, 7 studies) of partially, while those aged ≥65 years showed 32.1% completely edentulous (95% CI: 27.8%–36.4%, 4 studies). The rural population showed higher prevalence estimates for partially edentulous than the urban population in completely edentulous. Most of the studies (n = 16) had a high score for methodological parameters for cross-sectional studies. Dental caries as a reason for the loss of tooth in the partially edentulous state shows a higher proportion, while in completely edentulous in periodontal disease as a reason for the loss of tooth 28.5% (95%CI: 25.2%–32.6%). Except for partially edentulous dentate status in southern regions, northern zones of India did not reveal substantial variation in the prevalence of partial or complete type of tooth mortality.

Discussion

Rationale for conducting the review

While point prevalence studies is a valuable metric to help researchers assess a disease burden among a specific population at a particular point in time, a synthesis of this data in a systematic manner has a significant potential to inform social and healthcare professionals, policy makers and the

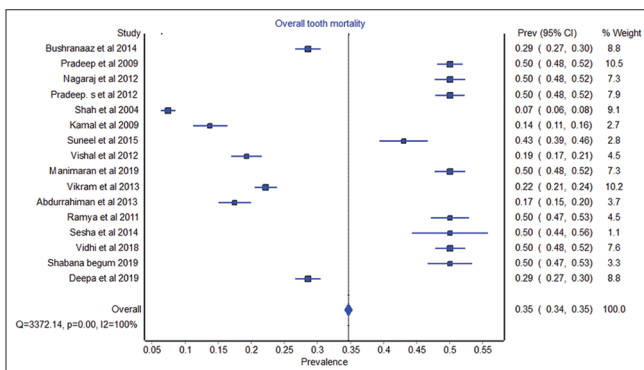


Figure 2: Forest plot of pooled estimate of the tooth mortality

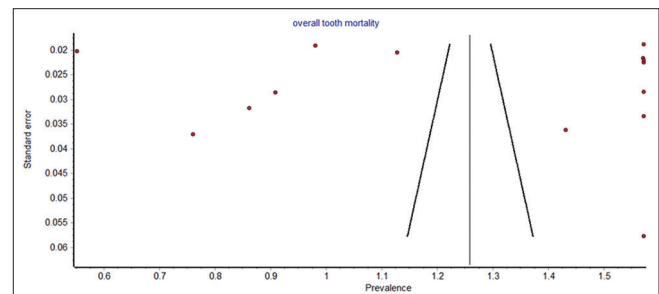


Figure 3: Funnel plot of included studies

public to better manage and plan for the disease burden. With practical and economic difficulties for conducting national surveys for assessing burden of oral diseases in the frequency recommended by the WHO in a country like India, we need

to fall back on collating the available evidence from well conducted point prevalence studies for generating a nationally representative data. This is the reason why systematic reviews of prevalence studies are conducted.

Table 2: Overall prevalence of tooth loss

Characteristics	Variables	Number of studies	Total sample (n)	Number participants with loss (n)	Pooled prevalence, n (%)	95% CI (lower limit-upper limit)
Overall	Total	16	27,324	9775	34.6	34.1-35.2
Gender	Male	11	5516	3725	76.4	75.2-77.5
	Female	10	3095	2188	80.1	78.6-81.4
Population	Urban	9	6391	2227	31.3	30.2-32.5
	Rural	10	5951	2710	47.5	46.2-48.7
	General population	9	6667	3353	53.2	52.0-54.4
Age (years)	0-35	7	2825	2267	90.6	89.5-91.7
	35-65	8	3820	3071	91.5	90.6-92.4
	>65	4	450	450	99.8	99.3-100
Reason for loss of tooth	Dental caries	4	686	621	93.9	92.0-95.6
	Periodontal disease	4	686	423	65.5	61.9-69.0

CI: Confidence interval

Table 3: Overall prevalence of partially edentulous tooth loss

Characteristics	Variables	Number of studies	Total sample (n)	Number participants with loss (n)	Pooled prevalence, n (%)	95% CI (lower limit-upper limit)
Overall	Total	16	13,662	7526	58.8	57.9-59.6
Gender	Male	11	5516	2413	41.1	39.8-42.4
	Female	10	3095	1504	48.2	46.4-50.0
Population	Urban	6	2818	970	30.6	28.9-32.3
	Rural	7	3579	1995	60.5	58.9-62.1
	General population	6	5362	2567	46.8	45.5-48.2
Age (years)	0-35	7	2825	2245	88.9	87.7-90.0
	35-65	8	3820	1950	51.6	50.0-53.9
	>65	4	450	275	67.9	63.6-72.8
Reason for loss of tooth	Dental caries	4	686	406	69.4	65.9-72.8
	Periodontal disease	4	573	270	53.5	49.4-57.5
Geographical zone	North	5	6047	2531	40.7	39.4-41.9
	South	11	8770	4998	87.8	87.1-88.5

CI: Confidence interval

Table 4: Overall prevalence of completely edentulous tooth loss

Characteristics	Variables	Number of studies	Total sample (n)	Number participants with loss (n)	Pooled prevalence, n (%)	95% CI (lower limit-upper limit)
Overall	Total	16	13,662	2249	10.7	10.2-11.2
Gender	Male	11	5516	1330	20.2	19.1-21.2
	Female	10	3095	684	18.6	17.2-20.2
Population	Urban	7	5076	1591	27.1	25.9-28.3
	Rural	7	4058	77	6.1	5.4-6.9
	General population	4	2917	607	46.8	44.0-49.6
Age (years)	0-35	7	2740	22	0.6	0.3-0.9
	35-65	8	3786	1153	23.8	22.5-25.2
	>65	4	450	175	32.1	27.8-36.4
Reason for loss of tooth	Dental caries	4	686	215	21.5	18.5-24.7
	Periodontal disease	4	573	215	28.5	25.2-32.6
Geographical zone	North	5	6047	1494	6.7	6.2-7.1
	South	11	8770	1177	2.8	2.5-3.1

CI: Confidence interval

Summary of evidence

Several studies have been conducted to investigate the loss of tooth in various populations. These include surveys, studies targeting local populations, and institution-based studies. However, very little data is available regarding the prevalence rate of tooth mortality among a nationally representative sample of adult patients in India. In this systematic review and meta-analysis, the attempt was to generate the national representative data on the prevalence of tooth mortality using the estimates of these point prevalence studies published, to account the pooled prevalence of the tooth mortality among adult population in India.

Our systematic review included sixteen articles covering a population of 13,662 adults were eligible for the outcome measurement of tooth mortality in the meta-analysis. Of these 13,662 populations, we found that the overall prevalence of complete tooth mortality (loss of 32 teeth) was 10.7% (95% CI: 10.2%–11.2%, 16 studies, $n = 2249$) and partial tooth mortality (having one or more teeth) was 58.8% (95% CI: 57.9%–59.6%, 16 studies, $n = 7526$). The loss of teeth reflects a major public health problem in many countries.^[10] Edentulism has a significant impact on health and the overall quality of life.^[11] However, studies on self-perception have shown that tooth loss is associated with aesthetical, functional, psychological, and social impacts on individuals.^[12-14] The review concludes that nearly 35% of the adult population has complete or partial tooth mortality. It means greater tooth mortality indicates the burden of the prosthetic needs. Among the top hundred detailed causes of DALYs oral conditions, severe tooth loss ranked 81st (95%UI, 61–103). In 2010, oral conditions combined accounted for 15 million DALYs globally (1.9% of all YLDs and 0.6% of all DALYs), implying an average health loss of 224 years per 100,000 people.^[15] All other domains have been adequately addressed in the included studies.

All studies used clinically measured and self-reported number of teeth or missing teeth as measurement. Most studies used the number of remaining teeth, number of teeth, and number of missing teeth. Few studies employed, the number of unreplaced teeth and number of natural teeth as exposure. Many confounders (age, sex, social determinants such as socioeconomic status and marital status, smoking, risky alcohol consumption, tobacco chewing, oral health behavior, periodontitis, and caries) were considered in determining the relationship between the tooth loss. When stratifying the data into subgroups based on different exclusion criteria, similar results were obtained for causes of the tooth mortality; however, the strength of the association differed among the studies. Heterogeneity was very high in the overall and subgroup analyses.

Overall completeness and applicability of evidence

There was considerable heterogeneity in the meta-analysis of the primary outcome. Further, it can be stated that these studies exhibited high heterogeneity ($I^2 = 97\%$) due to methodological variance. Since we used the random effects model, it was assumed that there is heterogeneity between the studies and the heterogeneity within the studies is due to methodological aspect as the only source of the variance. We found the CIs of each of the individual studies overlapping. Hence this variability can be attributed to the uncertainty around each point estimate.

Methodological heterogeneity

But our systematic review shows that prevalence estimates of tooth mortality vary widely among studies. Of the sixteen studies, DMF index was used to assess tooth mortality in 6 studies, while the rest 10 studies followed DSTN index. Differences of this magnitude are unlikely to reflect real differences between populations and more likely to be due to biases in methods. In addition to their differing geographic settings, the studies differed in recruitment method, sample size, data collection, and multimorbidity, including the number of conditions and the conditions selected. All these factors may affect prevalence estimates. Significant heterogeneity in the handling of confounders in studies and hence the lack of confounder calibration, further raises caution in summarizing as well as interpretation of the results. These factors together contribute to diversifying the quality of the papers. Besides the heterogeneity on the part of confounders, the review also highlights a significant lack of consistency in the studies for measurement of independent variables to capture tooth loss in their study population. This heterogeneity is not only important for the interpretation of the results, but it also raises questions about the most appropriate measure of tooth loss.

Subgroup analysis

We carried out the subgroup analysis to investigate the heterogeneity among studies. Subgroup analysis according to the dentate status type showed that, Indian population have more prevalent tooth mortality found to be in partially dentate (59%) than completely dentate (10.7%). The reason for this might be expected to be poor awareness, inaccessible or unavailable dental service and negligence, and lower socio-economic conditions. Similar observation is done by researchers where the elderly people tend to consult a dentist only when they are in trouble.^[16,17] Furthermore, the review highlighted more female Indian had partial dentate predominance than male Indian population, though similar observation was found in study Caucasian population.^[8] The rural Indian population showed higher prevalence estimates for partially edentulous than the urban population in completely edentulous. The difference in tooth loss among rural and urban counterparts' adults be explained by similar studies. Also, the attitude of the rural people is generally

such that they elect to have their symptomatic teeth extracted rather than conserving those.^[18] To summarize, the findings of this study provide an insight into the prevalence of tooth mortality in the Indian population. This national estimate and identified risk factors of edentulism among Indian adults across the country can help policy-makers and public-health researchers to understand the importance of edentulism and its overall impact on the health of the elderly. This study can help to advance the need for health programs focusing on edentulism that are also inclusive of oral health promotion and prevention.

This systematic review and meta-analysis have been done based on various point prevalence studies and the lone national survey on dental diseases. Although we acknowledge that it might not represent India *per se*, we believe this is the closest estimate ever to be reported in the literature as the cumulative data has been taken from studies conducted across the country.

Limitations

In the presence of risk of methodological bias and low quality of evidence, the pooled estimates need to be used cautiously. Furthermore, the missing data of some studies made it difficult to assess the other reasons for the tooth loss in subgroup analysis. Similarly, we could not perform metaregression, sensitivity analysis or to detect the publication bias due to the small number of data among the studies.

Conclusion

Based on this result, nearly 35% adult Indian population have completed or partial tooth mortality. Furthermore, the finding of this review justifies the greater need to educate the younger generation regarding the importance of teeth, treatment of diseased teeth as it shows higher predominance among adults. With this, edentulism continues to represent an enormous global health care burden that is often neglected in developing countries like India. It can be stated that the need for prosthodontic care is expected to increase in average life span of the adult Indian population. This epidemiological data across the country confirm the need for community-based oral health promotion and disease prevention programs.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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