

Is the inability to afford dental care associated with untreated dental caries in adults?

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Objective: To assess whether inability to afford dental care is associated with the number of teeth with untreated dental caries and whether this association is independent of socioeconomic factors and ethnicity. **Basic research design:** Data were from the National Health and Nutrition Examination Survey (NHANES) (2015–2018), a cross-sectional national survey of non-institutionalised Americans. **Clinical setting:** The survey included clinical assessment of tooth condition, data on sociodemographic factors, use of dental services, health insurance, number of teeth and affordability of dental care when needed. **Participants:** The analysis included 9,440 participants aged 18 years and over. **Main outcome measures:** The association between number of teeth with untreated caries and affordability of dental care was assessed adjusting for age, gender, ethnicity, income, education, dental visits, and health insurance. **Results:** The mean number of teeth with untreated caries was 0.51, and 13% reported inability to afford care. Mean numbers of teeth with untreated caries among those unable and able to afford dental care were 1.46 and 0.36, respectively. In the fully adjusted model, the rate ratio for teeth with caries among those who could not afford dental care was 2.45 (95% Confidence Intervals 'CI': 2.04, 2.95). Income and education inequalities were slightly attenuated after accounting for inability to afford care. Other statistically significant predictors included education, and irregular dental visits. **Conclusion:** Inability to afford dental care may exacerbate inequalities in dental caries. The findings highlight the need for affordable access to dental services.

Keywords: Dental Caries, Affordability, Dental Care, Socioeconomic Status

Introduction

Oral diseases are amongst the most prevalent worldwide, causing serious health and economic burdens, the most prevalent oral diseases globally are dental caries, periodontal disease, tooth loss, and cancers of the lips and oral cavity. Most oral diseases are preventable. They are more common among individuals living in poverty, socially marginalised groups, older individuals, and those with limited access to dental care, reflecting widespread social and economic inequalities (Peres *et al.*, 2019).

In 2015 the American Dental Association (ADA) reported that 91% of Americans over the age of 20 have had dental caries at some point in their lives. These numbers are expected to worsen due to inadequate utilisation of dental facilities, an unmet need for dental services, and the current pattern of population growth (Bernabe *et al.*, 2020).

Oral health behaviours, particularly dietary patterns were found to predict dental caries experience (Blostein *et al.*, 2020). Given that oral health related behaviours are socially patterned and are clustered among lower socioeconomic groups and ethnic minorities, oral health outcomes differ according to socioeconomic position (Sabbah *et al.*, 2009).

Unsurprisingly, oral health inequalities exist in the United States (USA). Individuals are more likely to have poor oral health if they have low-income, are uninsured and/or members of racial/ethnic minority or immigrants.

These inequalities are apparent in untreated caries among children and adults. A recent analysis of national survey in USA showed that the prevalence of untreated caries was greatest among non-Hispanic black individuals. Family income level was also inversely related to untreated as well as total dental caries (Fleming and Afful, 2018). Socioeconomic factors also contribute to inadequate access to oral healthcare, and ability to afford dental services, which exacerbate inequality in oral health (Northridge *et al.*, 2020).

The US oral health system undoubtedly impacts inequality in oral health as individuals who are highly educated and from better socioeconomic backgrounds are more likely to be insured and have better oral health (Mejia *et al.*, 2018). With the increase in prices of dental care and the lack of universal coverage, the USA oral healthcare delivery system has failed to protect vulnerable populations from dental caries (Northridge *et al.*, 2020).

The Affordable Care Act increased dental coverage for children, but not for adults. Due to the high cost of oral healthcare few individuals can afford dental services without dental insurance coverage. Therefore, it is reasonable to hypothesise that inability to afford dental care will exacerbate inequalities in untreated dental caries.

The aim of this study is to evaluate whether inability to afford dental care is associated with number of teeth with untreated caries among American adults and whether any association is independent of ethnicity and socioeconomic factors.

Method

Data source

Data from the National Health and Nutrition Examination Survey (NHANES) 2015-2018 were used. This survey used complex multistage probability sampling to have a representative ethnically/racially diverse sample of noninstitutionalized civilian residing in the USA.

The Center for Disease Control (CDC)'s National Center for Health Statistics (NCHS) provided ethical approval for the surveys IRB/ERB protocol #2011-17 and #2018-01. Before participating in the survey all individuals gave written informed consent.

To increase the power and reliability of estimates, the data used a combination of surveys released in 2015-2016 and 2017-2018. All participants were interviewed in their homes, and clinically examined in a Mobile Examination Center (MEC) by trained and calibrated dentists. The CDC website shows further information on NHANES <https://www.cdc.gov/nchs/nhanes/index.htm>.

Sample

Data analysed included adults aged 18 years and above who participated in either NHANES 2015-2016 or NHANES 2017-2018 (9,544 and 8,704 participants respectively). Of those, 7,377 were children under 18. Of the remaining 10,871, 580 did not have assessment of dental caries. The remaining 851 missing cases (8.3%) had missing values in other variables included in the analysis. Participants who had missing data were excluded from the analysis due to case-wise deletion. Overall, 9,440 American adults were included in the analysis.

Variables

The outcome variable was the number of teeth with untreated dental caries lesions. According to NHANES examination methodology, a dental lesion is regarded as untreated only if it is cavitated. Therefore, non-cavitated lesions and decay of the root were not included in this study. Assessment of dental caries adhered to strict protocols and performed by trained and calibrated dentists using a mirror, No. 23 explorer, and air. The analysis only included the permanent dentition.

Ability to afford dental care was the main exposure. The survey asked participants whether affordability of dental services was the main reason for not seeking dental treatment when needed. The answer was documented as a binary variable: "yes" or "no".

Age was used as a continuous variable, gender as a binary variable (male or female), ethnicity/race was initially classified using the survey classification into; Mexican American, Non-Hispanic White, Non-Hispanic Black, Other Hispanic, and others. In this analysis they were sub-grouped into Hispanic, White, Black, Multiracial/Other.

Poverty Income Ratio (PIR) was calculated by dividing the family income by the poverty level particular to each state and depended on family size as per NHANES guidelines. PIR was used as a continuous variable in the present study. Health insurance involved any medical insurance whether governmental or private such as Medicare and was used as a dichotomous variable (present or absent).

The analysis also included education. Participants were asked about their highest level of schooling completed/degree received. They were classified into three categories: less than high school, high school or some college, or university degree or higher.

Participants were asked about the last time they visited the dentist and answers were classified into (more than 2 years or never visited a dentist) versus (last two years or more often). The analysis accounted for an individual's number of remaining teeth, the number ranged from 0 to 28.

Statistical analysis

Survey command in STATA were used throughout the analysis using 4-years examination weights to account for the complexity of the survey. Distribution of all variables were assessed and percentages of inability to afford dental care within each variable was calculated (Table 1). Negative binomial regression used affordability of care to predict number of teeth with untreated dental caries adjusting for possible confounders. First regression model was adjusted for gender, age and ethnicity/race. The second model was additionally adjusted for poverty income ratio, education, health insurance coverage, number of teeth, and last dental visit

Results

A total of 9,440 adults aged 18-years and above who had complete data were included in this analysis. There was no difference between those included in the analysis and those excluded in terms of demographic variables. The distribution of demographic and socioeconomic characteristics within the sample is summarized in Table 1. The mean number of teeth with untreated caries was 0.51 and 13% reported inability to afford care. The unweighted number of participants with untreated caries was 2,069, the number without untreated caries was 7,371. The mean number of teeth with untreated caries among individuals who were unable to afford dental care and those who could were 1.46 and 0.36, respectively (Table 1). Black people were more likely to be unable to afford the cost of dental care than other race/ethnicities including those who were Hispanic, White or Multi-racial. More individuals with an educational level less than a high school diploma (23.1%) were unable to afford dental care than individuals with a high school or university diploma. Income indicated by PIR was significantly lower among those who were unable to afford dental care.

Table 2 shows the rate ratio for untreated caries that was significantly higher among individuals who were unable to afford dental care, even after adjusting for socioeconomic factors and health insurance. In the semi adjusted model participants who were unable to afford dental care had a rate ratio (RR) of 3.87 [95%CI: 3.30, 4.53] for having untreated caries. This rate ratio was attenuated in the fully adjusted model (RR 2.45, 95% CI: 2.04, 2.59) but remained significant. Black participants showed greater rate ratios for having untreated caries (RR 1.63, 95% CI: 1.31, 2.02), but the significant differences disappeared in the fully adjusted model. Having higher income, higher education and more frequent dental visits were all significantly associated with lower rates of untreated caries (Table 2).

Table 1. Distribution of variables among 9,440 participants in the NHANES 2015-2018 dataset.

		<i>%/mean (95% CI)</i>	<i>% unable to afford dental care (95% CI)</i>	<i>P (Chi sq. or t test)</i>
Gender	Male	48.1 (47.3,49.1)	11.5 (10.2,12.9)	<0.001
	Female	51.8 (50.8,52.9)	14.5 (12.8,16.4)	
Mean Age	Cannot afford care	47.9 (47.0, 48.7)	44.0 (42.7, 45.3)	<0.001
	Afford care		48.5 (47.6, 49.4)	
Health Insurance	Yes	87.3 (84.8,89.4)	10.1 (9,11.3)	<0.001
	No	12.7 (10.6,15.1)	33.6 (29.3,38.1)	
Race/Ethnicity	Hispanic	14.5 (11.6,18)	17.4 (15.3,19.7)	<0.001
	White	64.7 (59.8,69.3)	11.4 (10.1,13.0)	
	Black	10.9 (8.4,14)	19.1 (16.8,21.6)	
	Other/Multi-racial	9.7 (8.1,11.7)	10.6 (8.1,13.8)	
Education	< High school	12.1 (10.4,14)	23.1 (19.9,26.6)	<0.001
	High school	55.8 (52.4,59.2)	15.5 (14,17.1)	
	University	32 (27.9,36.3)	5.11 (94.1,6.3)	
Mean Poverty Income Ratio	Cannot afford care	3.03 (2.91, 3.15)	1.88 (1.76, 2.00)	<0.001
	Afford care		3.20 (3.09, 3.32)	
Last dental visits	More than two years	29.4 (27.0, 32.0)	21.9 (19.5, 24.4)	<0.001
	Last two years	70.5 (67.9, 72.9)	9.4 (8.3, 10.6)	
Mean number of teeth	Cannot afford care	23.54 (23.09, 23.99)	23.72 (23.29, 24.14)	<0.001
	Afford care		22.39 (21.59, 23.18)	
No. teeth with untreated dental caries	Cannot afford care	0.51 (43.9, 57.4)	1.46 (1.27,1.65)	<0.001
	Afford care		0.36 (0.30, 0.41)	

Table 2. Factors associated with untreated caries among 9,440 adult participants in NHANES 2015-2018.

<i>Untreated Caries (UC)</i>	<i>Model 1 (Semi adjusted) RR [95% CI]</i>	<i>Model 2 (Fully adjusted) RR [95% CI]</i>
Gender (female)	0.74*** (0.64, 0.85)	0.76** (0.65, 0.89)
Age	0.98*** (0.97, 0.98)	0.98*** (0.97, 0.99)
Ethnicity/race (ref: White)		
Hispanic	1.13 (0.87, 1.48)	0.71* (0.53, 0.94)
Black	1.63*** (1.31, 2.02)	1.34** (1.13, 1.61)
Other/Mixed race	0.93 (0.75, 1.14)	0.90 (0.70, 1.17)
Could not afford cost of dental care	3.87*** (3.30, 4.53)	2.45*** (2.04, 2.59)
Poverty Income Ratio		0.79*** (0.73, 0.84)
Education (ref: < High school)		
High school		0.71** (0.55, 0.92)
University		0.33*** (0.24, 0.44)
Covered by the Health Insurance (Yes)		1.30** (1.10, 1.53)
Number of Teeth		1.00 (0.98, 1.01)
Dental Visits (last 2 year or more often)		0.58*** (0.46, 0.73)

P value * < 0.05, ** < 0.01, *** < 0.001.

Model 1 adjusted for age, gender, affordability of care and ethnicity/race.

Model 2 additionally adjusted for poverty income ratio, education, health insurance coverage, number of teeth, and last dental visit.

Discussion

This study assessed the relationship between ability to afford dental care and the number of teeth with untreated caries in the US adult population. Inability to afford dental care when needed was strongly and significantly associated with number of teeth with untreated caries, a relationship that persisted even accounting for socioeconomic factors and health insurance. These results correspond with the various literature showing the adverse effect of low socioeconomic status on oral health (Elani *et al.*, 2012; Mejia *et al.*, 2018; Schwendicke *et al.*, 2015; Singh *et al.*, 2019).

An analysis of earlier data from USA showed that one quarter of American adults had untreated caries. Differences in caries experiences were related to age, family income level, latest dental visit, financial and non-financial barriers, race/ethnicity, and gender (Gupta *et al.*, 2018). The current analysis confirms these findings in relation to the number of teeth with untreated caries using more recent data.

Northridge *et al.* (2020) concluded that individuals from low socioeconomic backgrounds, not covered by dental insurance and those belonging to a racial/ethnic minority were more likely to have poor oral health due to their lack of access to quality oral healthcare. Interestingly, studies that compared oral health in the USA to other English-speaking countries found greater socioeconomic inequalities in the USA. These studies also argued that the oral healthcare system in the USA has contributed to these inequalities (Elani *et al.*, 2012; Mejia *et al.*, 2018). Our study showed similar inequalities in untreated caries related to income, insurance, racial/ethnic minority, and inability to afford dental care. In this study, those who had general health insurance had higher rates of untreated caries. This was not surprising as health insurance does not cover dental services. Furthermore, it includes Medicaid (the poor and unemployed) and Medicare users (older adults), both groups are unlikely to have dental insurance. It is worth noting that an analysis of the same survey found that not being able to afford dental care was also associated with root caries (Badr and Sabbah, 2020).

Multiple studies demonstrated that ethnic minorities, particularly African Americans, were more likely to develop caries than Whites (Kim *et al.*, 2012; Liang *et al.*, 2013). In this study African Americans showed a higher prevalence of not being able to afford the cost of dental treatment when needed compared to other race/ethnicities. This could partially explain differences in number of teeth with untreated caries between African Americans and White Americans observed in this study. Interestingly, ethnic inequalities were attenuated after controlling for other socioeconomic factors.

Mandatory dental coverage for children helps to reduce racial/ethnic and gender inequalities during childhood. However, as children age this trend reverses and coverage disintegrates. Others have argued that frequent or routine dental visits could help in preventing tooth decay and other adverse dental conditions whilst also providing an opportunity for early intervention. (Gupta *et al.*, 2018) Unsurprisingly, earlier studies found that infrequent or lack of dental visit is a precursor to poor oral health. (Reda *et al.*, 2018b) Even after controlling for confounding factors

regular use of dental services was associated with lower dental caries experience, more retained teeth, and better subjective oral health (Reda *et al.*, 2018a). Others have also demonstrated that American adults in lower socioeconomic positions are less likely to have yearly dental visits (Kailembo *et al.*, 2018). In the current analysis, individuals who had a dental visit in the past 2 years were less likely to have untreated caries. It was not surprising that those who with infrequent or no dental visits were more likely to report inability to afford dental visits than those who saw a dentist within past 2 years.

This study defined socioeconomic position (SEP) using various indicators, including the poverty-income ratio, education, health insurance and ability to afford care. When we accounted for all these socioeconomic indicators in one model, affordability of dental care remained a significant and stronger predictor of untreated caries than income, education and insurance coverage. Expectedly, mean income in the sample was lower among individuals who could not afford care.

In the current analysis, individuals with lower education were more likely to report inability to afford dental care and to have untreated caries. An earlier study argued that educational background usually determines income and subsequently affects access to professional dental care (Schwendicke *et al.*, 2015).

The study focused on affordability of dental care as an indicator of direct financial barrier for use of service. However, it is worth noting that reasons for not seeking dental care are multifactorial. For example, indirect cost of use of services such as cost of transportation and inability to take time of work. Fear of dentists is another contributing factor for inadequate use of services. Undoubtedly, all these factors combine to affect dental attendance behaviour.

We used a recent national survey of American adults to assess the relationship between inability to afford dental care when needed and number of teeth with untreated caries adjusting for socioeconomic factors, health insurance and dental visits. The study has some limitations. The cross-sectional data can only establish associations, not causality. Part of the study used self-reported data which have the potential of recall or report bias. The analysis did not include factors related to oral hygiene as they were not available in the survey.

Conclusion

Inability to afford dental care appeared to exacerbate inequalities in dental caries and showed a persistent and significant association with untreated caries even after accounting for other socioeconomic indicators. The findings highlight the need for policies that aim at improving access to good quality and affordable oral healthcare to the whole population, particularly those subjected to socioeconomic adversity.

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None

Conflict of interests

The authors have no conflict of interests including financial, personal or other relationships.

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