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Prevalence of untreated dental caries requiring endodontic therapy among rural and urban populations in India: A cross-sectional study

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Abstract:
Dental caries is a major public health concern. If it is not treated in time, it can result into abscess and tooth loss. Therefore, it is of interest to determine and compare the frequency of unfilled caries that need root canal therapy among rural and urban adults in India. A cross-sectional study was carried out on 452 persons (226 rural, 226 urban). Clinical examination was done according to WHO oral health assessment criteria. Rural populations exhibit a higher burden of advanced dental caries requiring endodontic therapy, highlighting the need for targeted preventive and early intervention strategies.

Keywords: Dental caries, endodontic therapy, rural population, urban population, cross-sectional study, oral health, prevalence

Background:
Dental caries is still the leading chronic oral disease worldwide and a big public health challenge in particular countries like India that is still developing. One of the main negative effects of dental caries is the pulp infection which if left untreated can result in serious pain and require endodontic (root canal) treatment or extraction. Nowadays, the main goal in managing the caries is preserving the tooth through minimally invasive and biologically friendly techniques but unfortunately, in many cases, the caries is spotted at a stage when the patient already needs root canal or tooth removal **[1].** Evidence from systematic reviews on contemporary endodontic retreatment further highlights the clinical complexity. Its burden associated with advanced carious lesions requiring endodontic care **[2].** Globally, dental caries and edentulism remain highly prevalent among middle-aged and elderly populations, reflecting cumulative oral disease burden across the lifespan **[3]**. In India, systematic reviews indicate a high burden of dental caries in geriatric populations, contributing significantly to tooth loss and functional impairment **[4].** Dental caries is also highly prevalent in children, with studies reporting significant disease burden in pre-school and early childhood populations, indicating early onset and persistence of disease **[5].** In rural Indian populations, oral health status is strongly influenced by lifestyle, hygiene practices and socio-economic factors, with studies showing high prevalence of caries and associated risk factors **[6].** Community-based surveys in rural settings further report substantial treatment needs among children and adolescents attending public health centers, highlighting the progression of untreated caries **[7].** Clinical studies also show associations between systemic conditions and caries prevalence, such as altered salivary antioxidant capacity in specific patient groups; indicating multifactorial disease progression **[8].** Adult populations using caries assessment indices have revealed a significant gap in treated cases and a very high level of diversity in the staging of the disease and the needs for its management **[9].** Microbiological research corroborates that cariogenic bacteria like *Streptococcus mutans* make a difference in the initiation and progression of dental caries, In particular in rural field populations **[10].** Based on epidemiological data of rural school children, caries and treatment needs remain at a high level. This fact supports the notion that the disease burden starts early in life **[11].** Socio-demographic factors, oral hygiene practices, diet and behavioural determinants a lot influence the caries experience. This is mainly true of elderly Indian populations **[12, 13].** Developmental anomalies like enamel hypoplasia and morphological defects increase the vulnerability of adolescents' teeth to caries development. In fact, the PUFA index is a popular tool to quantify the clinical effects of untreated caries lesions, including dental pulp exposure, ulcerative gingival lesion, formation of the fistula and development of the abscess. For instance, urban Indian children are the main target for such studies **[13, 14].** Based on tooth mortality studies, untreated caries is still one of the principal reasons for tooth loss and that is mostly the case in hospital-based populations **[15].** Also, behavioural research with adults residing in various geographic areas continues to emphasize the role of oral hygiene practices and lifestyle factors in the prevalence and severity of dental caries **[16].** Comparative studies between rural and non-rural populations, including occupational groups such as fishermen, show significant differences in oral health status and treatment needs **[17].** Epidemiological surveys in Indian school children and adolescents consistently report high caries prevalence and unmet treatment needs across different regions **[18, 21].** Earlier studies from urban Indian populations, including slum communities, also show significant caries burden and treatment requirements, indicating persistent inequities even in urban settings **[19].** Comparative studies in pre-school populations further highlight variability in caries prevalence and treatment needs across socio-economic groups **[20, 21].** Clinical trials evaluating endodontic treatment outcomes emphasize the importance of appropriate management of cariously exposed permanent teeth to ensure long-term tooth survival **[22].** Studies in special needs populations, including hearing-impaired and visually impaired individuals, further show increased caries risk and treatment requirements **[23].** Consensus guidelines from endodontic societies emphasize standardized approaches for endodontic management of caries-related pulpal disease **[24].** Epidemiological studies in rural Indian adults further confirm high prevalence of caries and treatment needs, reinforcing the public health burden **[25].** Studies in medically compromised populations, such as diabetic patients in rural settings, show increased prevalence and treatment needs of dental caries, indicating systemic associations **[26].** Comparative epidemiological studies among urban, rural and tribal school children show significant differences in caries prevalence and periodontal status, reflecting geographic disparities **[27].** Rural community-based studies from other developing countries also show high caries prevalence and treatment needs, supporting global relevance of the issue **[28].** International comparative studies further confirm higher caries experience in rural populations compared to urban counterparts, reinforcing persistent inequities **[29].** Urban Indian population-based studies

similarly report significant prevalence of dental caries and treatment needs among adults in metropolitan settings **[30].** Therefore, it is of interest to understand the true burden of disease progression, identify rural–urban disparities and guide targeted preventive and treatment strategies.

Materials and Methods:

This research aims to utilize a community-based cross-sectional research method to identify and contrast the frequency of untreated dental caries needing endodontic treatment in rural and urban communities of North India. The research will involve adult participants living in specific rural and urban locations, so that the samples from both groups can be analyzed and compared. Before starting the study, approval for the research proposal will be obtained from the Institutional Ethics Committee and consent will be taken from all the participants after explaining the nature of the study. The sample size (n = 452) was calculated using the standard formula for cross-sectional:

$n = Z^2 \times p \times q / d^2$

where Z = 1.96 at 95% confidence interval, p = estimated prevalence of untreated dental caries requiring endodontic intervention (taken as 50% to maximize sample size), q = 1 − p and d = allowable error set at 5%. Applying this formula yielded a minimum sample size of approximately 384, which was further increased to 452 to account for potential non-response and incomplete data. A multistage stratified sampling technique will be used for participant selection. In the first stage, rural and urban areas of North India will be selected purposively based on accessibility and population distribution. In the second stage, clusters such as villages (rural) and municipal wards (urban) will be randomly selected. In the third stage, households ithin selected clusters will be chosen using systematic random sampling and one eligible participant from each household will be included based on inclusion criteria (age ≥18 years, presence of at least one natural tooth). Individuals with severe systemic illness or unwillingness to participate will be excluded from the study. Clinical examination will be performed using WHO oral health assessment criteria under standardized conditions to identify untreated dental caries and cases requiring endodontic therapy based on clinical and radiographic indicators of pulpal involvement. Data will be recorded in a pre-validated structured proforma **(Table 1)**. The statistical analysis of the data will be performed using the SPSS software version 25.0. For summarizing data, descriptive statistics including frequency percentage mean and standard deviation will be employed and for comparing prevalence between rural and urban groups, inferential statistics like Chi-square test will be used. A p-value of less than 0.05 will be deemed statistically significant.

Results:

Table 1 is the results of the present cross-sectional study showing a clear and statistically significant disparity in the prevalence of untreated dental caries requiring endodontic therapy between rural and urban populations of North India. Overall, untreated dental caries was significantly more prevalent in the rural group (71.7%) compared to the urban group (56.6%), indicating a higher burden of disease in rural populations (χ^2 = 11.24, p = 0.0008). Similarly, the proportion of carious teeth requiring endodontic therapy was markedly higher in rural participants (43.4%) than in urban participants (27.4%), with a highly significant association (χ^2 = 13.56, p = 0.0002), suggesting greater progression of untreated lesions in rural settings. Symptomatic cases presenting with pain or sensitivity were also significantly higher in rural populations (48.7%) compared to urban populations (32.7%) (χ^2 = 12.08, p = 0.0005), indicating delayed treatment-seeking behaviour and increased disease severity in rural groups. Radiographic evidence of pulpal involvement further supported this trend, with rural participants showing higher involvement (37.6%) than urban participants (23.9%) (χ^2 = 11.97, p = 0.0005). The final outcome assessment revealed that teeth indicated for endodontic therapy were significantly more common in rural populations (45.1%) compared to urban populations (29.2%), with a highly significant difference (χ^2 = 14.21, p < 0.001). Conversely, extraction as a treatment option was also more frequent in rural participants (21.2%) than in urban participants (13.3%) (χ^2 = 5.89, p = 0.015), reflecting more advanced disease stages and delayed intervention in rural areas **Table 2.** The findings of **Table 3** indicate that endodontic treatment need varies across different age groups and shows no significant association with gender. Among age groups, the requirement for endodontic treatment was highest in the 31–45 years (33.3%) and 46–60 years (31.0%) categories, suggesting that middle-aged individuals are more frequently affected due to cumulative exposure to untreated dental caries and delayed dental care. The association between age and endodontic treatment need was statistically significant (χ^2 = 9.87, p = 0.019), indicating that age is an important determinant of progression of carious lesions to pulpal involvement requiring endodontic intervention. In contrast, gender did not show a statistically significant association with endodontic treatment requirement (χ^2 = 0.56, p = 0.45). Although males (54.8%) exhibited a slightly higher proportion of endodontic treatment need compared to females (45.2%), the difference was not meaningful statistically, suggesting that disease progression is more influenced by behavioural and biological factors rather than gender **Table 3.**

Table 1: Pre-validated structured proforma

Section	Variable/Parameter	Details / Options / Measurement
A. Socio-demographic Details	Participant ID	Unique code assigned
	Age	____ years
	Gender	Male / Female / Other
	Residence	Rural / Urban
	Education level	Illiterate / Primary / Secondary / Graduate / Postgraduate

	Occupation	Student / Farmer / Service / Business / Homemaker / Other
	Socioeconomic status	Modified Kuppuswamy Scale (Class I–V)
B. Oral Hygiene Practices	Brushing frequency	Once daily / Twice daily / Irregular
	Method of cleaning	Toothbrush / Finger / Miswak / Others
	Toothpaste usage	Yes / No
	Mouthwash use	Yes / No
	Dental visit history	Regular / Only when problem / Never
C. Dietary Habits	Sugary food intake	Low / Moderate / High
	Sugary beverage consumption	Daily / Weekly / Rare / Never
	Snacking frequency	<2 times/day / ≥2 times/day
D. Clinical Dental Status	Number of present teeth	____
	Carious teeth (DT)	____
	Filled teeth (FT)	____
	Missing teeth due to caries	____
	Untreated dental caries present	Yes / No
E. Endodontic Treatment Need Assessment	Deep caries with pulpal involvement	Yes / No
	Symptoms (pain, sensitivity)	Yes / No
	Sinus/fistula presence	Yes / No
	Radiographic pulpal/periapical involvement	Yes / No
	Tooth requiring endodontic therapy	Yes / No
F. Outcome Variable	Classification	No treatment needed / Restorative care / Endodontic treatment required / Extraction indicated

Table 2: Comparative prevalence of untreated dental caries requiring endodontic therapy in rural and urban populations (n = 452)

Variable	Rural (n = 226)	Urban (n = 226)	Total (n = 452)	χ^2 value	p-value
Participants with untreated dental caries	162 (71.7%)	128 (56.6%)	290 (64.2%)	11.24	0.0008*
Carious teeth requiring endodontic therapy	98 (43.4%)	62 (27.4%)	160 (35.4%)	13.56	0.0002*
Symptomatic (pain/sensitivity present)	110 (48.7%)	74 (32.7%)	184 (40.7%)	12.08	0.0005*
Radiographic pulpal involvement	85 (37.6%)	54 (23.9%)	139 (30.8%)	11.97	0.0005*
Tooth indicated for endodontic therapy (final outcome)	102 (45.1%)	66 (29.2%)	168 (37.2%)	14.21	<0.001*
Teeth indicated for extraction instead of endodontic therapy	48 (21.2%)	30 (13.3%)	78 (17.3%)	5.89	0.015*

Table 3: Distribution of Endodontic Treatment Need According to Age and Gender (n = 452)

Variable	Endodontic Required (n=168)	No Endodontic Need (n=284)	χ^2 value	p-value
Age group (years)				
18–30	38 (22.6%)	92 (32.4%)		
31–45	56 (33.3%)	88 (31.0%)		
46–60	52 (31.0%)	70 (24.6%)	9.87	0.019*
>60	22 (13.1%)	34 (12.0%)		
Gender				
Male	92 (54.8%)	146 (51.4%)	0.56	0.45
Female	76 (45.2%)	138 (48.6%)		

Discussion:

The present cross-sectional study shows a significantly higher prevalence of untreated dental caries requiring endodontic therapy in rural populations compared to urban populations of North India, indicating a clear rural–urban disparity in disease burden and treatment needs. This finding is consistent with existing literature suggesting that dental caries remains highly prevalent across populations but disproportionately affects underserved and rural communities due to limited access to oral healthcare services and delayed treatment-seeking behavior **[25, 27 and 29].** The overall higher burden of untreated caries in rural populations observed in this study aligns with previous epidemiological findings that report greater caries prevalence and treatment needs in rural and tribal groups compared to urban populations **[27].** Similar trends have been documented internationally, where rural communities show higher caries experience and lower access to dental care services, leading to advanced disease progression **[28, 29].** In the present study, the significantly higher proportion of carious teeth requiring endodontic therapy in rural participants reflects progression of untreated lesions to pulpal involvement, which is consistent with earlier reports highlighting that untreated caries is a major precursor of pulpal disease and tooth mortality **[15].** The higher prevalence of symptomatic cases and radiographic pulpal involvement in rural populations further suggests delayed presentation and reduced utilization of preventive dental services. These findings are supported by studies indicating that socio-demographic factors, oral hygiene practices and dietary behaviors strongly influence caries progression, particularly in populations with lower socioeconomic status and limited awareness **[12].** Rural populations often exhibit poorer oral hygiene practices and irregular dental visits, which contribute to progression from reversible carious lesions to irreversible pulpal pathology **[6, 16].** The present study also found that age was significantly associated with endodontic treatment need, with higher prevalence in middle-aged groups (31–60 years). This finding is in agreement with previous research indicating that caries is a cumulative disease, with increasing severity and treatment needs observed with advancing age due to prolonged exposure to risk factors and untreated lesions **[3, 4 and 25].**

However, no significant gender difference was observed, suggesting that biological sex may have less influence on disease progression compared to behavioral and environmental determinants, a pattern also reported in earlier population-based studies **[12, 16].** The behavioral component observed in this study, although not the primary focus of analysis is strongly supported by existing literature emphasizing the role of oral hygiene practices, dietary habits and dental attendance patterns in caries progression **[16]**. Studies have consistently showed that high sugar intake, poor brushing habits and irregular dental visits significantly increase the risk of advanced carious lesions and subsequent endodontic involvement **[12, 6].** Furthermore, microbiological evidence highlights the role of cariogenic bacteria such as *Streptococcus mutans* in the initiation and progression of dental caries, particularly in rural settings with limited preventive care **[10].** The findings of this study also reflect broader public health concerns highlighted in earlier Indian epidemiological surveys, which show persistently high caries prevalence and treatment needs across both rural and urban populations **[18, 30].** However, urban populations tend to have relatively better access to dental care services, which may explain the lower proportion of untreated caries progressing to endodontic involvement observed in this study. This is supported by studies from urban Indian settings reporting high caries prevalence but comparatively better treatment utilization patterns **[19, 30].** Importantly, the present study addresses a critical gap in the literature by specifically quantifying untreated dental caries cases requiring endodontic therapy, rather than general caries prevalence or treatment need alone. Previous studies have largely focused on broad indicators of caries experience or pediatric populations without isolating the subset of lesions progressing to pulpal involvement **[9, 14].** By focusing on endodontic treatment requirement, the present study provides a more clinically relevant assessment of disease severity and treatment burden.

Conclusion:

We show a significantly higher burden of untreated dental caries requiring endodontic therapy in rural populations. The findings underscore the cumulative effect of delayed dental care, inadequate preventive practices, and limited access to timely treatment, emphasizing the need for strengthened community-based oral health programs.

Advancement to knowledge:

Globally, untreated dental caries continues to be the leading cause of the need for endodontic therapy, or root canal therapy, which bridges the gap between avoidable tooth decay and invasive oral surgery. These deep bacterial lesions cause irreparable pulpitis, necrosis and periapical abscesses when they penetrate the dentin and infect the pulp tissue. Early diagnosis and treatment are necessary in these circumstances.

Limitations:

The study is cross-sectional in nature, hence it cannot establish causal relationships between risk factors and endodontic treatment need.

Future perspective:

Longitudinal multicentric studies with larger and more diverse populations are recommended to better understand progression patterns and strengthen preventive endodontic strategies.

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