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Risk of dental caries and periodontal disease among older adults and elderly persons with diabetes in India: a population-based cross-sectional study

Subhojit Shaw¹ and Junaid Khan^{2*}

Abstract

Background Oral health is a key indicator of overall well-being, and diabetes, a complex metabolic disorder, often leads to related oral health problems. Given the high prevalence of diabetes among Indian older adults and elderly persons, this study examines the diabetes associated risk of dental caries and periodontal disease among them.

Methods This cross-sectional study analysed data from 65,562 adults aged 45 and above, based on the 2017-18 Longitudinal Ageing Study in India (LASI) Wave-1 survey. We used bivariate cross-tabulation to estimate the prevalence, chi-square analysis to examine the prevalence differentials and multivariate logistic regression to estimate the adjusted odds ratio (AOR).

Results Bivariate analysis shows that diabetic older adults demonstrate a slightly higher prevalence of dental caries (20.43%) compared to those without diabetes (18.62%), but there is no significant difference in periodontal disease between the two groups. The regression analysis confirms that diabetes significantly increases the risk of both dental caries (AOR: 1.18, p < 0.001) and periodontal disease (AOR: 1.10, p = 0.008). Additionally, females and urban residents are at a higher risk of dental caries, while rural residents face a greater risk of periodontal disease. Socioeconomic factors, such as lower education and higher wealth, play a key role in caries and periodontal problems.

Conclusion Effective management of diabetes-associated oral health problems in India requires a comprehensive, population-specific approach due to the country's diverse demographic and socioeconomic landscape. Tailored interventions focusing on diabetes care, education, and access to oral health services are essential, particularly for high-risk groups like older adults, women, rural residents, and those with lower education or socioeconomic status.

Keywords Oral health, Diabetes, Dental caries, Periodontal disease, Older adults, Elderly population

Introduction

Diabetes presents a significant and escalating challenge globally and the prevalence of diabetes has been steadily increasing, with projections indicating a further rise

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in the upcoming years [1-3]. In 2022, approximately 828 million adults (aged 18 years and older) were estimated to have diabetes, reflecting an increase of 630 million since 1990 [3]. At the same time, the prevalence of diabetes in India has been on the rise, reflecting a global trend, where developing countries, including India, are experiencing a surge in diabetes cases [4]. According to the International Diabetes Federation (IDF) estimates, diabetes prevalence in the South-East Asia region is projected to rise significantly over the coming decades. In 2019, an estimated



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87.6 million people had diabetes in South-East Asia, with a world-age standardized prevalence of 11.3% and the number of people with diabetes is expected to increase to 115.1 million, with a prevalence of 12.2% in the same region [5]. This trend continues into 2045, where projections indicate 152.8 million individuals with diabetes and a prevalence of 12.6% [5]. In India, the number of people living with diabetes was estimated at 77 million in 2019, this figure is projected to rise to 101 million by 2030 and further increase to 134 million by 2045, highlighting a significant public health concern [5].

Diabetes is a prevalent chronic condition with significant implications for oral health, creating a substantial public health burden globally. Individuals with diabetes are at a heightened risk of experiencing oral health problems, including periodontal disease, dental caries, and candidiasis [6]. The intricate interplay between diabetes and oral health is crucial to understand, especially considering the escalating burden of both conditions worldwide [7, 8]. Notably, the burden of oral diseases is not limited to high-income countries but is also growing in low- and middle-income countries, further emphasizing the need to address oral health problems as part of the broader public health agenda [9].

In 2021, the global age-standardized prevalence of major oral conditions including untreated dental caries, severe periodontitis, edentulism, and other oral disorders was estimated at 45,900 cases per 100,000 population and approximately 3.69 billion individuals worldwide were affected by these conditions [10]. Among them, untreated dental caries in permanent teeth and severe periodontitis were the most prevalent, with global agestandardized prevalence rates of 27,500 and 12,500 per 100,000 population, respectively [10]. The global burden of untreated caries in permanent teeth and severe periodontitis has increased significantly from 1990 to 2021, with 2.24 billion and 1.07 billion cases, respectively [10]. While the number of cases rose by 53.0% for caries and 91.5% for periodontitis, the age-standardized prevalence per 100,000 population was 27,500 for caries (a 2.78% decline) and 12,500 for periodontitis (a 1.76% increase) [10]. According to WHO estimates for South-East Asia, dental caries had a high prevalence of 28.69% in 2019, affecting over 525 million individuals, but its prevalence increased only marginally (0.67%) over three decades during 1990-2019 [11]. However, the number of cases rose significantly by 65.26%, due to population growth [11]. At the same time, severe periodontal disease had a prevalence of 20.77% in 2019, with over 306 million cases in South-East Asia [11]. Unlike caries, its prevalence increased substantially by 22.66%, and the number of cases more than doubled (125.95%), indicating a growing public health concern in the region [11].

Oral health is a critical but often overlooked component of overall well-being, particularly among older adults. Diabetes, a major public health concern in India, is known to be intricately linked with oral health problems, including dental caries and periodontal diseases. However, the extent of this burden among older adults from diverse socioeconomic and demographic backgrounds remains inadequately explored in the Indian context. A population-based study is essential to comprehensively assess the diabetes-associated burden of oral health issues in this group. First, older adults aged 45 and above are at an increased risk of both diabetes and oral health complications due to physiological aging [12], lifestyle factors [13], and inadequate healthcare access [14]. Second, socioeconomic disparities can influence oral health outcomes due to variations in healthcare access [15], dietary habits [16], oral hygiene practices [16], and affordability of dental care [15].

By analysing a diverse sample representative of India's older adult population, this study will help identify highrisk groups, inform targeted interventions, and guide health policies aimed at integrating oral healthcare with diabetes management. Ultimately, it will contribute to a more holistic understanding of aging and chronic disease management in India's rapidly growing elderly population.

In the above context, the purpose of this study is to investigate the risk of dental caries and periodontal disease among older adults (aged 45–59 years) and elderly (60 years and above) individuals with diabetes in India, using data from the Longitudinal Ageing Study in India (LASI) Wave-1 survey. The research seeks to inform public health interventions by identifying high-risk groups and exploring the role of diabetes in oral health disparities among Indian older adults.

Methods

Data

This study employs data from Wave 1 of the Longitudinal Aging Study in India (LASI), conducted across 35 Indian states and territories between 2017 and 2018. Aligned with the Global Health and Retirement Study (HRS), LASI gathered comprehensive information on the physical and mental health, well-being, financial security, and family structures of individuals aged 45 and older, as well as their spouses. To select participants, a multistage stratified probability cluster sampling method was used, with a three-stage design for rural areas and a fourstage design for urban areas. Before data collection, the survey instruments underwent rigorous testing. Detailed information on the sampling methodology, survey tools, and statistical estimates is accessible through the LASI India report [17]. The flowchart (Fig. 1) shows the analytical sample of this study. Following the LASI definition,



Fig 1 Analytical sample of this study, India, LASI, 2017-18

individuals aged 45–59 are referred to as older adults, while those aged 60 and above are referred to as the elderly persons in this study.

Outcome variable

The present study focused on two primary oral health problems among older adults: dental caries and periodontal disease. Data from the LASI were utilized to assess the prevalence of these conditions within the previous 12 months. Participants were asked about their dental health using the following questions: "Have you ever been diagnosed with a dental cavity or dental caries?" Responses were coded as "1" for yes and "0" for no. Additionally, participants were asked, "Have you ever been diagnosed with ulcers lasting more than two weeks, or bleeding or swollen gums?" Responses to this question were coded as "1" for yes (indicating periodontal disease) and "0" for no. This coding scheme allowed for the identification and quantification of these two major oral health problems among India's older population.

Independent variable (predictor)

Diabetes status was determined through self-reported information from the respondent, as available in the LASI data. Participants were asked, "Has a healthcare professional ever diagnosed you with diabetes?" Responses were coded as "1" for yes and "0" for no. This information was used to assess the relationship between diabetes as a primary predictor and its relationship to the specified oral health problems.

Control variables (confounders)

To account for potential confounders, the association between diabetes and the two specified oral health problems was adjusted for a set of sociodemographic, economic, and behavioural variables. Age was categorized into two groups: 45–59 and 60 and above. Residence was dichotomized as rural or urban. Religion was classified as Hindu, Muslim, Christian, or other. Social group in India is represented by caste (Scheduled Caste-SC, Scheduled Tribe-ST, Other Backward Class-OBC, or other) and educational attainment (no schooling, primary, secondary, or diploma/college). Economic status was assessed using monthly per capita consumption expenditure (MPCE), categorized into five quintiles from poorest to richest. And behavioural factors such as alcohol and tobacco consumption were categorized as yes or no.

Statistical analysis

Univariate descriptive statistics, including frequencies and percentages for categorical variables, were employed to characterize the study population. Bivariate analysis using cross-tabulations and chi-square tests assessed the association between dental caries and periodontal disease and participants' background characteristics. Choropleth maps accompanied by bar diagrams (within the maps) were utilized to visualize the prevalence of diabetes, caries, and periodontal disease across different age and sex groups. Multivariate logistic regression analysis was conducted to examine the statistical association between the dependent and independent variables, with adjusted odds ratios calculated to account for potential confounders. Level of significance was considered at level alpha 1%, 5% and 10% accordingly.

Results

The analysis of a sample of 65,562 individuals reveals significant insights into their health status and demographic characteristics (Table 1). A notable portion of the population (12.86%) have diabetes, while 19.63% suffer from dental caries, and 14.26% are affected by periodontal disease. The age distribution shows a slight predominance of individuals aged 45–59 (52.01%), with a sex distribution (46.49% males, 53.51% females). Most individuals reside in rural areas (64.71%). Hinduism is the predominant religion (73.36%), and the majority belong to Other Backward Classes (37.57%). Educational attainment is low, with nearly half of the population (47.01%) having no formal education. Tobacco and alcohol consumption are reported by 36.37% and 17.87% of the study population, respectively.

Table 1 Descriptive statistics of the study variables, India, LASI,2017–2018

Study variables	N	Distribution (%)
Diabetes		
No	57,133	87.14
Yes	8,429	12.86
Dental Caries		
No	52,691	80.37
Yes	12,871	19.63
Periodontal problem		
No	56,045	85.74
Yes	9,323	14.26
Age		
45–59	34,098	52.01
60+	31,464	47.99
Sex		
Male	30,479	46.49
Female	35,083	53.51
Residence		
Rural	42,424	64.71
Urban	23,138	35.29
Religion		
Hindu	48,099	73.36
Muslim	7,803	11.90
Christians	6,536	9.97
Others	3,124	4.76
Caste		
SC	10,959	16.72
ST	11,365	17.33
OBC	24,629	37.57
None	18,609	28.38
Education		
No schooling	30,821	47.01
Primary	16,096	24.55
Secondary	14,929	22.77
Diploma/college	3,716	5.67
MPCE quintile		
Poorest	12,941	19.74
Poorer	13,190	20.12
Middle	13,163	20.08
Richer	13,210	20.15
Richest	13,058	19.92
Tobacco Consumption		
No	41,720	63.63
Yes	23,842	36.37
Alcohol Consumption		
No	53,844	82.13
Yes	11,718	17.87
Total	65,562	

Prevalence of dental caries and periodontal disease among older adults

Diabetes, age, gender, urban residence, and higher economic status are associated with higher caries rates (Table 2). Specifically, those with diabetes (20.43%) and urban residents (22.21%) show the highest prevalence. Education inversely correlates with caries, and Christian (21.91%) have the highest prevalence among religious groups. Both tobacco and alcohol consumption show slight but statistically significant differences in the prevalence of dental caries (p < 0.001).

The analysis of periodontal disease (15.70% overall prevalence) reveals significant demographic patterns (Table 2). Those aged 60 and above, females (16.94%), and rural residents (17.41%) show higher prevalence rates. Muslim (17.18%) and Scheduled Castes (17.73%) also have the highest prevalence among religious and caste groups. Lower education correlates with higher periodontal prevalence rates, with those lacking schooling (17.65%) most affected. While economic status shows no significant impact, tobacco users (16.48%) have higher prevalence, and alcohol consumers (14.49%) have lower prevalence of periodontal disease (p < 0.001 for most comparisons).

Spatial pattern (state level)

Figure 2 highlights India's diverse diabetes prevalence among older adults, ranging from 4% in Meghalaya to 30% in Kerala, with 13% as the national average. Lakshadweep demonstrates the highest caries prevalence (38%), particularly among women (57% of the cases) and those aged 45–59 (51% of the cases), while Assam reports the lowest caries prevalence (9%). Periodontal disease is most prevalent in Bihar(29%), where elderly constitute 60% of the cases and women constitute 56% of the cases (Fig. 2-(b) & (d)). In India, Lakshadweep has the lowest periodontal disease prevalence (3%), though adults aged 45–59 (72% of the cases) are more affected than elderly (28% of the cases). Across India, women consistently show higher susceptibility to both caries and periodontal disease than men.

Multivariate regression results

Table 3 presents the adjusted odds ratios (AORs), *p*-values, and 95% confidence intervals (CIs) to assess the subpopulation specific risk of caries and periodontal disease among older adults.

The analysis highlights key risk factors for dental caries, revealing that diabetes, being female, older age, and urban living significantly increase the likelihood of caries. Notably, older adults with diabetics have an 18% higher likelihood of developing dental caries compared to nondiabetics (AOR: 1.18, p < 0.01). Urban residents have a 26% higher risk, and females face a 41% higher risk than males. Wealthier individuals, especially those in the richest

Background characteristics	Dental Caries			Periodontal Disease		
	%	X ²	<i>p</i> -value	%	X ²	<i>p</i> -value
Diabetes						
No	18.62	76.964	<0.001	15.75	1.871	0.171
Yes	20.43			15.34		
Age						
45–59	18.14	11.300	0.001	15.45	5.050	0.025
60+	19.55			15.96		
Sex						
Male	17.10	72.840	< 0.001	14.24	92.703	< 0.001
Female	20.21			16.94		
Residence						
Rural	17.31	153.188	<0.001	17.41	270.092	< 0.001
Urban	22.21			11.95		
Religion						
Hindu	18.79	173.072	<0.001	15.79	114.525	< 0.001
Muslim	19.62			17.18		
Christians	21.91			9.03		
Others	14.94			14.56		
Caste						
SC	17.20	58.899	<0.001	17.73	99.400	< 0.001
ST	16.23			15.05		
OBC	19.72			14.78		
None	19.38			16.02		
Education						
No schooling	17.88	84.084	< 0.001	17.65	282.370	< 0.001
Primary	20.12			15.17		
Secondary	21.25			13.51		
Diploma/college	13.61			8.40		
MPCE quintile						
Poorest	16.18	100.346	<0.001	15.77	4.212	0.378
Poorer	18.81			16.25		
Middle	18.97			15.85		
Richer	19.11			14.33		
Richest	21.56			16.30		
Tobacco Consumption						
No	18.91	20.618	< 0.001	15.25	31.923	< 0.001
Yes	18.74			16.48		
Alcohol Consumption						
No	18.82	12.357	<0.001	15.92	6.286	0.012
Yes	18.99			14.49		
Total	18.85			15.70		

 Table 2
 Prevalence of dental caries and periodontal disease among older adults and elderly persons by socio-demographic, economic and behavioural characteristics in India, LASI, 2017-2018

quintile, show a striking 36% increased risk. Education also plays a critical role, with less educated individuals at greater risk. Additionally, lifestyle factors like tobacco (AOR:1.22, p<0.01) and alcohol consumption (AOR: 1.25, p<0.01) demonstrates higher odds of dental caries.

The analysis also reveals intriguing patterns in the risk of periodontal problems. While diabetes modestly increases the risk (AOR: 1.10, p = 0.008), older adults (60+) surprisingly face a reduced risk (AOR: 0.90, p < 0.001). Women, however, have a 22% higher risk than



Fig 2 Spatial distribution of diabetes with age-wise and gender-wise distribution of dental caries and periodontal disease among older adults and elderly in India, LASI, 2017-2018

men (AOR: 1.22, p < 0.001). Urban residents are less likely to experience periodontal disease compared to rural dwellers (AOR: 0.71, p < 0.001). Religion plays a role, with Christians showing a significantly reduced risk (AOR: 0.73, p < 0.001), while caste groups like SC and ST also have lower risks. Tobacco use is a strong risk factor, increasing the likelihood by 20% (AOR: 1.20, p < 0.001). Interestingly, wealthier individuals face a slightly higher

risk (AOR: 1.13, p = 0.001), while alcohol consumption does not show any statistically significant association with periodontal disease.

Age-specific adjusted risk of caries and periodontal disease Figures 3 and 4 reveal that individuals with diabetes consistently exhibit a higher probability of caries and periodontal disease compared to non-diabetics, though the **Table 3** Results from the multivariate logistic regression analysisfor dental caries and periodontal disease among older adults andelderly in India, LASI, 2017-2018

Background	Dental Caries		Periodontal Disease		
characteristics	AOR	(95% CI)	AOR	(95% CI)	
Diabetes					
No	1	[1.00,1.00]	1	[1.00,1.00]	
Yes	1.18***	[1.11,1.25]	1.10**	[1.02,1.18]	
Age					
45-59	1	[1.00,1.00]	1	[1.00,1.00]	
60+	1.09***	[1.05,1.14]	0.90***	[0.86,0.94]	
Sex					
Male	1	[1.00,1.00]	1	[1.00,1.00]	
Female	1.41***	[1.35,1.48]	1.22***	[1.16,1.29]	
Residence					
Rural	1	[1.00,1.00]	1	[1.00,1.00]	
Urban	1.26***	[1.20,1.31]	0.71***	[0.68,0.75]	
Religion					
Hindu	1	[1.00,1.00]	1	[1.00,1.00]	
Muslim	1.30***	[1.23,1.38]	1.03	[0.96,1.10]	
Christians	1.28***	[1.19,1.37]	0.73***	[0.66,0.80]	
Others	0.82***	[0.75,0.91]	0.98	[0.88,1.09]	
Caste					
SC	1	[1.00,1.00]	1	[1.00,1.00]	
ST	1.08*	[1.00,1.16]	0.75***	[0.69,0.82]	
OBC	1.08*	[1.01,1.14]	0.93*	[0.87,0.99]	
None	1.08*	[1.01,1.15]	1.02	[0.95,1.09]	
Education					
No schooling	1	[1.00,1.00]	1	[1.00,1.00]	
Primary	1.20***	[1.14,1.26]	0.86***	[0.81,0.91]	
Secondary	1.16***	[1.10,1.23]	0.77***	[0.72,0.83]	
Diploma/college	0.94	[0.85,1.04]	0.57***	[0.50,0.65]	
MPCE quintile					
Poorest	1	[1.00,1.00]	1	[1.00,1.00]	
Poorer	1.17***	[1.10,1.25]	1.04	[0.97,1.12]	
Middle	1.13***	[1.06,1.21]	1.07	[1.00,1.15]	
Richer	1.25***	[1.17,1.33]	1.04	[0.97,1.12]	
Richest	1.36***	[1.27,1.45]	1.13**	[1.05,1.21]	
Tobacco Consumption					
No	1	[1.00,1.00]	1	[1.00,1.00]	
Yes	1.22***	[1.16,1.28]	1.20***	[1.14,1.26]	
Alcohol Consumption					
No	1	[1.00,1.00]	1	[1.00,1.00]	
Yes	1.25***	[1.18.1.32]	0.98	[0.92.1.05]	

CI denotes confidence interval

*** denotes *p*-value<0.01

** denotes p-value<0.05

* denotes *p*-value<0.1

likelihood of caries increases with age while for periodontal issues it shows a decline. Figure 5 shows females have a higher caries risk than males, with diabetes amplifying the disparity, especially among females. Figure 6 highlights a similar pattern in periodontal disease, with females with diabetes at the highest risk and males without diabetes at the lowest. Figure 7 shows urban individuals with diabetes have the highest caries risk, while rural non-diabetics face the lowest, with a similar age-related increase across groups. Figure 8 highlights rural diabetics as having the highest probability of periodontal problems, contrasting with urban non-diabetics, who have the lowest probability. Figure 9 reveals that caries risk rises with age and is amplified by diabetes and tobacco use, with the combination resulting in the highest probability. Figure 10 shows a similar pattern for periodontal disease, where diabetes and tobacco use jointly elevate risk, which declines with age for all groups.

Discussion

This study highlights the increased risk of dental caries and periodontal disease among diabetic older adults in India, with diabetes significantly amplifying the odds for both conditions. Multivariate regression reveals that individuals aged 60+, females, and urban residents are at greater risk of dental caries, while urban individuals are less prone to periodontal disease. Socioeconomic factors, such as lower education and higher wealth, elevate caries risk, while their influence on periodontal health varies. Across different religious groups, Muslims and Christians are more susceptible to caries, though Christians show lower periodontal risk. Study findings also indicate that lifestyle factors like tobacco and alcohol consumption increase caries risk, with tobacco also worsening periodontal problems. These findings underscore the complex demographic, socioeconomic, and behavioural influences on oral health outcomes in India. The graphs (Figs. 3 and 4) show an increasing trend of caries and decreasing periodontal problems with age. This may reflect a cumulative exposure to risk factors for caries over time, such as diet, oral hygiene practices [16], and general wear on teeth. In contrast, the decreasing trend in periodontal disease might be linked to tooth loss in older age [18, 19], resulting in fewer teeth susceptible to periodontal risks, or possibly a survivor bias where those with severe periodontal disease may not live to older ages [20, 21]. This study reveals sex-based disparities in oral health. Females are more likely to experience caries than males, potentially due to differences in oral hygiene, hormones, or dental care access [22]. While females also have a higher probability of periodontal disease, the effect of diabetes on these problems appears to be more pronounced in females, possibly due to hormonal fluctuations, especially



Fig 3 Risk of caries among older adults of different ages and by diabetes, India, LASI, 2017-18



Fig 4 Risk of periodontal problems among older adults of different ages and by diabetes, India, LASI, 2017-18

around menopause, when estrogen levels drop, potentially impacting oral health negatively [23]. As evident from this study, tobacco users, regardless of their diabetes status, consistently show higher probabilities of both dental caries and periodontal disease compared to nonusers. Tobacco consumption has been shown to have deleterious effects on oral tissues, including reduced blood flow, impaired healing, and the promotion of bacterial



Fig 5 The age-specific risk of caries by sex and diabetes status of the older adults, India, LASI, 2017-18



Fig 6 The age-specific risk of periodontal problems by sex and diabetes status of the older adults, India, LASI, 2017-18

growth, which likely contributes to these elevated risks [24, 25]. When combined with diabetes, tobacco use further elevates the risk, indicating a synergistic negative impact on oral health as evident from this study.

Studies have shown that individuals with diabetes are at a higher risk of experiencing oral health problems compared to those without diabetes [26, 27]. Patients with type 2 diabetes have been found to exhibit a higher prevalence of unsatisfactory oral hygiene and a significantly increased prevalence of dental caries compared to non-diabetic individuals [28]. The intersection of diabetes, socioeconomic status (SES), and oral diseases creates a challenging cycle, particularly affecting those from lower socioeconomic backgrounds. Individuals



Fig 7 The age-specific risk of caries by place of residence and diabetes status of older adults, India, LASI, 2017-18



Fig 8 The age-specific risk of periodontal problems by place of residence and diabetes status of older adults, India, LASI, 2017-18

with diabetes from certain backgrounds are more likely to experience severe oral health problems, partly due to reduced access to timely dental care, which is crucial for managing diabetes-related oral complications [29]. For instance, previous studies in Tamil Nadu found that diabetic patients with low SES faced higher rates of severe periodontal disease compared to their higher-SES counterparts [30]. This compounded burden of diabetes and



Fig 9 The age-specific risk of caries by tobacco consumption and diabetes status of older adults, India, LASI, 2017-18



Fig 10 The age-specific risk of periodontal problems by tobacco consumption and diabetes status of older adults, India, LASI, 2017-18

oral diseases among socioeconomically disadvantaged groups underscores the need to address broader social determinants of health [31].

Rural-urban disparities in oral health among Indian adults are pronounced, with rural areas experiencing higher rates of dental caries and periodontal diseases due to limited access to dental care and lower oral health awareness [32]. Urban residents generally have better oral hygiene practices, such as brushing twice daily, whereas rural individuals often rely on traditional cleaning methods like 'datun' [33]. There is a dearth of studies showing evidences on caste and religion-based differential of caries and periodontal problems. However, a previous study compares the periodontal status of two tribal populations from Telangana, India, based on their oral hygiene practices and indicates that poor oral hygiene and high prevalence of periodontal disease, influenced by limited dental care access, low socioeconomic status, and cultural factors [34].

The education gradient in oral health problems, notably dental caries and periodontal disease, demonstrates that higher educational attainment is linked to better oral health [35]. Those with lower education levels experience higher rates of these problems, often due to limited health literacy and poor access to dental care [36]. Parental education also impacts children's oral health, as lower parental education correlates with higher dental caries rates in children [37]. Economic status significantly impacts oral health, with lower socio-economic groups facing higher rates of dental caries and periodontal disease due to limited access to care, poor hygiene, and inadequate nutrition [38]. Economic barriers also reduce preventive care access, worsening untreated conditions [38]. In contrast, higher socio-economic groups benefit from better access to dental care and favourable health practices [39].

As evident from this study, a previous study also suggests that alcohol and tobacco use are significant risk factors for oral health problems, particularly dental caries and periodontal disease [40]. Tobacco, both smoked and smokeless, increases periodontal disease risk by damaging periodontal tissues and weakening the immune response [41]. Alcohol consumption is also linked to greater severity of periodontal conditions [42], as both alcohol and tobacco use contribute to poor oral hygiene practices and heightened risk of oral inflammation and tissue damage [43]. Given the oral health burden among older persons with diabetes in India, addressing these behavioural/lifestyle risk factors is essential for reducing the dental disease burden. This study specifically shows that tobacco consumption is associated with higher odds of both caries and periodontal disease among Indian older adults, while alcohol consumption is linked specifically to caries in this population.

This population-based cross-sectional study has several strengths. It utilizes data from the Longitudinal Ageing Study in India (LASI), which covers all Indian states (except Sikkim) and union territories, with a robust sample size. Analytically, this study provides a comprehensive understanding of the diabetes associated burden of oral health problems, such as dental caries and periodontal disease among the older population in India. Another strength of this study is that LASI's alignment with the Global Health and Retirement Study (HRS) enables comparability of findings with international research, adding a global relevance to the study's results. Also, the survey tools were rigorously tested before data collection, ensuring that the data collected from the older persons are reliable and valid. The multivariate framework of the study adjusts for a wide range of sociodemographic, economic, and behavioural confounders, including age, residence, caste, education, economic status, alcohol, and tobacco use. This enhances the robustness of the findings by reducing the risk of biased associations between diabetes and oral health problems. The use of choropleth maps helps to identify geographic patterns and trends across age and gender groups. The study targets two major oral health problems-caries and periodontal disease-that are highly relevant to the overall health and quality of life of older persons. The investigation provides policy-relevant findings by identifying high-risk groups, such as women, rural residents, and those with lower education or socioeconomic status. Thus, provides valuable information for policymakers to design targeted interventions for managing diabetes-associated oral health problems among India's older adults.

This study, has several limitations. Being cross-sectional, it cannot establish causality between diabetes and oral health issues like caries and periodontal disease. Selfreported data and the absence of clinical dental examinations may introduce reporting bias and inaccuracies in prevalence estimates. Important oral health behaviours, such as brushing frequency and sugar consumption, are unmeasured, leading to potential residual confounding. Broad age categories (45-59, 60+) may obscure finer variations in risk, and the lack of longitudinal data limits understanding of disease progression. Additionally, diabetes duration and severity, key factors influencing oral health, are not accounted for. Finally, findings are specific to the Indian context and may not generalize internationally. The findings from this study are likely generalizable to older adults aged 45 and above in India due to the large, nationally representative sample from the Longitudinal Ageing Study in India (LASI) covering 65,562 individuals aged 45 and above. The study captures a diverse demographic, including variations by sex, residence (urban/rural), socioeconomic status, and substance use type making the results applicable to a broad range of older adults in the country. However, the cross-sectional design limits causal inference, and the results may be less applicable to other countries with different healthcare systems, cultural practices, or socioeconomic conditions.

Global oral health inequality is a major challenge, especially in LMICs, where access to affordable dental care is limited [44]. Universal health coverage (UHC) models in countries like Brazil and Thailand have successfully integrated oral health services, improving accessibility for lower-income groups [45–47]. Task-shifting strategies and community-based care are essential for expanding dental services, but health systems need significant strengthening to support sustainable, long-term solutions [47–49]. As evident from this study the prevalence of dental caries and periodontal problem is comparatively higher among older adults with diabetes which highlights the need for integrating oral health within India's existing NCD programs [50]. Policy recommendations include incorporating oral health screenings in primary care, increasing public awareness, training healthcare workers, and providing subsidized dental care for the older adult population from diverse socioeconomic and demographic background. And integration of oral health into public health programs by countries like Brazil, offer valuable models for India and other LMIC countries.

Conclusion

The results of this study have important implications for public health policies and interventions aimed at improving oral health among older adults in India. The significant associations between socioeconomic factors, such as education and wealth, and the prevalence of dental caries and periodontal problems suggest the need for targeted strategies that address these disparities. Public health initiatives should focus on increasing access to dental care, particularly in rural areas, and promoting oral health education to raise awareness of preventive measures. Additionally, integrating oral health care with general health services for older adults, especially those with diabetes, could help in the early detection and management of oral health problems, thereby improving overall wellbeing and quality of life among older population in India.

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Authors' contributions

S.S. and J.K.: Conceptualization, methodology, validation, formal analysis, investigation: J.K. and S.S.: writing original draft, review and editing. All authors have read and approved the final manuscript.

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Data availability

This study is based upon the Longitudinal Ageing Study in India (Wave-1), 2017-18 round of dataset which is publicly available through https://www.iipsi ndia.ac.in/content/LASI-data and could be accessed upon a data request.

Declarations

Ethics approval and consent to participate

The analysis relies on secondary data which is available in the public domain for research purposes, so no approval from an institutional review board (IRB) was necessary. Thus, no ethical approval was required further to conduct the study. The Longitudinal Ageing Study in India (LASI) is a survey of individuals aged 45 and older and their spouses irrespective of their age. The survey was conducted by International Institute for Population Sciences (IIPS), Mumbai; the Harvard T. H. Chan School of Public Health (HSPH), Boston; and the University of Southern California (USC), Los Angeles. To conduct the survey, the

aforementioned institutes obtained the ethical approvals from the following collaborating organizations: Indian Council of Medical Research (ICMR), Delhi; IRB, International Institute for Population Sciences (IIPS), Mumbai; IRB, Harvard T.H. Chan School of Public Health (HSPH), Boston; IRB, University of Southern California (USC), Los Angeles; IRB, ICMR National AIDS Research Institute (NARI), Pune; and IRB, Regional Geriatric Centres (RGCs), MoHFW. The survey agencies conducted the fieldwork after obtaining prior consent from the respondents.

As part of the implementing the survey, survey participants were informed of the survey's purpose, measures to protect their privacy, and the safety of health assessments as part of the informed consent process. In line with human subject protection protocols, four consent forms were utilized in LASI: household informed consent, individual informed consent, consent for dried blood sample collection for storage and future use, and consent for proxy interviews. Additionally, following recommended ethical guidelines, participants were provided with a copy of the consent forms, a biomarker results report card, and referral letters to public health facilities if any health measurements were found to be outside the normal range.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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