Socio-Economic Inequalities in Dental Care Utilization Among the U.S. Population: A Study of Trends From 2010 to 2019

Socio-Economic Inequalities in Dental Care Utilization Among the U.S. Population:
A Study of Trends From 2010 to 2019

Harvard University

Presentation and Defense of Doctoral Dissertation

Hesham A. Alhazmi BDS, MS

To

The Faculty of Medicine in Partial Fulfillment of the Requirements for the Degree of

Doctor of Medical Sciences

Research Mentor: Mary Tavares DMD, MPH

Harvard School of Dental Medicine

Boston, Massachusetts

April 2021

Defense form

HARVARD
School of Dental Medicine

We, the undersigned, have read and approved the thesis of Dr. Hesham Alhazmi submitted in partial fulfillment of requirements for the degree of a Doctorate of Medical Sciences at Harvard School of Dental Medicine.

Hesham Alhazmi

Christine A Riedy PhD, MPH

Arthur J. Garvey, Ph.D.

Brittany Seymour, DDS, MPH

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Background

Almost two decades ago, the Surgeon General's report, Oral Health in America, recognized the oral health disparities among Americans and stated that "a silent epidemic of oral diseases is affecting our most vulnerable citizens."[1] Health disparities/inequalities are defined as "potentially avoidable differences in health (or in health risks that policy can influence) between groups of people who are more and less socially advantaged; these differences systematically place socially disadvantaged groups at further disadvantage on health".[2] The Surgeon General's report made several recommendations to minimize disparities and improve oral health in America. The recommendations included: integrating oral health and overall health, eliminating barriers to oral health services, and establishing public-private partnerships to improve oral health among those who disproportionately suffer from oral diseases.[1] Achieving these goals requires paying greater attention to populations carrying a disproportionate burden of oral and craniofacial diseases and increasing access to such groups through efforts that directly affect the scope of services and facilities serving those populations.

With the publication of Healthy People: The Surgeon General's Report on Health Promotion and Disease Prevention in 1979, the Healthy People (HP) initiative was born. The concept of health disparities was first introduced in HP 2010 as an overarching goal. However, 69% of the HP 2010's health disparities-related objectives did not achieve significant improvements. For instance, the reported annual dental visits in 2008 decreased from 44% (in 1996) to 43% moving away from the target of 56%. Further, disparities in annual dental visits increased among all racial/ethnic

groups compared to White individuals, among females compared to males, among those with less than high school and high school graduates compared to those with some college education, and among individuals with disabilities compared to those with no disabilities.[3] As a result, the percentage of persons who used the oral health care system was added as a leading health indicator in HP 2020.

According to HP 2020 monitoring data, in 2015, only 43.3% of the population had visited a dentist in the past year compared to the baseline rate (44.5%) and the target rate (49%) (Figure 1). Disparities by dental insurance status and educational attainment were evident. Among individuals above 65 years of age, 49.5% of those with insurance visited the dentist in the previous year compared to 17.4% of uninsured individuals (Figure 2). Among 25-year-old individuals, 57.7% of those with some college education had a dental visit in the previous year compared to 19.2% of those with less than high school education (Figure 3).[4]

Poverty status has also been associated with the likelihood of a dental visit in the past year. According to an analysis of the National Health Interview Survey in 2010, low-income adults are less likely to visit the dentist in the previous 12 months as compared to high-income adults, only 42% of adults living below 200% of the federal poverty level (FPL) had a dental visit compared to 70% of adults living above 200% FPL (Figure 4). Further, it has been reported that more than 1 in 5 low-income adults had not had a dental visit in the past five years or have never had a dental visit. Hispanic adults were the least likely to have had a dental visit in 2010, and they were also

the most likely (27%) to have not had a dental visit in the past five years or more or to have never had a dental visit compared to low-income White adults (20%).[5]

Low-income adults disproportionately experience poor oral health due to their limited access to dental care. More than one-quarter of adults aged 19-64 experience untreated dental caries. Low-income adults living below 100% FPL are over three times as likely to have untreated dental caries relative to adults living above 400% FPL.[5] In addition, Hispanics and African American adults have greater rates of untreated dental caries compared to White adults, with a prevalence of 41%, 39%, and 22% respectively. Further, uninsured adults are more likely to experience dental caries than adults with any form of health insurance (22% versus 43%) (Figure 5).[6] In 2010, tooth retention prevalence among adults aged 25–44 was the lowest for non-Hispanic Blacks (43%) followed by Hispanics (46%), with the highest prevalence reported for non-Hispanic White adults (58%). They also had the highest prevalence of complete tooth retention (35% at ages 45–64 compared to non-Hispanic Black (11%) and Hispanic adults (19%). For the same age group, complete tooth retention among those living above FPL (32%) was higher than among those living at or below FPL (15%) (Figure 6). Complete tooth loss among adults aged 65-74 living at or below 100% FPL was more than twice as high (34%) as those living above FPL (13%) (Figure 7).[7]

Oral health disparities can result due to several factors. Cost has been cited by adults as the primary reason of not visiting a dentist.[8] Additional factors on the systemic level may include the lack of water fluoridation in low-income communities and the location where people live (rural vs urban).[1] Medicaid expansion under the Affordable Care Act (ACA) has tremendously improved

the utilization of dental services among children under 19 years of age.[9] In spite of this progress, there are no dental coverage requirements for adults, and adult benefits remain at the discretion of the states. Comprehensive dental benefits for adults are offered only in 19 states among the 35 states that have Medicaid services beyond emergency situations.[10] Deficit in dental coverage for low-income adults has been referred to as a "neglected epidemic".[11] Although the ACA closed many gaps in health disparities, oral health care was not included. Location can also influence healthcare services utilization; dental services were more likely to be accessed and utilized in urban areas with high dentist supply relative to rural areas that lack Medicaid-contracted dentists.[12] On the personal level, poor oral health literacy transportation barriers, and the feasibility to take time from work negatively impact visits to the dentist.[1]

Although the terms "disparities" and "inequalities" are often used interchangeably, their particular meanings better explain and address disadvantaged populations' health issues. A disparity study is usually a pair-wise comparison between the least advantaged to the most advantaged groups using a simple quantitative measure such as a prevalence ratio, where all groups are equally important despite their size. On the other hand, inequality studies involve a single complex statistic that summarizes an outcome's dispersion across all socio-economic levels, accounting for differences in subgroup sizes.[13] Using both pair-wise and global measures offer complementary information that demonstrates the progress in reducing the differences between groups and inequality in society, respectively. Unfortunately, inequality measures are underutilized in the dental literature.

Assessing socio-economic inequalities in access to dental care can inform decision-makers about the necessary steps to be taken in relation to research, surveillance, training, and innovative solutions with regard to the health workforce and health systems. Furthermore, patterns and trends in inequalities can examine the impact of access-related policies at both the community and population levels. To the best of our knowledge, the current literature lacks recent reports that assess the trends of inequalities in access to dental care in the United States and how these trends relate to different socio-economic indicators.

Figures

Figure 1

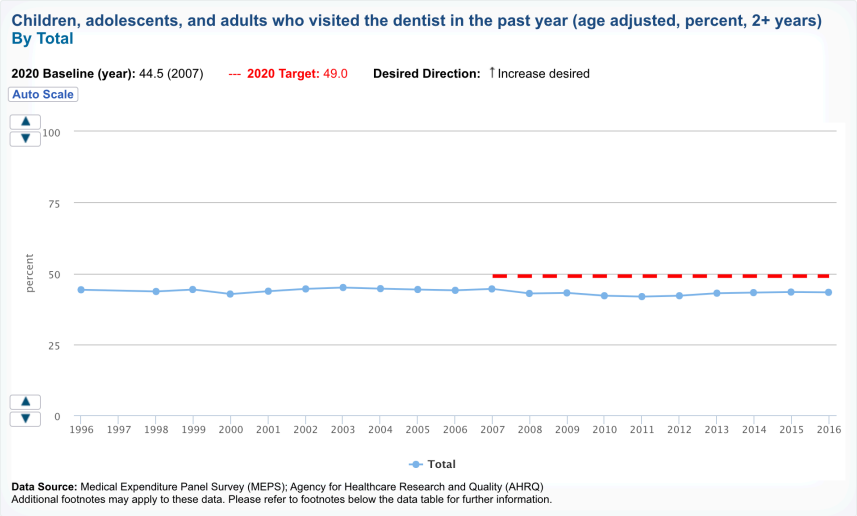

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Figure 2

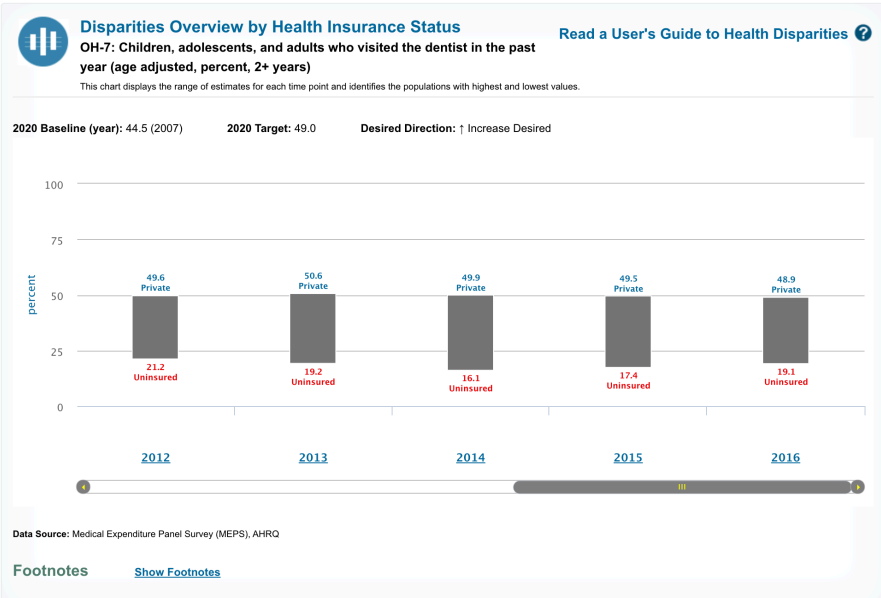

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Figure 3

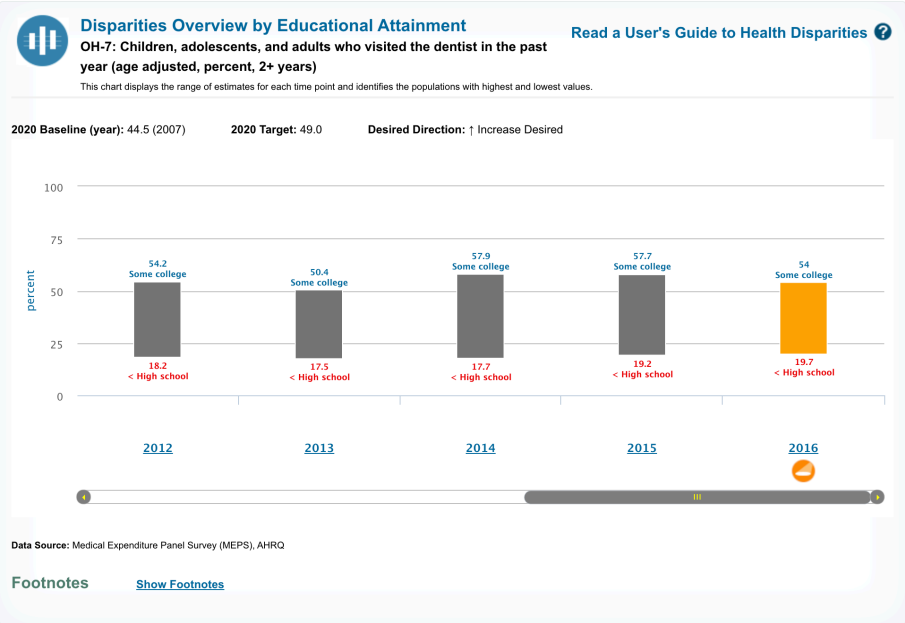

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Figure 4

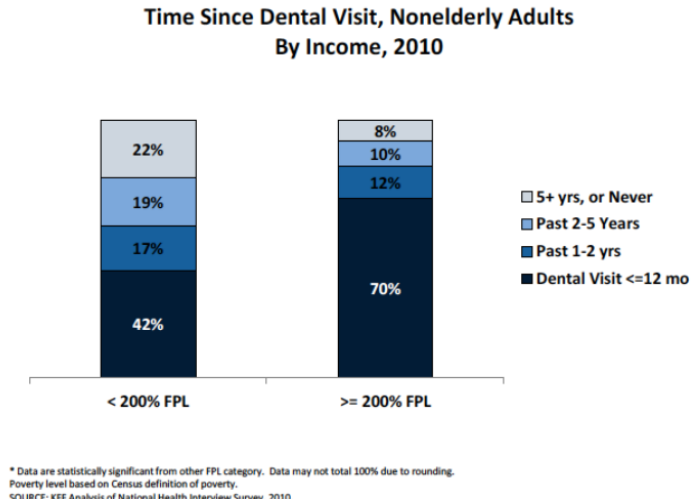

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Figure 5

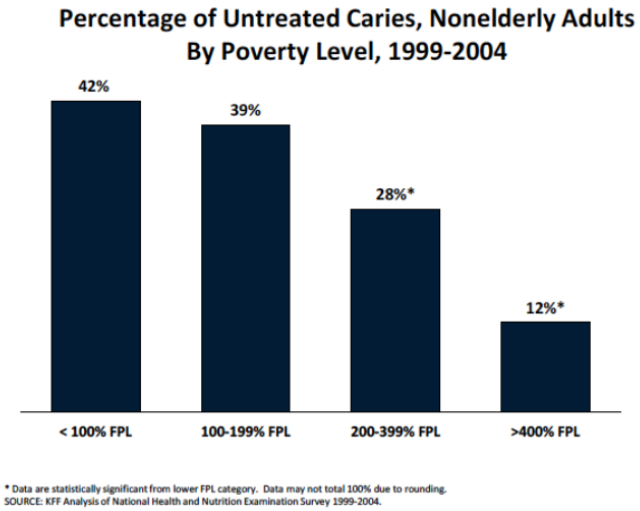

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Figure 6

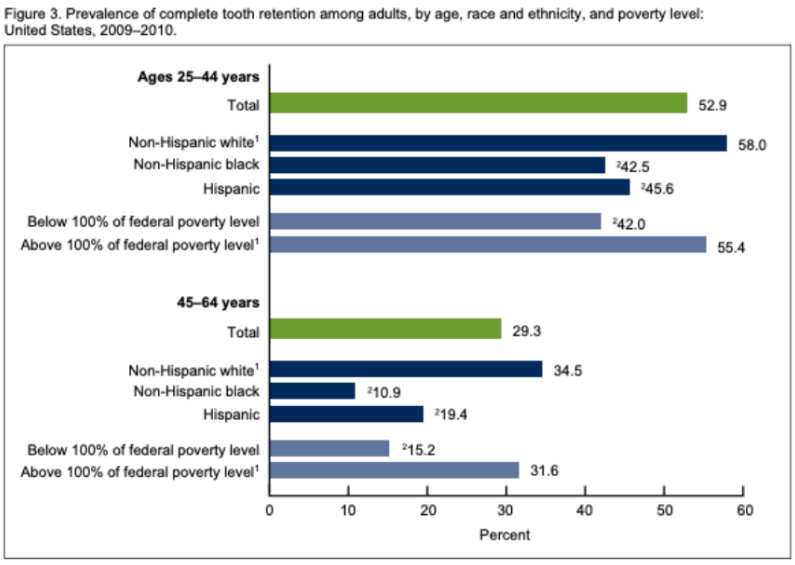

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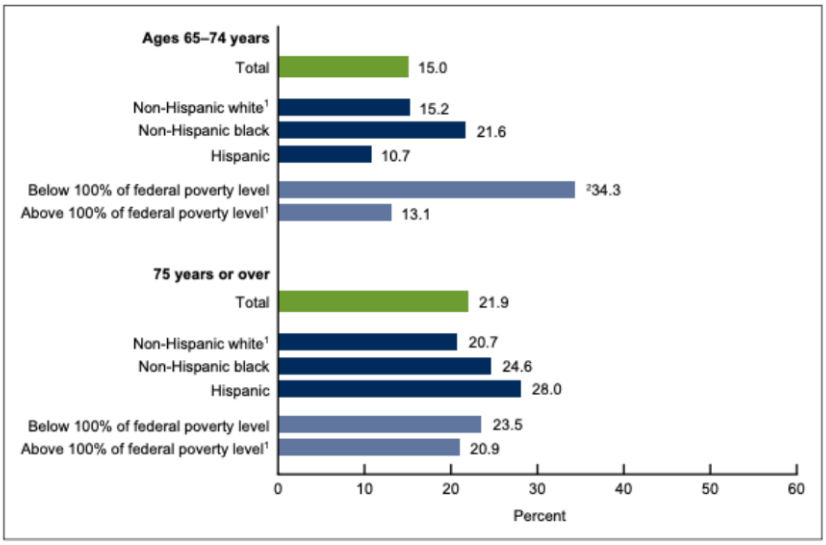
Figure 7

Figure 4. Prevalence of edentulism among older adults, by age, race and ethnicity, and poverty level: United States, 2009–2010.



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Manuscript 1: Socio-Economic Inequalities in Dental Care Utilization Among the U.S. Adults: A Study of Trends From 2010 to 2019

Abstract

Objectives for aim1 a and aim1 b:

Medicaid expansion under the Affordable Care Act (ACA) has tremendously improved the utilization of dental services among children under 19 years of age.[9] Despite this progress, there are no dental requirements for adults, and adult coverage remains at the discretion of individual states.[14] The concept of health disparities was first introduced in HP 2010 as an overarching goal. However, 69% of the HP 2010's health disparities-related objectives did not achieve significant improvements.[3] In this study, we assessed dental care utilization among U.S. adults (≥18 years) in general (aim1 a) and U.S. adults (≥18 years) who cannot afford dental treatment (aim1 b) using the National Health Information Survey (NHIS) data from 2010 to 2019.

Methods for aim1a and aim1b:

This analysis included 316,806 respondents. Eight socioeconomic indicators (SEI) were analyzed to assess their associations with past-year utilization of dental care. The Slope Index of Inequality (SII) and Relative Index of Inequality (RII) were used to measure inequality for ordinal variables. Risk difference and risk ratio were calculated to measure inequality for variables that lack natural ordering. Logistic regression was used to assess trends.

Results:

Aim1a

A significant increase in last year's dental visit was observed from 2010 to 2019 (60.56 % to 65.28 %; *p*-trend<.001). Within the pooled analyses, lower odds of visiting the dentist were seen among respondents who were uninsured (OR:0.33, 95%CI:0.32-0.34) or who have public insurance (OR:0.76, 95%CI:0.73-0.78) compared to respondents with private insurance. Respondents between 200%-399% FPL (OR:1.48, 95%CI:1.42-1.53),or more than 400% FPL (OR:2.78, 95%CI:2.66-2.90) had lower odds of visiting the dentist compared to respondent with annual family income less than 100% FPL. Inequality decreased on both the absolute and relative scales for all the socio-economic indicators.

Aim1b

Among the respondents, a significant increase in last year's dental visit was observed from 2010 (35.39) to 2019 (43.11%) (p-trend<0.001). Within the pooled analyses, the adjusted odds of visiting the dentist were lower among uninsured (OR:0.41, 95%CI:0.38-0.44) or adults with public health insurance (OR:0.87, 95%CI:0.80-0.95) compared to respondents with private health insurance. Adults with annual family income between 200%-399% FPL (OR:1.36, 95%CI:1.25-1.49), or more than 400% FPL (OR:2.25, 95%CI:2.02-2.51) had higher odds of visiting the dentist compared to adults with annual family income less than 100% FPL. During the study period, measured inequalities by annual family income increased on the absolute scale (2010 SII:0.28 - 2019 SII:0.34). Furthermore, the absolute inequality didn't change for people who were uninsured or who had a public insurance compared to people who had private insurance.

<u>Conclusion:</u>

Although dental care utilization increased between 2010 and 2019, absolute inequality increased by annual family income for people who cannot afford dental treatment. Closing the gap in dental care utilization by targeted intervention can help in achieving Healthy People goals for equitable oral health.

Introduction

Medicaid expansion under the Affordable Care Act (ACA) has tremendously improved the utilization of dental services among children under 19 years of age.[9] In spite of this progress, there are no dental requirements for adults, and adult coverage remains at the discretion of individual states.[14] Comprehensive dental benefits for adults are only offered in 19 states.[10] Only 35.5% of U.S. adults visited the dentist in the past year in 2014 compared to 41% in 2003.[9]

Several possible explanations for the decline in utilizing dental care include the cost of treatment, the perception of necessity of dental treatment, and lack of time to obtain dental treatment.[15-17] Previous research suggests that financial barriers are most commonly reported with underutilized oral services compared to other health services regardless of income level and type of insurance.[18] A study in 2009, reported that one out of five individuals was unable to afford needed dental care.[19] Another study in 2016, found that one third of US adults did not have any dental visits during the previous year.[20] Deficit in dental coverage for low-income adults has been referred to as a "neglected epidemic".[14]

Health disparities/inequalities are defined as "potentially avoidable differences in health (or in health risks that policy can influence) between groups of people who are more and less socially advantaged; these differences systematically place socially disadvantaged groups at further disadvantage on health".[2] Although the ACA closed many gaps in health disparities, large gaps in oral health care still exist.[3, 21] Reduction in health disparities was first introduced as an overarching goal in Healthy People (HP) 2010. However, 69% of the HP 2010's health disparities-

related objectives did not achieve any significant improvements.[3] For instance, the reported annual dental visits in 2008 decreased from 44% in 1996 to 43% moving further from the target of 56%. Further, disparities in annual dental visits increased among all racial/ethnic groups compared to White individuals, among females compared to males, among those with less than high school and high school graduates compared to those with some college education, and among individuals with disabilities compared to those with no disabilities.[3] As a result, the percentage of persons who used the oral health care system was added as a leading health indicator in HP 2020.

The health inequality measure examines the difference in the outcome between a particular group and the entire population instead of only the extreme subgroups as in disparity measures.[13] Unfortunately, these inequality measures are underutilized in the dental literature. Therefore, in this study inequality measures were used to illustrate the trends in differences of dental care utilization among U.S. adults over a 10 -year period (2010-2019) using the National Health Information Survey (NHIS).[22]

Methods

Data source and Measures

Our main source of data was the 2010 - 2019 National Health Interview Survey (NHIS).[22] The NHIS is conducted annually and is nationally representative of the civilian non-institutionalized US population. During 2010 and 2019, 316,806 individuals were interviewed for NHIS. The analyses in this study were restricted to adult persons aged ≥18 years. The annual sample size for the adult population averaged 35,200 (25,417 in 2018 (lowest) to 36,697 in 2014(highest)). Furthermore, a sub analysis was done to assess the dental care utilization among adults aged ≥18 years who cannot afford dental treatment and included 42,000 individuals.

Dental care Utilization Among during the past 12 months

The outcome was dental care utilization which defined as the percentage of persons who self-reported visiting the dentist during the past year.

The main predictor variable was affordability of dental treatment. People who cannot afford dental treatment are those who responded yes to the question: "During the past 12 months, was there any time when you needed any of the following, but didn't get it because you couldn't afford it?"

Indicator variables

The following indicator variables were analyzed in our study: sex; age; education; annual family income; race/ethnicity; marital; past week employment status; dental insurance; and past-year health insurance coverage. The selection of the indicators variables was based on whether it was

a social determinant health associated with social disadvantage status, or relevance to the public or clinical health. Detailed descriptions are presented in the table1.

Data analyses

To obtain nationally representative estimates, all data used were weighted to account for the complex design of the NHIS. Analyses were conducted using Stata V.15 (Stata Corporation, College Station, TX). Prevalence estimates were computed for each year in the period examined. Trends during the entire study period were assessed using estimates of relative percentage change (RPC) between the first and last survey years. To determine if the observed changes were statistically significant, age and sex adjusted slope estimates expressed as log-odds in a binary logistic model were measured.

Assessment of Inequalities

The absolute inequality measures were used to quantify the differences across all levels of socioeconomic positions rather than measuring the differences relative to a specific referent group (i.e., a global measure).[23] A single number was used to describe the overall inequality for each indicator within a specific year. For ordinal variables, such as education, age, and income, the Slope Index of Inequality (SII) and relative index of inequality (RII) were calculated. Other variables that lack natural ordering, pairwise comparisons (risk difference (RD) and risk ratio (RR) were calculated.

SII and RII for each year were calculated by regressing the outcome (dental utilization; 0=no dental visit during the past year, 1= dental visit during the past year), against an individual's relative rank in the cumulative distribution of socio-economic position that is weighted based on the group size (ridit score). The interaction variable (year*ridit score) was utilized as a trend test at $p<0.05$. We assumed that dental care utilization is distributed equally among all socio-economic groups if SII had a value of zero and RII had a value of one. On the other hand, it was assumed that the utilization of dental care is more among socially advantage groups if SII had a positive value and RII had a value above one. If dental care utilization increased by the same amount in all socio-economic groups, the SII would increase while the RII would not change. For that, both measures were analyzed to present a complete picture of inequalities.

RR and RD for each year were calculated by comparing the risk of dental care utilization between two subgroups. To calculate RD and RR, logistic regression was used to model the log odds of using dental care and the coefficients was transformed into marginal predicted risks.

Results

Aim 1a: Trends among all US adults

Among the study population, dental care utilization increased significantly from 2010 to 2019 (60.56 % to 65.28 %; *p*-trend<.001).

Within the pooled analyses, the adjusted odds of visiting the dentist were lower among males compared to females (OR:0.69, 95%CI:0.68-0.71) and Black, Asians compared to Whites (OR:0.92, 95%CI:0.89-0.96) (OR:0.89, 95%CI:0.84-0.91), respectively). Also, lower odds of visiting the dentist were seen among respondents who were uninsured (OR:0.33, 95%CI:0.32-0.34) or those with public insurance (OR:0.76, 95%CI:0.73-0.78) compared to respondents with private insurance, those with less than high school (OR:0.44, 95%CI:0.43-0.46), with high school diplomas (OR:0.56, 95%CI:0.55-0.58), or with some college (OR:0.72, 95%CI:0.70 -0.74) compared to respondents with a college degree or higher. Respondents between 200%-399% FPL (OR:1.48, 95%CI:1.42-1.53),or more than 400% FPL (OR:2.78, 95%CI:2.66-2.90) had lower odds of visiting the dentist compared to respondents with annual family income less than 100% FPL. Finally, respondents who were widowed/divorced/separated (OR:0.79, 95%CI:0.77-0.81) had lower odds of visiting the dentist compared to respondents who were married (**Table 2**).

Trends among population subgroups

Education

Between 2010-2019, a significant increase in dental care utilization was detected among all educational levels (*p*-trend<0.05): less than a high school diploma (37.64% to 45.41%); high

school diploma (52.24% to 57.7%); some college (61.57% to 67.24%); or more than or equal a college degree (74.46% to 75.39%) (**Table 3 & Figure 1**). In the most disadvantaged group (<high school diploma; RPC = 20.64), the percentage increase in dental care utilization was 16.5 times greater than those with ≥college degree (RPC = 1.25), 1.98 times greater than those with a high school diploma (RPC = 10.45), and 2.24 times more than those with some college (RPC = 9.21).

Annual family income

From 2010 to 2019, a significant increase in dental care utilization was detected among all annual family income categories (*p*-trend<0.05): <100% FPL (39.52% to 47.52%); 100-199% FPL (42.94% to 49.42%); 200-399% FPL (59.03% to 62.92%); and ≥ 400 FPL (77.74% to 79.74%) (**Table 3 & Figure 1**). Among the most disadvantaged group (<100% FPL; RPC = 20.24), the percentage increase in dental care utilization was 1.34 times more compared to 100-199% FPL group (RPC = 15.09), 3.07 times more compared to 200-399% FPL group (RPC = 6.59), and 7.88 times more compared to ≥ 400 FPL group (RPC = 2.57)

Sex

Between 2010-2019, there was a significant increase in dental care utilization among both men (56.69% to 67.9%) and women (64.17%–68.8%) (p-trend <0.001) (**Table4**). The percentage increase in dental care utilization was 1.18% more among males compared to females (RPC=8.52 vs 7.22, respectively).

Race/ethnicity

A significant increase in dental care utilization was detected among all race/ethnic groups: Whites (64.47% to 68.23%); Blacks (51.8% to 59.27%); Asians (64.65% to 70.06%); and Hispanics (47.92% to 57.57%); (p-trend <0.05) (**Table 4 & Figure 1**). Among the most disadvantaged group (Hispanics; RPC = 20.14), the percentage increase in dental care utilization was 3.45 times larger than Whites (RPC = 5.83) , 1.4 times larger than Blacks (RPC = 14.42), and 2.4 times larger than Asians (RPC = 8.37).

Marital status

A significant increase in dental care utilization was detected for all marital groups: never married (56.77% to 65.05%); widowed, divorced, or separated (53.14% to 56.54%); and married (63.95% to 67.9%)(p-trend <0.05)(**Table 4 & Figure 1**). Among the most disadvantaged group (Widowed/divorced/separated; RPC = 6.4), the percentage increase in dental care utilization was 1.03% more compared to the most advantaged group (married; RPC = 6.18) and was 56% less compared to the never married group (RPC = 14.59).

Employment status

From 2010 to 2019, a significant increase in dental care utilization was detected among both employed (64.64%–67.67%) and unemployed (54.52%–61.27%) (p-trend <0.01) (**Table 5 & Figure 1**). The percentage increase in dental care utilization was 2.64 times more among unemployed (the most disadvantaged group) compared to employed (RPC=12.38 vs 4.69, respectively).

Health Insurance

A significant increase in dental care utilization was observed for all insurance groups: private (71.56% to 73.67%); public (51.15% to 57.55%); and uninsured (31.93% to 38.3%) (**Table 5 & Figure 1**). For the uninsured group (RPC = 19.95), the percentage increase in dental care utilization was 6.76 times larger than for those with private insurance (RPC = 2.95) and 1.59 times larger than for those with public insurance (RPC= 12.51).

Dental coverage

A significant increase in dental care utilization was detected only among people who don't have dental coverage (70.95% to 72.75%) (*p* trend<. 05) (**Table 5 & Figure 1**). The percentage increase in dental care utilization was 1.26 times more among people who have coverage (the most advantaged group) compared to people who don't have dental coverage (RPC=3.2 vs 2.54, respectively).

Age

A significant increase in dental care utilization was observed for all groups: 18-24 (57.67% to 70.7%); 24-44 (58.8% to 62.58%); 45-64 (64.76% to 66.59%); and 65+ (57.74% to 64.59%) (**Table 6**). Among the most disadvantaged group (24-44; RPC = 6.43), the percentage increase in dental care utilization was 71% lower than those aged 18-24 (RPC = 22.59), 2.27 times larger than those aged 45-64 (RPC= 2.83), and 46% lower than those aged 65+ (RPC= 11.86).

Assessment of Inequalities

Race/ Ethnicity

Measured inequalities by race/ethnicity decreased during the past 10 years for Whites compared to Hispanics (2010 RR: 1.35, RD:0.17 - 2019 RR:1.19, RD:0.11) and Blacks (2010 RR:1.24, RD:0.13 - 2019 RR:1.15, RD:0.09) (**Table 8**). In 2019, dental care utilization for Whites was higher by 11 percentage-points compared to Hispanics (95% CI: 0.08, 0.13) and by 9 percentage-points compared to Blacks (95% CI: 0.07, 0.11). Regarding the relative risk, Whites were 1.19 times more likely to have dental visit compared to Hispanics (RR = 1.19, 95% CI = 1.14, 1.23) and 1.15 times compared to Blacks (95% CI: 1.11, 1.19).

Insurance

On both the relative and absolute scales, the inequality decreased between private-public insurance (2010 RR: 1.40, RD:0.20 - 2019 RR:-1.28, RD:0.16) and private-uninsured (2010 RR: 2.24, RD:0.40 - 2019 RR:1.92, RD:0.35) (**Table 9 & Figure2**). In 2019, dental care utilization for people with private insurance was 16 percentage-points higher (95% CI: 0.14, 0.18) compared to adults with public insurance and 35 percentage-points higher compared to uninsured adults (95% CI: 0.33, 0.38). The relative risk showed that adults with private insurance were 1.28 times higher to utilize dental services compared to adults with private insurance (95% CI: 1.24, 1.31) and 1.92 times higher compared to uninsured adults (95% CI: 1.81, 2.04).

Education

Table 10 presents inequality estimates during the study period. Both SII and RII showed a decrease in inequality between the highest and the lowest educational groups from 2010 (SII:0.45, RII:2.23) to 2019 (SII:0.36, RII:1.80). The SII for education in 2019 was 0.36 (95% CI: 0.34, 0.39) indicating that dental care utilization is on average 36 percentage points higher at the top vs. the bottom of the education distribution. For the RII, the more educated adults were 1.80 times more likely to have dental services in the past year than the less educated adults (95% CI: 1.72, 1.87).

Age

Measured inequalities by age deceased during the 10 years of the study (2010 SII:0.04, RII:1.07 - 2019 SII:-0.01, RII:0.98) (**Table 10**). The SII for age in 2019 was -0.01 (95% CI: -0.04, 0.98) indicating that dental care utilization is on average 1 percentage points lower at the top vs. the bottom of the age distribution. On the relative scale, the older adults were 2% less likely to have dental services in the past year than older adults (95% CI: 0.95, 1.02).

Annual family income

On both relative and absolute scales, the inequalities by annual family income decreased during the study period (2010 SII:0.52, RII:2.60 - 2019 SII:0.45, RII:2.10) (**Table 10 & Figure3**). The SII for Annual family income in 2019 was 0.45 (95% CI: 0.43, 0.47) indicating that dental care utilization is on average 45 percentage points higher at the top vs. the bottom of the annual family income distribution. On the relative scale, families with higher annual income were 2.1 times more likely

to have dental services in the past year than families with lower family income (95% CI: 2.01, 2.19).

Aim 1b: Trends among all US adults who can't afford dental treatment

The analysis included 42,000 respondents aged 18 and above who self-reported that they can't afford dental treatment in the previous year. Among this study population, dental care utilization increased significantly during the between 2010 to 2019 (35.39 % to 43.11 %; *p*-trend<.001).

Within the pooled analyses, the adjusted odds of visiting the dentist were lower among males compared to females (OR:0.86, 95%CI:0.81-0.91) and Hispanics, Asians compared to Whites (OR:1.13, 95%CI:1.04-1.22)(OR:1.28, 95%CI:1.1-1.48) respectively) (**Table 13**). Also, lower odds of visiting the dentist were seen among respondents who were uninsured (OR:0.41, 95%CI:0.38-0.44) or those with public insurance (OR:0.87, 95%CI:0.80-0.95) compared to respondents with private insurance, those with less than high school (OR:0.59, 95%CI:0.54-0.65), with high school diploma (OR:0.67, 95%CI:0.62-0.72), or with some college (OR:0.82, 95%CI:0.76-0.89) compared to respondents who had a college degree or higher. Respondents between 200%-399% FPL (OR:1.36, 95%CI:1.25-1.49) or more than 400% FPL (OR:2.25, 95%CI:2.02-2.51) had lower odds of visiting the dentist compared to respondent with 100% FPL. Finally, respondents who were widowed/divorced/separated (OR:0.87, 95%CI:0.81-0.93) had lower odds of visiting the dentist compared to respondents who were married.

Trends among population subgroups

Education

Between 2010 and 2019, a significant increase in dental care utilization was detected among all educational levels (*p*-trend<0.05): less than high school diploma (25.93% to 33.34%); high school diploma (31.39% to 37.92%); some college (34.66% to 48.19%); or more than or equal a college degree (47.33% to 52.37%) (**Table 14 & Figure 4**). In the most disadvantaged group (<high school diploma; RPC = 28.58), the percentage increase in dental care utilization was 2.68 times greater than those with ≥college degree (RPC = 10.65), 1.37 times greater those with a high school diploma (RPC =20.8), and 27% less than those with some college (RPC = 39.04).

Annual family income

From 2010 to 2019, a significant increase in dental care utilization was detected among all annual family income categories (*p*-trend<0.05): <100% (28..28% to 33.26%); 100-199% (28.28% to 53.63%); 200-399% (36.90% to 45.76%); and ≥ 400 (54.48% to 62.40%) (**Table 14 & Figure 4**). Among the most disadvantaged group (<100%; RPC = 16.62), the percentage increase in dental care utilization was about 36% less compared to 100-199% level group (RPC = 25.99), 31% less compared to 200-399% level group (RPC = 24.01), and 1.14 times more compared to ≥ 400% level group (RPC = 14.54)

Sex

Between 2010-2019, there was a significant increase in dental care utilization among both men (33.29% to 37.58%) and women (36.96%–46.64%) (p-trend <0.001) (**Table 15**). The percentage

increase in dental care utilization was 1.43 times more among males compared to females (RPC=37.58 vs 26.19, respectively).

Race/ethnicity

A significant increase in dental care utilization was detected among all race/ethnic groups: Whites (38.01% to 43.81%); Blacks (29.85% to 39.49%); Asians (35.71% to 58.27%); and Hispanics (32.18% to 41.28%); (p-trend <0.05) (**Table 15 & Figure 4**). Among the most disadvantaged group (Hispanics; RPC = 28.28), the percentage increase in dental care utilization was 1.83 times larger than Whites (RPC = 15.26) , 0.05% less than Blacks (RPC = 29.85), and 87% less than Asians (RPC = 63.18).

Marital status

A significant increase in dental care utilization was detected for all marital groups: never married (33.87% to 40.54%); widowed, divorced, or separated (33.22% to 38.36%); and married (36.97% to 45.80%)(p-trend <0.05)(**Table 15 & Figure 4**). Among the most disadvantaged group (widowed/divorced/separated; RPC = 15.47), the percentage increase in dental care utilization was 35% less compared to the most advantaged group (married; RPC = 23.88) and the percentage increase in dental care utilization was 21.14% less compared to the Never married group (RPC = 19.69).

Employment status

From 2010 to 2019, a significant increase in dental care utilization was detected among both employed (38.18%–46.09%) and unemployed (31.95%–38.53%) (p-trend <0.01) (**Table 16 & Figure 4**). The percentage increase in dental care utilization was 1.01 times more among unemployed (the most disadvantaged group) compared to employed (RPC=20.72 vs 20.59, respectively).

Health Insurance

A significant increase in dental care utilization was observed for all health insurance groups; private (50.54% to 54.83%); public (37.41% to 42.82%); and uninsured (22.10% to 26.40%) (**Table 16 & Figure 4**). For the uninsured group (RPC = 19.46), the percentage increase in dental care utilization was 2.29 times larger than for those with private insurance (RPC = 8.49) and 1.35 times larger than for those with public insurance (RPC= 14.46).

Dental coverage

A significant increase in dental care utilization was detected only among people who didn't have dental coverage (53.13% to 60.66%) (*p* trend<. 05) (**Table 16 & Figure 4**). The percentage increase in dental care utilization was 2.04 times more among people who had dental coverage (the most advantaged group) compared to people who didn't have dental coverage (RPC=14.17 vs 6.93, respectively).

Age

A significant increase in dental care utilization was observed for all age groups: 18-24 (34.20% to 43.59%); 24-44 (34.13% to 43.77%); 45-64 (36.86% to 42.81%); and 65+ (37.36% to 42.02%) (**Table 17**). Among the most disadvantaged group (24-44; RPC = 28.24), the percentage increase in dental care utilization was 1.03 times more than those aged 18-24 (RPC = 27.46), 1.75 times larger than those aged 45-64 (RPC= 16.14), and 2.26 times more than those aged 65+ (RPC= 12.47).

Assessment of Inequalities

Race/ Ethnicity

Measured inequalities by race/ethnicity decreased during the past 10 years for Whites compared to Hispanics (2010 RR: 1.18, RD:0.06 - 2019 RR:1.06, RD:0.03) and Blacks (2010 RR:1.27, RD:0.08 - 2019 RR:1.11, RD:0.04) (**Table 19**). In 2019, dental care utilization for Whites was higher by 3 percentage-points compared to Hispanics (95% CI: -0.02, 0.07) and by 4 percentage-points compared to Blacks (RD = 0.04, 95% CI = -0.01, 0.09). On the relative scale, Whites were 1.06 times higher compared to Hispanics (95% CI: 0.96, 1.17) and 1.15 time higher compared to Blacks (95% CI: 0.97, 1.25) in utilizing dental services.

Insurance

During the study period, the inequality decreased on the relative scale only for private compared to public insurance (2010 RR: 1.35- 2019 RR:-1.28) and private-uninsured adults (2010 RR: 2.29-2019 RR:2.08) (**Table 20 & Figure 5**). In 2019, adults with private insurance were 1.28 times higher

compared to adults with private insurance (95% CI: 1.24, 1.31) and 1.92 time higher compared to uninsured adults (95% CI: 1.81, 2.04).

Education

During the study period, there was a decrease in inequality on the relative scale only (2010 RII:2.17 - 2019 RII:1.89) (**Table 21**). In 2019, the more educated adults were 1.89 times more likely to have dental services in the past year than the less educated adults (95% CI: 1.60, 2.17).

Age

Measured inequalities by age deceased during the 10 years of the study (2010 SII:0.05, RII:1.15 - 2019 SII:-0.02, RII:0.95) (**Table 21**). The SII for age in 2019 was -0.02 (95% CI: -0.81, 1.08) indicating that dental care utilization is on average 2 percentage points lower at the top vs. the bottom of the age distribution. On the relative scale, the older adults were 5% less likely to have dental services in the past year than older adults (95% CI: 0.81, 1.08).

Annual family income

During the study period, measured inequalities by annual family income increased on the absolute scale (2010 SII:0.28 - 2019 SII:0.34) and almost did not change on the relative scale (2010 RII:2.28 - 2019 RII:2.26) (**Table 21 & Figure 6**). The SII for annual family income in 2019 was 0.34 (95% CI: 0.28, 0.39) indicating that dental care utilization is on average 34 percentage points higher at the top vs. the bottom of the annual family income distribution.

Discussion

In our study, dental care utilization during the past year increased for all adults and for adults who cannot afford dental treatment across all the socio-economic indicator variables. However, there was a disproportionately lower prevalence of dental care utilization among persons below the poverty level, who were Hispanic, had less than a high school diploma, who were uninsured, who were never married, or unemployed. Our results were in agreement with the previous literature; only 20.3% of low-income people (FPL<100%) had a dental visit while almost 50% of high-income people had a dental visit in 2014. Further, the percentage of adults who were uninsured and visited a dentist in 2014 was 15% while almost half of the adults who had private insurance visited the dentist at the same year.[9]

Inequalities in dental care utilization are shrinking within the society with the respect to most indicators for all adults. However, the absolute inequality increased for adults who cannot afford dental treatment by annual family income. Furthermore, absolute inequality didn't change for people who cannot afford dental treatment, uninsured or with public insurance compared to people who had private insurance. This might be due to the slower improvement in dental care utilization among the most disadvantaged groups compared to the most advantaged groups.

Accomplishing equity in dental care utilization necessitates an understanding that not all individuals start from the same point. Therefore, it is important to recognize and consider the multi-level barriers faced by the most disadvantaged populations in accessing, utilizing, and benefiting from implemented interventions. Discrepancies exist in policies adoption of dental

coverage expansion under Medicaid. Unfortunately, there are still an estimated 108 million Americans without access to dental care in the United States after the passage of ACA.[24]

Implementing population-based interventions across all states, including tailoring outreach intervention, engaging oral health stakeholders, improving providers' reimbursement under Medicaid and expanding the dental workforce can minimize the gap of dental care utilization among US adults. Moreover, healthcare financing can significantly impact inequalities in health in general. It is vital to adopt a public healthcare financing system that ensures equality among the population. Further, securing dental benefits for adults' beneficiaries through Medicaid expansion would significantly minimize the gaps in access to dental care and improve utilization among the adults' population.

Our study had several limitations. First, it wasn't feasible to compare between states that expanded Medicaid and those that didn't due to the lack of state-level data in NHIS. Second, our outcome variable is self-reported, which is more subjected to recall bias. Further, participants might have different interpretations of the need for dental treatment and affordability. Finally, due to the cross-sectional nature of the collected data it is not possible to assess the outcome (dental care utilization) among the same population in a longitudinal fashion.

Conclusion

Although inequalities in dental care utilization are shrinking within the society with the respect to most indicators for all adults, the absolute inequality increased for adults who cannot afford dental treatment by annual family income. Closing the gap in dental care utilization by targeted intervention can help in achieving Healthy People goals for equitable oral health. Policy makers should recognize that macro-environmental factors (socio-economic, physical and social environment factors) are the principal determinants of health inequalities. Focused interventions that tackle these macro-environmental factors among high-risk groups, as well as mandating dental coverage under Medicaid in all states, can greatly reduce disparities and inequalities in dental care utilization.

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Tables and graphs

Aim1a: All U.S adults

Table 1: Socio-Demographic characteristics of adult respondents. National Health Information Survey 2010 and 2019

		2010		2019	
	Category	n	Weighted %	n	Weighted %
Sex	Male	11,986	48.33	14,733	48.29
	Female	15,171	51.67	17,261	51.71
Age	18-24	2,801	12.83	2,165	11.75
	25-44	9,779	35.37	9,859	34.12
	45-64	9,127	34.94	10,597	32.89
	65+	5,450	16.86	9,376	21.24
Race/Ethnicity	Hispanic	5,158	13.98	4,152	16.54
	White (non-Hispanic)	15,570	68.56	21,915	63.23
	Black (non-Hispanic)	4,511	11.95	3,483	11.75
	Asian (non-Hispanic)	1,726	4.69	1,648	5.88
	Other	192	0.81	799	2.6
Education	<High school diploma high	4,653	14.41	2,954	12.44
	High school diploma	7,171	26.91	8,201	27.46
	Some college	5,267	19.99	5,216	17.83
	≥college degree	9,941	38.69	15,447	42.27
Poverty Level	Less than 100%	4,595	12.5	3,548	11.22
	100- 199%	4,825	15.86	5,788	18.69
	200%- 399%	6,940	26.45	9,606	30.98
	More than 400%	7,744	33.33	13,055	39.11
	Unspecified	3,053	11.87	-	-
Marital status	Never married	6,449	21.48	6,368	.2254
	Widowed /Divorced/ Separated	7,057	17.34	7,888	.1617
	Married	13,603	61.17	16,895	.613
Employment status	Yes	15,413	59.6	18,810	64.56
	No	11,731	40.4	12,416	35.44
Dental coverage	Yes	6,217	40.92	7,284	40.27
	No	8,877	59.08	12,125	59.73
Insurance Type	Private	15,471	62.14	19,594	61.86
	Public	5,088	15.35	7,430	21.13
	Other	1,423	4.56	1,980	5.34
	Uninsured	5,095	17.96	2,887	11.67

Table 2 Multivariable logistic regression of socio-economic indicators and dental care utilization during the past y among US adults. National Health Information Survey, 2010–2019			
Characteristics	OR* of dental care utilization	95% CI**	P-value
Sex (Referent group: female)			
Male	0.670	0.68-0.71	<0.001
Age (Referent group: 18-24)			
25-44	0.65	0.62-0.68	<0.001
45-64	0.75	0.71-0.78	<0.001
65+	0.76	0.72-0.81	<0.001
Race/ethnicity (Referent group: White)			
Hispanic	1.03	1.00-1.07	0.067
Black	0.92	0.89-0.96	<0.001
Asian	0.89	0.84-0.92	<0.001
Other	0.94	0.82-1.08	0.41
Poverty level (Referent group: Less than 100%)			
100- 199%	1.01	0.98- 1.05	0.512
200%- 399%	1.48	1.42-1.53	<0.001
More than 400%	2.78	2.66- 2.90	<0.001
Unspecified	1.74	1.65-1.83	<0.001
Education (Referent group: ≥college degree)			
<High school diploma	0.44	0.43-0.46	<0.001
High school diploma	0.56	0.55-0.58	<0.001
Some college	0.72	0.70-0.74	<0.001
Insurance (Referent group: Private)			
Public	0.76	0.73-0.78	<0.001
Uninsured	0.33	0.32-0.34	<0.001
Other	0.71	0.68-0.74	<0.001

Uninsured	0.33	0.32-0.34	<0.001
Marital status (Referent group: Married)			
Never married	1.02	0.99-1.05	0.258
Widowed /divorced/ separated	0.79	0.77- 0.81	<0.001
Employment (Referent group: Employed)			
Not employed	0.99	0.97-1.02	0.582

*OR = Odd ratio

*95%CI= 95% Confidence interval

Table 3 Mean dental care utilization and 95% CI among adults by education and annual family income groups. National Health Information Survey, 2010–2019 (RPC: Relative Percentage Change)

	Education				Annual family income				
	<High School diploma	High School diploma	Some College	≥College degree	< 100%	100- 199%	200%- 399%	> 400%	unspecified
2010	37.64 (35.71-39.56)	52.24 (50.57-53.90)	61.57 (59.80-63.35)	74.46 (73.38-75.55)	39.52 (37.66-41.39)	42.94 (41.12-44.76)	59.03 (57.56-60.49)	77.74 (76.51-78.96)	61.32 (58.99-63.65)
2011	39.66 (37.97-41.34)	54.08 (52.76-55.41)	62.28 (60.65-63.90)	74.34 (73.37-75.31)	40.08 (38.24-41.92)	42.6 (40.98-44.22)	60.18 (58.83-61.54)	79.33 (78.22-80.44)	62.41 (60.27-64.55)
2012	38.14 (36.38-39.90)	53.64 (52.09-55.19)	62.46 (60.92-64.00)	75.22 (74.26-76.19)	39.79 (37.98-41.60)	44.6 (43.00-46.19)	59.31 (57.89-60.72)	79.47 (78.53-80.40)	63.54 (61.36-65.72)
2013	39.00 (37.09-40.93)	52.75 (51.30-54.19)	62.70 (61.23-64.17)	74.54 (73.65-75.43)	41.22 (39.18-43.25)	42.95 (41.13-44.78)	60.43 (59.14-61.72)	79.1 (77.99-80.20)	61.03 (58.97-63.10)
2014	39.28 (59.12-62.15)	53.18 (51.70-54.66)	62.42 (60.74-64.11)	75.19 (74.07-76.31)	40.58 (38.58-42.58)	46.00 (44.40-47.60)	61.02 (59.59-62.46)	78.93 (77.55-80.31)	63.97 (60.82-67.12)
2015	41.17 (39.07-43.27)	55.19 (53.66-56.72)	63.49 (61.96-65.01)	75.54 (74.48-76.60)	43.61 (41.41-45.81)	45.84 (44.01-47.67)	61.23 (59.93-62.54)	79.61 (78.58-80.65)	66.41 (63.67-69.14)
2016	42.49 (40.40-44.59)	54.5 (52.89-56.11)	64.93 (63.12-66.73)	76.07 (75.04-77.11)	47.28 (45.05-49.51)	44.86 (43.04-46.68)	61.19 (59.79-62.59)	79.83 (78.77-80.90)	66.64 (63.69-69.58)
2017	43.96 (41.39-46.53)	55.7 (54.08-57.32)	62.93 (61.18-64.68)	74.98 (73.97-75.99)	47.35 (44.74-49.96)	45.95 (43.89-48.00)	60.94 (59.34-62.54)	78.72 (77.65-79.79)	64.16 (61.35-66.98)
2018	48.03 (45.64-50.42)	55.96 (54.29-57.63)	66.22 (64.39-68.05)	75.84 (74.80-76.88)	47.38 (44.89-49.86)	48.19 (46.19-50.19)	62.12 (60.58-63.66)	79.16 (78.19-80.14)	67.61 (64.32-70.91)
2019	45.41 (42.91-47.92)	57.7 (56.30-59.10)	67.24 (65.71-68.77)	75.39 (74.51-76.28)	47.52 (45.19-49.85)	49.42 (47.59-51.25)	62.92 (61.66-64.19)	79.74 (78.93-80.54)	-
RPC	**20.64**	**10.45**	**9.21**	**1.25**	**20.24**	**15.09**	**6.59**	2.57	10.26
Trend	↑	↑	↑	-	↑	↑	↑	-	↑
P-Trend	**<0.001**	**<0.001**	**<0.001**	**0.149**	**<0.001**	**<0.001**	**<0.001**	**0.278**	**<0.001**

Table 4 Mean dental care utilization and 95% CI among adults by race/ethnicity, marital status, and sex. National Health Information Survey, 2010–2019 (RPC: Relative Percentage Change)

	Race/ethnicity				Marital status			Sex	
	Hispanic	White	Black	Asian	Never married	Widowed/divorced/separated	Married	Male	Female
2010	47.92 (46.07-49.77)	64.47 (63.32-65.61)	51.8 (49.74-53.86)	64.65 (61.97-67.34)	56.77 (55.13-58.41)	53.14 (51.63-54.65)	63.95 (62.80-65.09)	56.69 (55.42-57.96)	64.17 (63.16-65.18)
2011	46.53 (44.91-48.15)	65.68 (64.69-66.66)	54.55 (52.71-56.39)	64.08 (61.25-66.91)	58.8 (57.09-60.51)	53.66 (52.37-54.94)	64.71 (63.74-65.67)	58.06 (56.94-59.18)	64.74 (63.80-65.68)
2012	49.05 (47.20-50.90)	65.53 (64.61-66.46)	55.28 (53.28-57.27)	62.69 (59.88-65.50)	59.25 (57.70-60.80)	54.86 (53.49-56.24)	64.45 (63.44-65.46)	58.13 (57.08-59.18)	64.88 (63.92-65.85)
2013	49.95 (48.30-51.59)	65.46 (64.54-66.39)	53.77 (51.83-55.71)	63.97 (61.19-66.75)	59.28 (57.56-61.01)	53.67 (52.17-55.18)	64.7 (63.79-65.61)	57.68 (56.54-58.82)	65.1 (64.17-66.02)
2014	50.29 (48.51-52.07)	66.34 (65.34-67.34)	53.47 (51.37-55.58)	63.65 (60.86-66.43)	59.69 (57.95-61.43)	54.05 (52.64-55.45)	65.27 (64.20-66.34)	58.85 (57.68-60.02)	65.1 (64.10-66.11)
2015	53.07 (51.31-54.83)	67.04 (66.14-67.95)	57.58 (55.49-59.68)	68.82 (65.72-71.92)	61.75 (60.25-63.24)	56.06 (54.57-57.55)	66.7 (65.65-67.74)	60.76 (59.66-61.87)	66.48 (65.51-67.44)
2016	54.95 (52.65-57.25)	68.12 (67.18-69.05)	57.4 (54.70-60.10)	65.26 (61.89-68.62)	63.05 (61.26-64.83)	56.94 (55.22-58.66)	66.99 (65.95-68.03)	61.11 (59.80-62.41)	67.47 (66.41-68.53)
2017	54.1 (51.52-56.69)	68.23 (67.24-69.21)	58.77 (56.14-61.41)	61.61 (58.29-64.93)	62.53 (60.82-64.24)	55.68 (53.94-57.42)	67.46 (66.34-68.58)	61.89 (60.67-63.11)	66.59 (65.37-67.82)
2018	58.22 (55.82- 60.62)	68.87 (67.91-69.82)	61.3 (58.99-63.62)	66.57 (63.35-69.78)	63.64 (61.84-65.45)	58.66 (57.17-60.15)	68.67 (67.60-69.74)	62.05 (60.85-63.24)	69.39 (68.28-70.50)
2019	57.57 (55.52-59.63)	68.23 (67.37-69.10)	59.27 (57.03-61.51)	70.06 (67.20-72.91)	65.05 (63.47-66.63)	56.54 (55.04-58.04)	67.9 (66.97-68.84)	61.52 (60.44-62.60)	68.8 (67,82-69.77)
RPC	**20.14**	**5.83**	**14.42**	**8.37**	**14.59**	**6.4**	**6.18**	8.52	7.22
Trend	↑	↑	↑	↑	↑	↑	↑	↑	↑
P-Trend	**<0.001**	**<0.001**	**<0.001**	**0.016**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**

Table 5 Mean dental care utilization and 95% CI among adults by health insurance status, dental coverage status, and employment status. National Health Information Survey, 2010–2019 (RPC: Relative Percentage Change)

	Health insurance status				Dental insurance coverage status		Employment status	
	Private	Public	Other	Uninsured	Covered	Not covered	Employed	Not employed
2010	71.56 (70.52-72.60)	51.15 (49.31-53.00)	54.33 (50.80-57.86)	31.93 (30.34-33.52)	73.8 (72.29-75.31)	70.95 (69.67-72.22)	64.64 (63.53-65.75)	54.52 (53.21-55.84)
2011	72.98 (72.08-73.87)	51.51 (49.86-53.16)	55 (52.25-57.75)	31.72 (30.36-33.08)	75.28 (73.98-76.59)	72.37 (71.26-73.49)	65.16 (64.18-66.15)	56.21 (55.08-57.34)
2012	72.75 (71.95-73.55)	52.18 (50.60-53.76)	56.79 (53.34-60.25)	31.62 (30.03-33.21)	73.76 (72.48-75.04)	72.74 (71.68-73.80)	65.18 (64.28-66.08)	56.37 (55.15-57.60)
2013	72.67 (71.86-73.47)	52.08 (50.36-53.80)	55.9 (53.18-58.61)	32.43 (30.80-34.07)	74.8 (73.45-76.15)	71.82 (70.71-72.93)	64.55 (63.63-65.47)	57.03 (55.81-58.25)
2014	71.67 (70.70-72.64)	52.35 (50.72-53.97)	60.05 (56.82-63.27)	31.93 (30.11-33.75)	72.35 (70.71-74.00)	72.59 (71.36-73.81)	65.54 (64.51-66.57)	56.83 (55.64-58.03)
2015	72.47 (71.56-73.38)	53.42 (51.81-55.03)	56.05 (53.00-59.10)	34.12 (31.94-36.29)	75.1 (73.67-76.53)	72.23 (71.06-73.40)	66.77 (65.80-67.75)	59.03 (57.84-60.21)
2016	72.77 (71.78-73.77)	54.63 (53.00-56.26)	57.42 (54.24-60.61)	34.73 (32.17-37.29)	74.63 (73.12-76.14)	73 (71.82-74.19)	67.4 (66.28-68.51)	59.82 (58.59-61.05)
2017	72.31 (71.30-73.33)	56.59 (54.96-58.21)	57.04 (53.74-60.34)	33.75 (31.26-36.24)	72.66 (71.00-74.31)	72.82 (71.62-74.02)	66.5 (65.42-67.59)	60.78 (59.40-62.17)
2018	73.83 (72.90-74.76)	57.45 (55.80-59.09)	59.06 (56.18-61.94)	37.4 (34.72-40.08)	75.99 (74.57-77.40)	73.9 (72.72-75.07)	68.36 (67.31-69.40)	61.67 (60.33-63.01)
2019	73.67 (72.85-74.5)	57.55 (56.09-59.02)	57.04 (54.05-60.03)	38.3 (35.97-40.62)	76.16 (74.93-77.40)	72.75 (71.72-73.77)	67.67 (66.76-68.57)	61.27 (60.08-62.47)
RPC	**2.95**	**12.51**	**4.99**	**19.95**	**3.2**	**2.54**	**4.69**	**12.38**
Trend	↑	↑	↑	↑	-	↑	↑	↑
P-Trend	**0.012**	**<0.001**	**0.044**	**<0.001**	**0.130**	**0.004**	**<0.001**	**<0.001**

Table 6 Mean dental care utilization and 95% CI among adults by age. National Health Information Survey, 2010–2019 (RPC: Relative Percentage Change)

	Age			
	18-24	25-44	45-64	65 +
2010	57.67 (29.49-40.43)	58.8 (31.61-36.86)	64.76 (33.69-39.70)	57.74 (32.09-43.74)
2011	61.1 (58.81-63.38)	58.86 (57.77-59.95)	64.44 (63.21-65.67)	61.22 (59.75-62.70)
2012	61.17158 (58.90-63.45)	58.86 (57.71-60.03)	64.46 (63.23-65.69)	61.79 (60.24-63.35)
2013	61.79 (59.34-64.24)	58.95 (57.78-60.12)	64.4 (63.27-65.66)	60.64 (59.12-62.15)
2014	62.28 (59.51-65.04)	62.28 (58.13-60.66)	64.54 (63.30-65.78)	62.39 (60.96-63.81)
2015	65.58 (63.17-67.99)	61.13 (59.80-62.47)	66.19 (64.94-67.45)	62.73 (61.20-64.35)
2016	65.48 (62.93-68.02)	62.31 (60.81-63.81)	66.16 (64.78-67.55)	64.33 (62.85-65.80)
2017	66.16 (63.52-68.81)	61.08 (59.60-62.56)	66.2 (64.70-67.70)	65.59 (64.13-67.05)
2018	68.65 (66.07-71.23)	62.66 (61.15-64.16)	68.3 (66.96-69.64)	65.59 (64.15-67.03)
2019	70.7 (68.40-73.00)	62.58 (61.39-63.78)	66.59 (65.33-67.85)	64.59 (63.28-65.90)
RPC	**22.59**	**6.43**	**2.83**	**11.86**
Trend	↑	↑	↑	↑
P-Trend	**<0.001**	**<0.001**	**<0.001**	**<0.001**

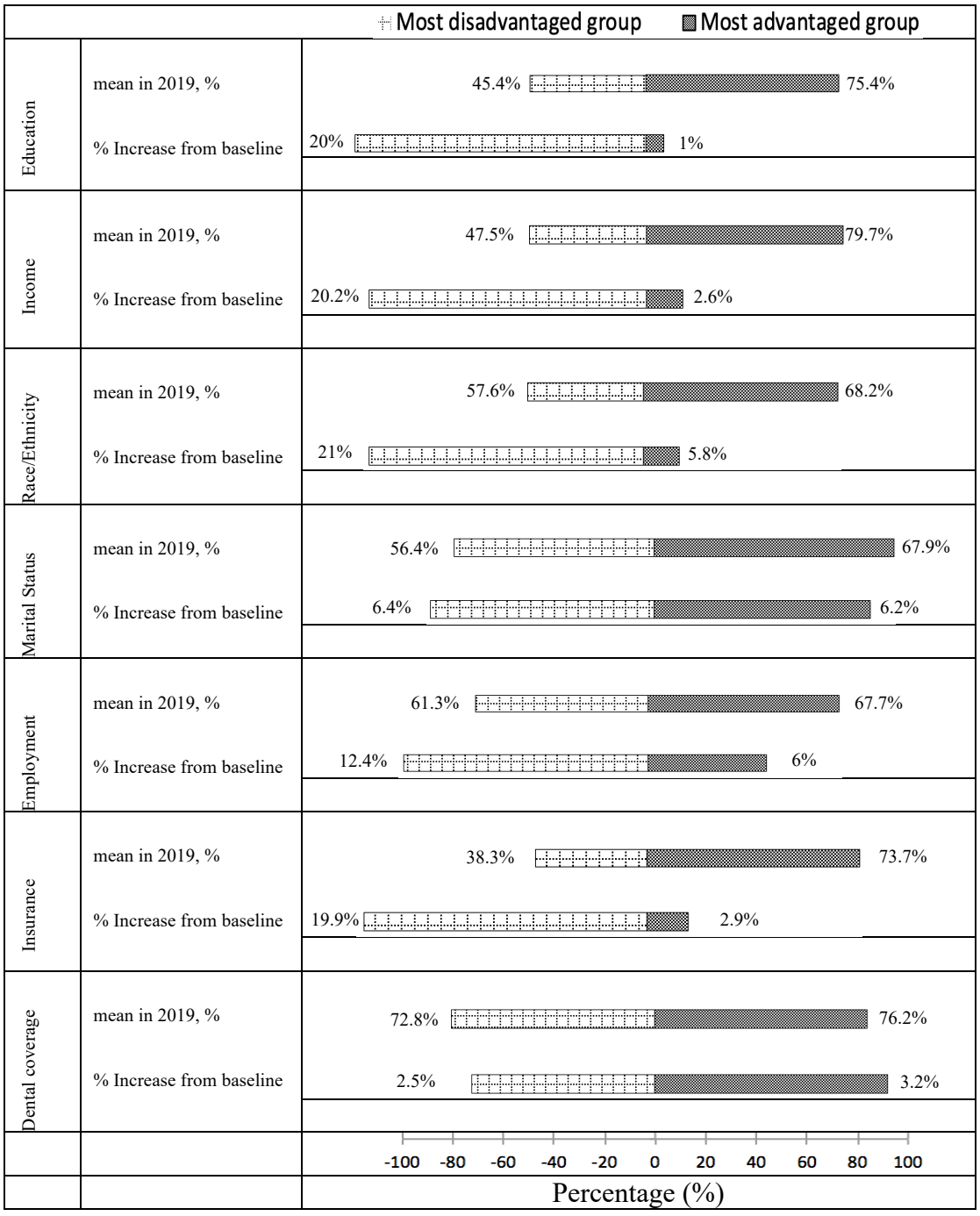

Figure1: The mean and the RPC of dental care utilization in 2019 among the most advantaged and disadvantaged groups. National Health Information Survey, 2010–2019 (RPC: Relative Percentage Change)

Table 7 Estimates and 95% CI of inequality in dental care utilization among adults by sex, employment status, and dental insurance coverage. National Health Information Survey, 2010–2019

	Female		Unemployed		Dental insurance coverage	
Reference	Male		Employed		No coverage	
	RR 95% CI	RD 95%CI	RR 95% CI	RD 95% CI	RR 95% CI	RD 95% CI
2010	1.13	0.07	1.19	0.10	1.05	0.04
	(1.11,1.16)	(.06,.09)	(1.15,1.22)	(.09,.12)	(1.02,1.08)	(.02,.05)
2011	1.11	0.07	1.16	0.09	1.05	0.04
	(1.09,1.14)	(.05,.08)	(1.13,1.19)	(.08,.10)	(1.03,1.07)	(.02,.05)
2012	1.12	0.07	1.16	0.09	1.02	0.01
	(1.09,1.14)	(.05,.08)	(1.13,1.18)	(.07,.10)	1.00,1.04)	(-.002,.03)
2013	1.13	0.07	1.13	0.08	1.04	0.03
	(1.10,1.15)	(.06,.09)	(1.10,1.16)	(.06,.09)	1.02,1.07)	(.01,.05)
2014	1.11	0.06	1.15	0.09	1.00	0.003
	(1.08,1.13)	(.05,.08)	(1.12,1.18)	(.07,.10)	(.98,1.03)	(-.02,.02)
2015	1.09	0.06	1.13	0.08	1.04	0.03
	(1.07,1.12)	(.04,.07)	(1.10,1.16)	(.06,.09)	(1.02,1.07)	(.01,.05)
2016	1.10	0.06	1.13	0.08	1.03	0.02
	(1.08,1.13)	(.05,.08)	(1.10,1.15)	(.06,.09)	(1.00,1.05)	(.003,.04)
2017	1.08	0.05	1.09	0.06	1.00	0.001
	(1.05,1.10)	(.03,.06)	(1.07,1.12)	(.04,.07)	(.97,1.03)	(-.02,.02)
2018	1.12	0.07	1.11	0.07	1.03	0.03
	(1.09,1.14)	(.06,.09)	(1.08,1.14)	(.05,.08)	(1.01,1.06)	(.01,.04)
2019	1.12	0.07	1.10	0.06	1.05	0.03
	(1.10,1.14)	(.06,.09)	(1.08,1.13)	(.05,.08)	(1.03,1.07)	(.02,.05)

95% CI: 95% Confidence Interval
RR: Risk Ratio RD: Risk Difference.

Table 8 Estimates and 95% CI of inequality in dental care utilization among adults by race/ethnicity. National Health Information Survey, 2010–2019

Reference	White Hispanic		White Black		White Asian	
	RR 95% CI	RD 95% CI	RR 95% CI	RD 95% CI	RR 95% CI	RD 95% CI
2010	1.35 (1.29,1.40)	0.17 (.14,.19)	1.24 (1.19,1.30)	0.13 (.10,.15)	1.00 (.95,1.04)	-0.002 (-.03,.03)
2011	1.41 (1.36,1.46)	0.19 (.17,.21)	1.20 (1.16,1.25)	0.11 (.09,.13)	1.02 (.98,1.07)	0.02 (-.01,.05)
2012	1.34 (1.28,1.39)	0.16 (.14,.19)	1.19 (1.14,1.23)	0.10 (.08,.12)	1.05 (1.00,1.09)	0.03 (-.00004,.06)
2013	1.31 (1.26,1.36)	0.16 (.14,17)	1.22 (1.17,1.26)	0.12 (.10,.14)	1.02 (.98,1.07)	0.01 (-.01,.04)
2014	1.32 (1.27,1.37)	0.16 (.14,.18)	1.24 (1.19,1.29)	0.13 (.11,.15)	1.04 (.99,1.09)	0.03 (-.002,.06)
2015	1.26 (1.22,1.31)	0.14 (.12,.16)	1.16 (1.12,1.21)	0.09 (.07,.12)	0.97 (.93,1.02)	-0.02 (-.05,.01)
2016	1.24 (1.19,1.29)	0.13 (.11,.16)	1.19 (1.13,1.24)	0.11 (.08, .13)	1.04 (.99,1.10)	0.03 (-.01,.06)
2017	1.26 (1.20,1.32)	0.14 (.11,.17)	1.16 (1.11,1.21)	0.09 (.07,.12)	1.11 (1.05,1.17)	0.07 (.03,.10)
2018	1.18 (1.13,1.23)	0.11 (.08,.13)	1.12 (1.08,1.17)	0.08 (.05,.10)	1.03 (.98,1.08)	0.02 (-.01,.06)
2019	1.19 (1.14,1.23)	0.11 (.08,.13)	1.15 (1.11,1.19)	0.09 (.07,.11)	0.97 (.93,1.02)	-0.02 (-.05,.01)

95% CI: 95% Confidence Interval
RR: Risk Ratio RD: Risk Difference.

Table 9 Estimates and 95% CI of inequality in dental care utilization among adults by insurance. National Health Information Survey, 2010–2019

Reference	Private Public		Private Other		Private Uninsured	
	RR 95% CI	RD 95% CI	RR 95% CI	RD 95% CI	RR 95% CI	RD 95% CI
2010	1.40 (1.35,1.45)	0.20 (.18,.22)	1.32 (1.23,1.40)	0.17 (.14,.21)	2.24 (2.13,2.35)	0.40 (.38,.41)
2011	1.42 (1.37,1.46)	0.21 (.20,.23)	1.33 (1.26,1.39)	0.18 (.15,.21)	2.30 (2.20,2.41)	0.41 (.40,.43)
2012	1.39 (1.35,1.44)	0.21 (.19,.22)	1.28 (1.20,1.36)	0.16 (.13,.19)	2.30 (2.18,2.42)	0.41 (.39,.43)
2013	1.40 (1.345,1.44)	0.21 (.19,.22)	1.30 (1.24,1.36)	0.17 (.14,.20)	2.24 (2.13, 2.35)	0.40 (.38, .42)
2014	1.37 (1.32,1.41)	0.19 (.17,.21)	1.19 (1.13,1.26)	0.12 (.08, .15)	2.24 (2.12,2.37)	0.40 (.38, .42)
2015	1.36 (1.31,1.40)	0.19 (.17,.21)	1.29 (1.22,1.36)	0.16 (.13,.20)	2.12 (1.99,2.26)	0.38 (.36,.41)
2016	1.33 (1.29,1.37)	0.18 (.16,.20)	1.27 (1.20,1.34)	0.15 (.12,.19)	2.10 (1.94,2.25)	0.38 (.35,.41)
2017	1.28 (1.24,1.32)	0.16 (.14,.18)	1.27 (1.19,1.34)	0.15 (.12,.19)	2.14 (1.98,2.30)	0.39 (.36,.41)
2018	1.29 (1.25,1.32)	0.16 (.15,.18)	1.25 (1.19,1.31)	0.15 (.12,.18)	1.97 (1.83,2.12)	0.36 (.34,.39)
2019	1.28 (1.24,1.31)	0.16 (.14,.18)	1.29 (1.22,1.36)	0.17 (.14,.20)	1.92 (1.81,2.04)	0.35 (.33,.38)

95% CI: 95% Confidence Interval
RR: Risk Ratio RD: Risk Difference.

Table 10 Slope and relative indices of inequality in dental care utilization among adults by age, education, and annual family income groups. National Health Information Survey, 2010–2019

	Age		Education		Annual family income	
	SII 95% CI	RII 95% CI	SII 95% CI	RII 95% CI	SII 95% CI	RII 95% CI
2010	0.04 (.016,.07)	1.07 (1.03,1.12)	0.45 (.43,.47)	2.23 (2.1,2.33)	0.52 (.50,.54)	2.60 (2.47,2.74)
2011	0.05 (.022,.07)	1.08 (1.03,1.12)	0.42 (.40,.44)	2.07 (1.99,2.16)	0.54 (.52,.56)	2.69 (2.56,2.81)
2012	0.05 (.02,.07)	1.08 (1.04,1.13)	0.44 (.42,.46)	2.17 (2.08,2.27)	0.53 (.51,.55)	2.65 (2.53,2.78)
2013	0.03 (.01,.06)	0.05 (1.01,1.10)	0.43 (.41,.46)	2.14 (2.05,2.23)	0.52 (.50,.54)	2.60 (2.5,2.72)
2014	0.04 (.02,.07)	1.07 (1.02,1.16)	0.44 (.42,.46)	2.14 (2.04,2.24)	0.51 (.49,.53)	2.50 (2.38,2.62)
2015	0.02 (-.01,.04)	1.03 (.98,1.07)	0.41 (.39,.43)	2.00 (1.91,2.09)	0.50 (.48,.52)	2.39 (2.28,2.50)
2016	0.02 (-.003,.05)	1.03 (.99,1.08)	0.41 (.39,.44)	1.99 (1.90,2.08)	0.49 (.46,.51)	2.31 (2.20,2.42)
2017	0.04 (.02,.07)	1.07 (1.02,1.11)	0.38 (.36,.41)	1.87 (1.79,1.96)	0.46 (.44,.49)	2.20 (2.09,2.31)
2018	0.02 (-.004,.05)	1.03 (.99,1.08)	0.36 (.34,.39)	1.78 (1.70,1.86)	0.45 (.43,.48)	2.12 (2.02,2.22)
2019	-0.01 (-.04,.01)	0.98 (.95,1.02)	0.36 (.34,.39)	1.80 (1.72,1.87)	0.45 (.43,.47)	2.10 (2.01,2.19)

95% CI: 95% Confidence Interval RII: Relative Index of Inequality
SII: Slope Index of Inequality

Table 11 Estimates and 95% CI of inequality in dental care utilization among adults by marital status. National Health Information Survey, 2010–2019

Reference	Married Never married		Married Wid/sep/div	
	RR 95% CI	RD 95% CI	RR 95% CI	RD 95% CI
2010	1.13 (1.09,1.16)	0.07 (.05,.09)	1.17 (1.13,1.20)	0.09 (.07,.11)
2011	1.10 (1.07,1.13)	0.06 (.04,.08)	1.18 (1.15,1.21)	0.10 (.08,.11)
2012	1.09 (1.06,1.12)	0.05 (.03,.07)	1.15 (1.19,1.18)	0.08 (.07,.10)
2013	1.09 (1.06,1.13)	0.05 (.03,.07)	1.18 (1.14,1.21)	0.10 (.08,.11)
2014	1.09 (1.06,1.13)	0.06 (.03,.08)	1.18 (1.15,1.21)	0.10 (.08,.11)
2015	1.08 (1.05,1.11)	0.05 (.03,.07)	1.17 (1.13,1.20)	0.09 (.08,.11)
2016	1.06 (1.03,1.09)	0.04 (.02,.06)	1.16 (1.12,1.19)	0.09 (.07,.11)
2017	1.08 (1.05,1.11)	0.05 (.03,.07)	1.19 (1.15,1.23)	0.10 (.09,.12)
2018	1.08 (1.05,1.11)	0.05 (.03,.07)	1.15 (1.11,1.18)	0.09 (.07,.10)
2019	1.04 (1.02,1.07)	0.03 (.01,.05)	1.19 (1.15,1.22)	0.11 (.09,.12)

95% CI: 95% Confidence Interval
RR: Risk Ratio RD: Risk Difference.
Wid/sep/div: Widowed/separated/divorced

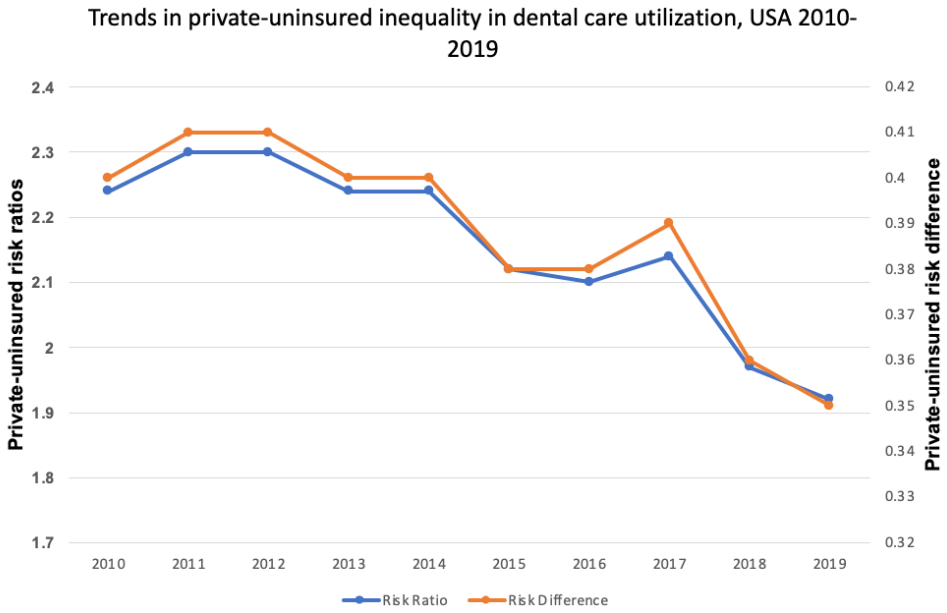

Figure 2: Trends in private-uninsured inequality in dental care utilization, USA 2010-2019

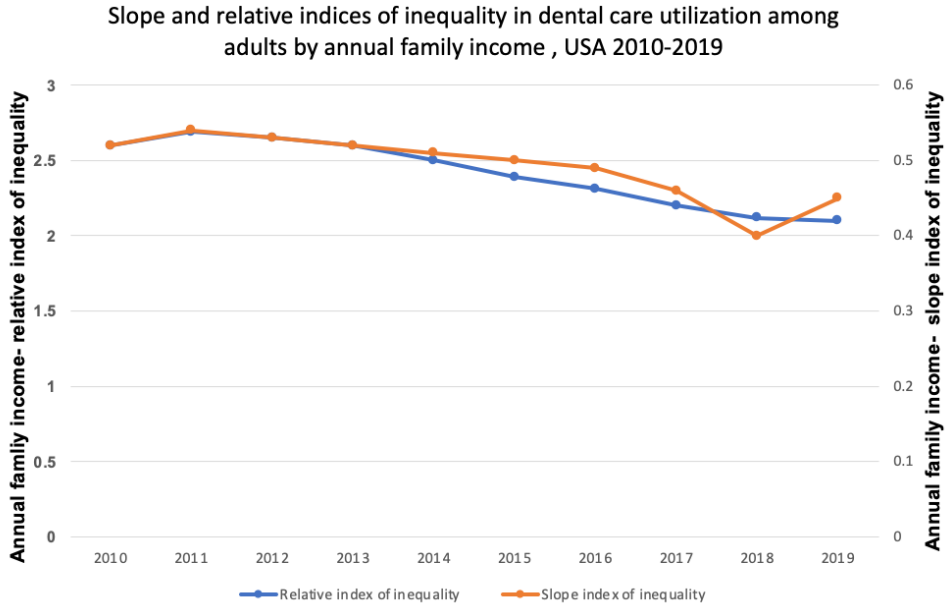

Figure 3: Slop and relative indices of inequality in dental care utilization by annual family income, USA 2010-2019

Aim1b: Adults who cannot afford dental treatment adults.

Table 12: Socio-Demographic characteristics of adult respondents who cannot afford dental treatment. National Health Information Survey 2010 and 2019

		2010		2019	
	Category	n	Weighted %	n	Weighted %
Sex	Male	1,704	42.97	2,129	43.18
	Female	2,734	57.03	3,066	56.82
Age	18-24	482	14.44	270	8.08
	25-44	1,823	41.04	1,753	37.73
	45-64	1,686	37.04	2,027	38.01
	65+	447	7.48	1,146	16.18
Race/Ethnicity	Hispanic	1,113	18.95	1,035	25.1
	White (non-Hispanic)	2,214	62.3	3,089	53.77
	Black (non-Hispanic)	908	15.24	742	14.57
	Asian (non-Hispanic)	161	2.49	179	3.97
	Other	42	1.02	151	2.59
Education	<High school diploma high	987	19.68	796	20.25
	High school diploma	1,241	29.53	1,613	31.95
	Some college	991	23.42	952	18.19
	≥college degree	1,203	27.38	1,799	29.61
Poverty Level	Less than 100%	1,279	23.15	1,088	19.35
	100- 199%	1,212	27.16	1,570	30.77
	200%- 399%	1,087	26.61	1,629	32.61
	More than 400%	497	13.86	909	17.28
	Unspecified	363	9.23	-	-
Marital status	Never married	1,199	25.5	1,013	20.55
	Widowed /Divorced/ Separated	1,321	21.6	1,597	21.07
	Married	1,906	52.9	2,422	58.38
Employment status	Yes	2,317	54.79	2,881	61.86
	No	2,117	45.21	2,167	38.14
Dental coverage	Yes	406	30.12	667	32.83
	No	914	69.88	1,434	67.17
Insurance Type	Private	1,379	34.46	2,187	42.54
	Public	885	16.41	1,473	25.41
	Other	283	5.81	415	06.54
	Uninsured	1,879	43.32	1,111	25.51

Table 13 Multivariable logistic regression of socio-economic indicators and dental care utilization during the past year among US adults who cannot afford dental treatment. National Health Information Survey, 2010–2019

Characteristics	OR* of dental care utilization	95% CI**	P-value
Sex (Referent group: Female)			
Male	0.86	0.81- 0.91	<0.001
Age (Referent group: 18-24)			
25-44	0.77	0.69-0.87	<0.001
45-64	0.75	0.66-0.84	<0.001
65+	0.74	0.65-0.85	<0.001
Race/ethnicity (Referent group: White)			
Hispanic	1.13	1.04- 1.22	0.003
Black	1.08	1.00- 1.17	0.042
Asian	1.28	1.11- 1.48	0.001
Other	0.97	0.75- 1.24	0.792
Poverty level (Referent group: Less than 100%)			
100- 199%	1.07	0.99- 1.16	0.094
200%- 399%	1.36	1.25-1.49	<0.001
More than 400%	2.25	2.02-2.51	<0.001
Unspecified	1.34	1.17-1.52	<0.001
Education (Referent group: ≥college degree)			
<High school diploma	0.59	0.54-0.65	<0.001
High school diploma	0.67	0.62-0.72	<0.001
Some college	0.82	0.76-0.89	<0.001
Insurance (Referent group: Private)			
Public	0.87	0.80-0.95	0.002
Other	0.73	0.65-0.81	<0.001
Uninsured	0.41	0.38-0.44	<0.001
Marital status (Referent group: Married)			

Never married	0.91	0.84-0.98	0.012
Widowed /divorced/ separated	0.87	0.81-0.93	<0.001
Employment (Referent group: Employed)			
Not employed	0.92	0.87-0.98	0.015

*OR = Odd ratio

*95%CI= 95% Confidence interval

Table 14 Mean dental care utilization and 95% CI among adults who cannot afford dental treatment by education and annual family income groups. National Health Information Survey, 2010–2019 (RPC: Relative Percentage Change)

	Education				Annual family income				
	<High School diploma	High School diploma	Some College	≥College degree	< 100%	100- 199%	200%- 399%	> 400%	unspecified
2010	25.93 (22.09-29.77)	31.39 (28.19-34.59)	34.66 (31.04-38.27)	47.33 (43.81-50.85)	28.52 (25.21-31.82)	28.28 (25.08-31.47)	36.90 (33.76-40.05)	54.48 (49.19-59.77)	40.43 (33.21-47.65)
2011	25.6 (22.24-29.01)	31.37 (22.24-29.06)	38.08 (34.95-41.22)	42.22 (39.02-45.42)	23.75 (21.22-26.30)	28.68 (26.04-31.33)	40.30 (37.14-43.46)	55.84 (50.20-61.48)	36.85 (50.20-61.48)
2012	25.81 (22.41-29.21)	32.23 (28.48-35.98)	37.23 (33.53-40.93)	47.39 (44.12-50.66)	27.08 (24.38-29.78)	31.76 (28.41-35.11)	41.76 (37.65-45.87)	54.95 (49.82-60.07)	34.53 (27.37-41.70)
2013	26.61 (22.94)-30.28)	29.78 (26.47-33.09)	37.55 (33.69-41.41)	45.02 (41.66-48.38)	28.53 (25.64-31.42)	30.06 (26.67-33.45)	37.35 (33.94-40.77)	58.46 (51.30-65.62)	33.74 (27.38-40.10)
2014	25.93 (22.09-29.77)	31.39 (22.09-29.77)	34.66 (31.04-38.27)	47.33 (43.81-50.85)	28.52 (25.21-31.82)	28.28 (25.09-31.47)	36.90 (33.76-40.05)	54.48 (49.19-59.77)	40.43 (33.21-47.65)
2015	28.30 (23.58-33.02)	35.49 (31.27-39.71)	41.45 (36.82-46.08)	49.17 (45.36-52.98)	31.28 (27.17-35.38)	35.41 (31.80-39.03)	43.88 (39.78-47.99)	56.67 (49.89-63.46)	36.99 (26.58-47.41)
2016	28.28 (22.53-34.03)	32.23 (27.99-36.47)	43.13 (38.43-47.82)	54.26 (49.90-58.62)	30.89 (26.32-35.45)	32.11 (27.93-36.30)	43.68 (39.17-48.20	63.42 (57.47-69.38)	46.85 (36.44-57.25)
2017	26.97 (21.79-32.15)	36.74 (32.47-41.01)	39.19 (34.30-44.08)	51.19 (47.30-55.08)	29.58 (25.06-34.11)	31.75 (28.02-35.48)	44.95 (40.40-49.49)	57.52 (51.23-63.82)	43.29 (32.47-54.11)
2018	35.00 (29.80-40.20)	36.52 (32.50-40.54)	44.67 (39.76-49.57)	55.84 (52.20-59.49)	36.38 (31.22-41.55)	38.22 (33.99-42.46)	44.04 (39.79-48.29)	61.83 (56.85-66.81)	44.37 (34.51-54.23)
2019	33.34 (29.02-37.67)	37.92 (35.09-40.77)	48.19 (44.36-52.02)	52.37 (49.56-55.19)	33.26 (29.45-37.08)	35.63 (32.30-38.96)	45.76 (42.79-48.72)	62.40 (58.71-66.10)	-
RPC	**28.58**	**20.8**	**39.04**	**10.65**	**16.62**	**25.99**	**24.01**	14.54	9.75
Trend	↑	↑	↑	↑	↑	↑	↑	↑	-
P-Trend	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.009**	0.178

Table 15 Mean dental care utilization and 95% CI among adults who cannot afford dental treatment, by race/ethnicity, marital status, and sex. National Health Information Survey, 2010–2019 (RPC: Relative Percentage Change)

	Race/ethnicity				Marital status			Sex	
	Hispanic	White	Black	Asian	Never married	Widowed/divorced/separated	Married	Male	Female
2010	32.18 (28.80-35.57)	38.01 (35.60-40.43)	29.85 (26.20-33.50)	35.71 (27.24-44.17)	33.87 (30.43-37.32)	33.22 (30.17-36.26)	36.97 (34.26-39.67)	33.29 (30.66-35.93)	36.96 (34.61-39.32)
2011	25.90 (23.18-28.62)	36.49 (34.36-38.63)	35.34 (31.64-39.04)	46.95 (38-55.90)	33.83 (30.54-37.11)	32.13 (29.33-34.92)	36.10 (33.94-38.26)	31.81 (29.27-34.36)	36.84 (34.83-38.85)
2012	33.01 (29.41-36.63)	37.59 (35.02-40.17)	34.27 (29.75-38.80)	40.60 (31.29-49.92)	30.18 (26.66-33.70)	37.16 (33.84-40.48)	38.60 (35.94-41.27)	33.39 (30.43-36.36)	38.22 (35.82-40.61)
2013	32.60 (29.14-36.07)	36.98 (34.48-39.48)	31.12 (27.12-35.12)	40.96 (32.14-49.79)	32.06 (28.55-35.57)	32.81 (29.88-35.75)	37.83 (35.16-40.51)	33.79 (31.19-36.40)	36.29 (34.09-38.48)
2014	32.18 (28.80-35.57)	38.01 (28.80-35.57)	29.85 (28.80-35.57)	35.71 (27.24-44.17)	33.87 (30.43-37.32)	33.22 (30.17-36.26)	36.97 (34.26-39.67)	33.29 (30.66-35.93)	36.96 (34.61-39.32)
2015	34.74 (30.48-39)	40.57 (37.62-43.51)	40.36 (34.55-46.18)	51.37 (39.05-63.69)	40.85 (36.58-45.13)	36.12 (32.45-40)	40.67 (37.61-43.72)	35.24 (31.92-38.56)	42.70 (40-45.41)
2016	39.98 (33.80-46.15)	41.80 (39.24-44.36)	36.24 (30.54-41.94)	49.20 (36.43-61.97)	43.18 (37.71-48.65)	37.84 (33.90-41.78)	41.28 (38.02-44.53)	37.52 (33.82-41.22)	43.18 (40.26-46.10)
2017	35.21 (29.26-41.16)	41.38 (38.54-44.23)	44.43 (37.81-51.05)	46.21 (34.25-58.18)	39.90 (34.67-45.13)	32.45 (28.36-36.55)	44.46 (41-47.93)	40.47 (36.66-44.28)	40.53 (37.45-43.61)
2018	39.01 (33.25-44.76)	45.47 (42.58-48.36)	47.87 (42.33-53.42)	52.36 (39.68-65.03)	40.69 (35.75-45.64)	42.50 (38.74-46.26)	47.36 (44.06-50.66)	41.14 (37.68-44.60)	46.97 (44.08-49.92)
2019	41.28 (37.54-45.02)	43.81 (41.60-46.03)	39.49 (34.89-44.09)	58.27 (49.58-66.97)	40.54 (36.37-44.71)	38.36 (35.43-41.29)	45.80 (43.36-48.24)	38.48 (35.86-41.19)	46.64 (44.26-49.02)
RPC	**28.28**	**15.26**	**32.29**	**63.18**	**19.69**	**15.47**	**23.88**	**37.58**	**26.19**
Trend	↑	↑	↑	↑	↑	↑	↑	↑	↑
P-Trend	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**

Table 16 Mean dental care utilization and 95% CI among adults who cannot afford dental treatment, by race/ethnicity, health insurance status, dental insurance coverage status, and employment status. National Health Information Survey, 2010–2019 (RPC: Relative Percentage Change)

	Health insurance status				Dental insurance coverage status		Employment status	
	Private	Public	Other	Uninsured	Covered	Not covered	Employed	Not employed
2010	50.54 (47.14-53.94)	37.41 (33.47-41.35)	35.29 (28.54-42.04)	22.10 (19.85-24.35)	53.13 (47-59.23)	49.37 (44.98-53.76)	38.18 (35.52-40.83)	31.95 (29.49-34.41)
2011	50.43 (47.20-53.66)	31.42 (28.03-34.81)	33.21 (28.03-34.81)	24.14 (21.97-26.30)	59.10 (53.57-64.63)	47.54 (43.50-51.60)	36.89 (34.66-39.12)	32.33 (30.14-34.53)
2012	50.44 (47.45-53.43)	38.38 (34.38-42.38)	37.11 (29.82-44.39)	23.92 (21.36-26.49)	55.71 (50.08-61.33)	48.76 (44.88-52.65)	39.27 (36.78-41.77)	32.78 (30.12-35.44)
2013	50.47 (47.16-53.79)	35.95 (32.06-39.85)	38.15 (31.26-45.04)	23.09 (20.66-25.52)	57.67 (51.76-63.58)	46.80 (42.83-50.7)	37.92 (35.53-40.31)	32.33 (30.01-34.67)
2014	50.54 (47.14-53.94)	37.41 (33.47-41.35)	35.29 (28.54-42.04)	22.10 (19.85-24.35)	53.12 (47.00-59.26)	49.37 44.98-53.76)	38.1 (35.52-40.83)	31.95 (29.49-34.41)
2015	51.60 (48.24-54.96)	37.79 (33.79-41.80)	37.51 (30.79-44.23)	24.73 (20.96-28.50)	65.99 (59.37-72.62)	47.69 (43.31-52.08)	43.74 (40.79-46.70)	35.30 (32.24-38.36)
2016	50.91 (47.22-54.59)	40.25 (36.24-44.27)	30.39 (23.22-37.57)	28.53 (23.67-33.39)	55.54% (48.27-62.82)	49.62 (45.35-53.89)	45.02 (41.79-48.26)	35.95 (32.82-39.08)
2017	53.39 (49.76-57.02)	40.62 (36.17-45.08)	34.12 (26.54-41.71)	22.45 (18.42-26.48)	60.58 (53.48-67.69)	49.80 (45.26-54.34)	43.38 (40.23-46.54)	37.02 (33.31-40.74)
2018	55.86 (52.31-59.42)	42.13 (37.61-46.65)	40.62 (31.75-49.49)	29.41 (24.88-33.94)	65.79 (59.24-72.33)	54.23 (49.86-58.60)	46.91 (43.70-50.12)	41.33 (38-44.66)
2019	54.83 (52.20-57.47)	42.82 (39.30-46.34)	32.54 (27.07-38.02)	26.40 (23.35-29.45)	60.66 (56.21-65.12)	52.79 (49.50-56.08)	46.09 (43.78-48.40)	38.53 (35.85-41.22)
RPC	**8.49**	**14.46**	**-7.79**	**19.46**	**14.17**	**6.93**	**20.72**	20.59
Trend	↑	↑	-	↑	↑	↑	↑	↑
P-Trend	**<0.001**	**<0.001**	**0.845**	**0.003**	**0.011**	**0.008**	**<0.001**	**<0.001**

Table 17 Mean dental care utilization and 95% CI among adults who cannot afford dental treatment age, National Health Information Survey, 2010–2019 (RPC: Relative Percentage Change)

	Age			
	18-24	25-44	45-64	65 +
2010	34.20 (28.81-40.60)	34.13 (31.48-36.78)	36.86 (33.88-39.84)	37.36 (31.57-43.16)
2011	37.07 (31.93-42.20)	33.12 (30.69-35.54)	35.77 (33.1-38.38)	34.26 (29.32-39.20)
2012	31.12 (25.25-37)	34.79% (32.28-37.30)	38.01% (34.78-41.25)	43.87% (38.77-48.97)
2013	35.19 (28.86-41.52)	33.51 (30.89-36.13)	37.17 (34.40-39.93)	35.00 (30.12-39.88)
2014	34.20 (28.81-39.60)	34.13 (31.48-36.78)	36.86 (33.88-39.84)	37.36 (31.57-43.16)
2015	48.98 (40.79-57.17)	39.68 (36,33-43.03)	37.89 (34.74-41.03)	36.96 (31.56-42.37)
2016	49.42 (39.73-59.11)	41.42 (37.26-45.59)	39.58 (36.00-43.17)	37.91 (32.68-43.15)
2017	42.54 (32.80-52.29)	40.24 (36.65-43.83)	39.97 (36.51-43.44)	41.44 (36.17-46.71)
2018	45.70 (36.89-54.51)	42.34 (38.61-46.07)	44.44 (40.73-48.16)	49.39 (44.52-54.26)
2019	43.59 (36.32-50.86)	43.77 (40.91-46.63)	42.81 (40.01-45.61)	42.02 (38.33-45.70)
RPC	**27.46**	**28.24**	**16.14**	**12.47**
Trend	↑	↑	↑	↑
P-Trend	**<0.001**	**<0.001**	**<0.001**	**.002**

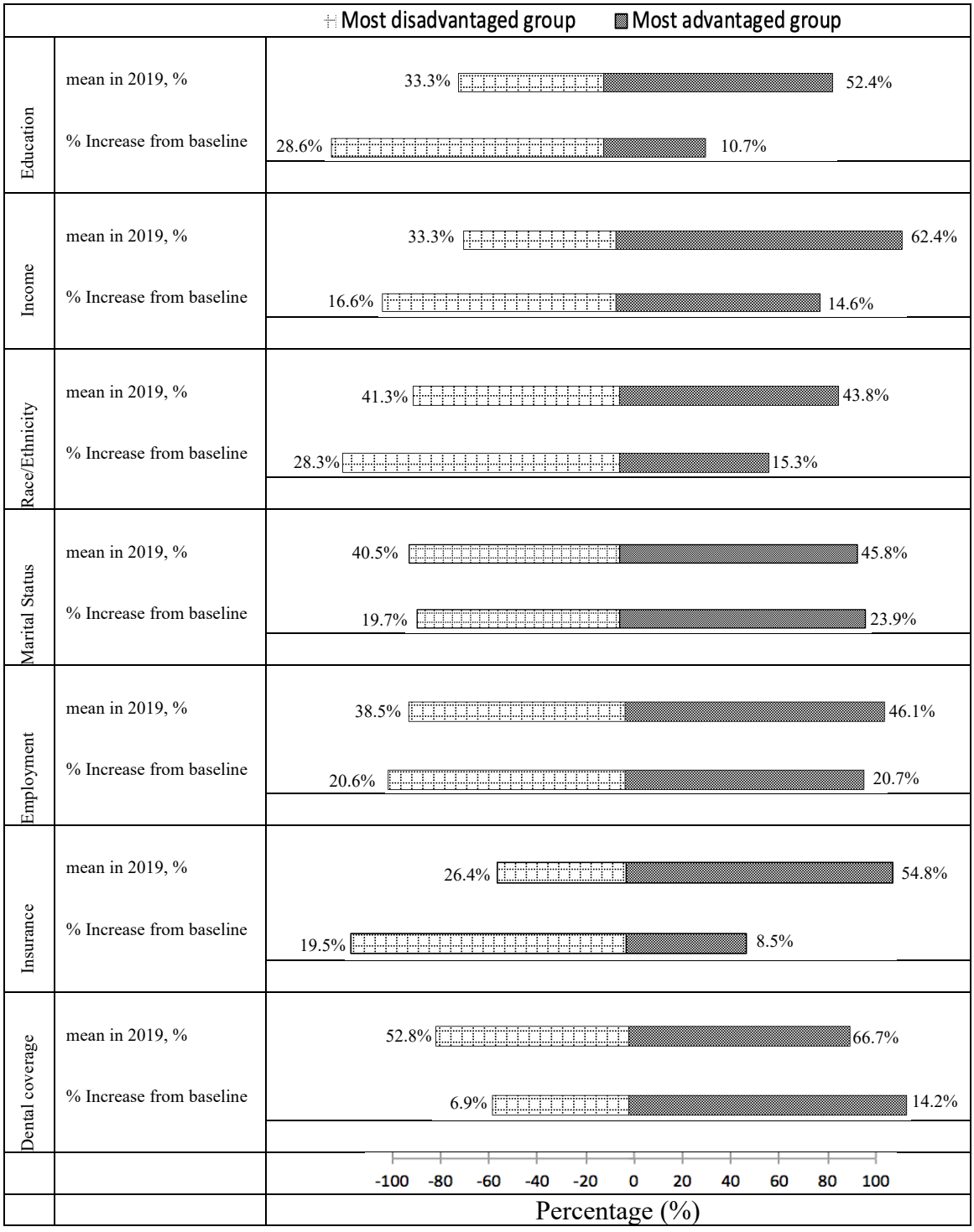

Figure 4: The RPC and the mean of dental care utilization in 2019 among the most advantaged and disadvantaged groups of people who cannot afford dental treatment by different socio-economic indicators. National Health Information Survey, 2010–2019 (RPC: Relative Percentage Change)

Table 18 Estimates and 95% CI of inequality in dental care utilization among adults by sex, employment status, and dental insurance coverage. National Health Information Survey, 2010–2019

Reference	Female Male		Unemployed Employed		Dental insurance coverage No coverage	
	RR 95% CI	RD 95% CI	RR 95% CI	RD 95% CI	RR 95% CI	RD 95% CI
2010	1.11	0.04	1.19	0.06	1.08	0.04
	(1.00,1.22)	(.002,.07)	(1.07,1.32)	(.03,.10)	(.91,1.24)	(-.04,.12)
2011	1.16	0.05	1.14	0.05	1.24	0.12
	(1.05,1.27)	(.02 ,.08)	(1.04,1.24)	(.01,.08)	(1.09,1.40)	(.05,.18)
2012	1.14	0.05	1.20	0.06	1.14	0.07
	(1.03,1.26)	(.01,.08)	(1.08,1.31)	(.03,.10)	(.99,1.29)	(-.001,.14)
2013	1.07	0.02	1.17	0.06	1.23	0.11
	(.98,1.17)	(-.01,.06)	(1.07,1.28)	(.02,.09)	(1.07,1.40)	(.04,.18)
2014	1.14	0.05	1.16	0.06	1.10	0.05
	(1.02,1.27)	(.010,.09)	(1.04,1.29)	(.02,.10)	(.93,1.28)	(-.03,.13)
2015	1.21	0.07	1.24	0.08	1.38	0.18
	(1.08,1.35)	(.03,.12)	(1.10,1.38)	(.04,.13)	(1.18,1.58)	(.10,.27)
2016	1.15	0.06	1.25	0.09	1.12	0.06
	(1.01,1.29)	(.01,.10)	(1.11,1.39)	(.05,.14)	(.95,1.29)	(-.02,14)
2017	1.00	0.001	1.17	0.06	1.22	0.11
	(.89 ,1.12)	(-.05,.05)	(1.03,1.31)	(.02,.11)	(1.03,1.40)	(.02,.19)
2018	1.14	0.06	1.14	0.06	1.21	0.12
	(1.03,1.26)	(.01,.10)	(1.01,1.26)	(.01,.10)	(1.06,1.37)	(.04,.20)
2019	1.21	0.08	1.20	0.08	1.15	0.08
	(1.11,1.31)	(.05,.12)	(1.10,1.29)	(.04,.11)	(1.04,1.26)	(.02,.13)

95% CI: 95% Confidence Interval
RR: Risk Ratio RD: Risk Difference.

Table 19 Estimates and 95% CI of inequality in dental care utilization among adults by race/ethnicity. National Health Information Survey, 2010–2019

Reference	White Hispanic		White Black		White Asian	
	RR 95% CI	RD 95% CI	RR 95% CI	RD 95% CI	RR 95% CI	RD 95% CI
2010	1.18 (1.04,1.32)	0.06 (.02,.10)	1.27 (1.10,1.44)	0.08 (.04,.12)	1.06 (.80,1.33)	0.02 (-.07,.11)
2011	1.41 (1.24,1.58)	0.11 (.07,.14)	1.03 (.91,1.15)	0.01 (-.03,.05)	0.78 (.62,.93)	-0.10 (-0.20,-0.01)
2012	1.14 (.99,1.28)	0.05 (.002,.09)	1.10 (.93,1.26)	0.03 (-.02,.09)	0.93 (.70,1.15)	-0.03 (-.13,07)
2013	1.13 (.99,1.28)	0.04 (.0003,.09)	1.19 (1.02,1.36)	0.06 (.01,.11)	0.90 (.70,1.10)	-0.04 (-.13,.05)
2014	1.23 (1.07,1.40)	0.08 (.02,.12)	1.06 (.91,1.22)	0.02 (-.03,.08)	1.06 (.75,1.37)	0.02 (-.09,.13)
2015	1.17 (1.00,1.34)	0.06 (.01,.11)	1.01 (.83,1.17)	0.002 (-.06,.07)	0.79 (.59,.99)	-0.11 (-.24,.02)
2016	1.05 (.87,1.22)	0.02 (-.05,.08)	1.15 (.96,1.35)	0.06 (-.01,.12)	0.85 (.63,1.07)	-0.07 (-.20,.06)
2017	1.18 (.96,1.39)	0.06 (-.005,.13)	0.93 (.78,1.08)	-0.03 (-.10,.04)	0.90 (.67,1.13)	-0.05 (-.17,.07)
2018	1.17 (.98,1.35)	0.06 (.001,.13)	0.95 (.82,1.08)	-0.02 (-.09,.04)	0.87 (.65,1.08)	-0.07 (-.20,.06)
2019	1.06 (.96,1.17)	0.03 (-.02,.07)	1.11 (.97,1.25)	0.04 (-.01,.09)	0.75 (.63,.87)	-0.14 (-.23,-.05)

95% CI: 95% Confidence Interval
RR: Risk Ratio RD: Risk Difference.

Table 20 Estimates and 95% CI of inequality in dental care utilization among adults by insurance. National Health Information Survey, 2010–2019

Reference	Private Public		Private Other		Private Uninsured	
	RR 95% CI	RD 95% CI	RR 95% CI	RD 95% CI	RR 95% CI	RD 95% CI
2010	1.35 (1.19,1.52)	0.13 (.08,.18)	1.43 (1.14,1.73)	0.15 (.07,.23)	2.29 (2.01,2.56)	0.28 (.24,32)
2011	1.61 (1.40,1.81)	0.19 (.14,.24)	1.52 (1.26,1.78)	0.17 (.11,.23)	2.09 (1.85,2.32)	0.26 (.22,.30)
2012	1.31 (1.16,1.47)	0.12 (.07,.17)	1.36 (1.09,1.63)	0.13 (.06,.21)	2.11 (1.86,2.36)	0.27 (.23,.30)
2013	1.40 (1.24,1.57)	0.15 (.10,.19)	1.32 (1.06,1.58)	0.12 (.04,.20)	2.19 (1.91,2.46)	0.27 (.23,.32)
2014	1.23 (1.08,1.38)	0.09 (.04,.14)	1.24 (.99,1.48)	0.09 (.01,.17)	1.94 (1.63,2.25)	0.24 (.18,.29)
2015	1.37 (1.20,1.53)	0.14 (.09,.19)	1.38 (1.11,1.64)	0.14 (.06,.22)	2.09 (1.74,2.43)	0.27 (.22,.32)
2016	1.26 (1.11,1.42)	0.11 (.05,.16)	1.68 (1.26,2.09)	0.21 (.12,.29)	1.78 (1.46,2.10)	0.22 (.17,.28)
2017	1.31 (1.15,1.48)	0.13 (.07,.18)	1.56 (1.21,1.92)	0.19 (.11,.27)	2.38 (1.92,2.84)	0.31 (.25,.36)
2018	1.33 (1.16,1.49)	0.14 (.08,.19)	1.38 (1.07,1.69)	0.15 (.06,.25)	1.90 (1.58,2.22)	0.26 (.21,.32)
2019	1.28 (1.16,1.40)	0.12 (.08,.16)	1.68 (1.39,1.98)	0.22 (.16,.28)	2.08 (1.82,2.34)	0.28 (.24,.32)

95% CI: 95% Confidence Interval
RR: Risk Ratio RD: Risk Difference.

Table 21 Slope and relative indices of inequality in dental care utilization among adults by age, education, and annual family income groups. National Health Information Survey, 2010–2019

	Age		Education		Annual family income	
	SII 95% CI	RII 95% CI	SII 95% CI	RII 95% CI	SII 95% CI	RII 95% CI
2010	0.05 (-.02,.12)	1.15 (.93,1.36)	0.27 (.21,.33)	2.17 (1.77,2.57)	0.28 (.22,.34)	2.28 (1.83,2.72)
2011	0.01 (-.05,.07)	1.03 (.85,1.21)	0.22 (.16,.27)	1.90 (1.58 ,2.22)	0.36 (.30,.42)	3.01 (2.46,3.55)
2012	0.11 (.05,.18)	1.37 (1.11,1.63)	0.27 (.22,.33)	2.17 (1.79,2.55)	0.31 (.25,.38)	2.44 (1.99,2.90)
2013	0.04 (-.03,.11)	1.12 (.90,1.33)	0.25 (.19,.32)	2.09 (1.70,2.48)	0.29 (.22,.35)	2.32 (1.86,2.78)
2014	0.04 (-.12,.03)	0.89 (.71,1.07)	0.29 (.22,.36)	2.20 (1.78,2.63)	0.34 (.27,.41)	2.55 (2.03,3.08)
2015	-0.10 (-.18,-.02)	0.78 (.62,.94)	0.27 (.20,.34)	2.00 (1.61,2.39)	0.27 (.20,.35)	2.03 (1.62,2.45)
2016	-0.08 (-.17,.003)	0.81 (.64,.99)	0.36 (.28,.44)	2.52 (1.95,3.09)	0.37 (.29,.45)	2.63 (2.03,3.22)
2017	-0.005 (-.09,.08)	0.99 (.78,1.20)	0.30 (.22,.37)	2.14 (1.69,2.58)	0.36 (.28,.44)	2.56 (1.99,3.13)
2018	0.06 (-.03,.14)	1.14 (.92,1.36)	0.30 (.23,.38)	2.02 (1.63,2.40)	0.29 (.21,.37)	1.96 (1.58,2.34)
2019	-0.02 (-.08,.04)	0.95 (.81,1.08)	0.27 (.21,.33)	1.89 (1.60,2.17)	0.34 (.28,.39)	2.26 (1.92,2.60)

95% CI: 95% Confidence Interval RII: Relative Index of Inequality
SII: Slope Index of Inequality

Table 22 Estimates and 95% CI of inequality in dental care utilization among adults by marital status. National Health Information Survey, 2010–2019

Reference	Married Never married		Married Wid/sep/div	
	RR 95% CI	RD 95% CI	RR 95% CI	RD 95% CI
2010	1.09 (.96,1.22)	0.03 (-.01,.07)	1.08 (.96,1.20)	0.03 (-.01,.07)
2011	1.07 (.94,1.19)	0.02 (-.02,.06)	1.10 (1.00,1.21)	0.03 (.001,.06)
2012	1.28 (1.11,1.45)	0.08 (.04,.13)	0.97 (.87,1.07)	-0.01 (-.05,.03)
2013	1.18 (1.03,1.33)	0.06 (.01,.10)	1.10 (.98,1.21)	0.03 (-.01,.07)
2014	1.10 (.96,1.23)	0.04 (-.01,.08)	1.23 (1.09,1.37)	0.08 (.04,.11)
2015	1.00 (.87,1.12)	-0.002 (-.05,.05)	1.13 (.99,1.26)	0.05 (.001,.09)
2016	0.96 (.82,1.10)	-0.02 (-.08,.04)	1.10 (.96,1.25)	0.04 (-.01,.09)
2017	1.11 (.94,1.29)	0.05 (-.02,.11)	1.33 (1.15,1.51)	0.11 (.06,.15)
2018	1.16 (1.00,1.32)	0.07 (.01,.13)	1.06 (.95,1.18)	0.03 (-.02,.07)
2019	1.13 (1.00,1.26)	0.05 (.01,.10)	1.16 (1.06,1.26)	0.06 (.03,.10)

95% CI: 95% Confidence Interval
RR: Risk Ratio RD: Risk Difference.
Wid/sep/div: Widowed/separated/divorced

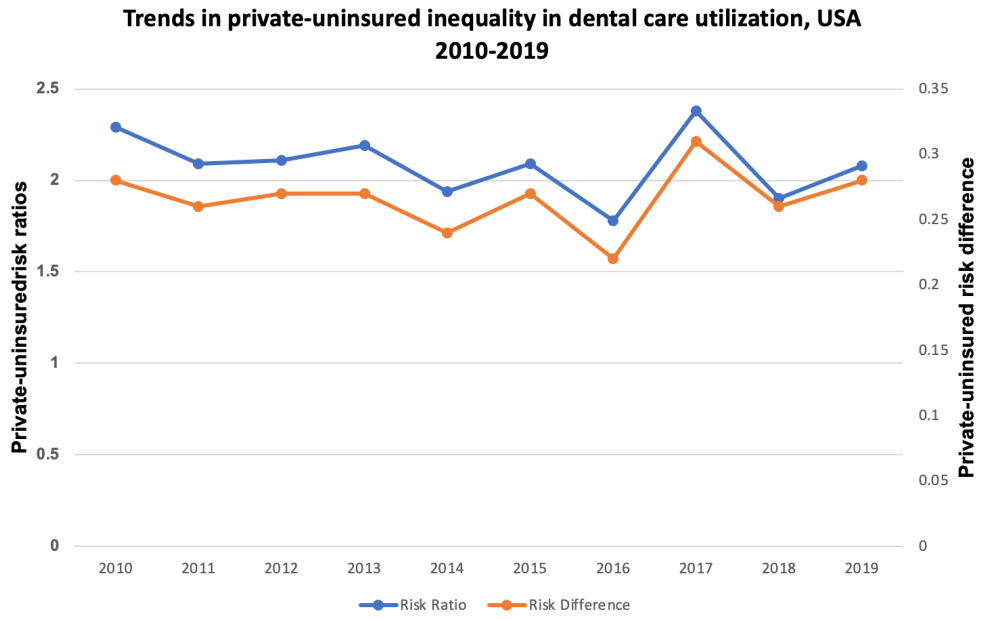

Figure 5: Trends in private-uninsured inequality in dental care utilization, USA 2010-2019

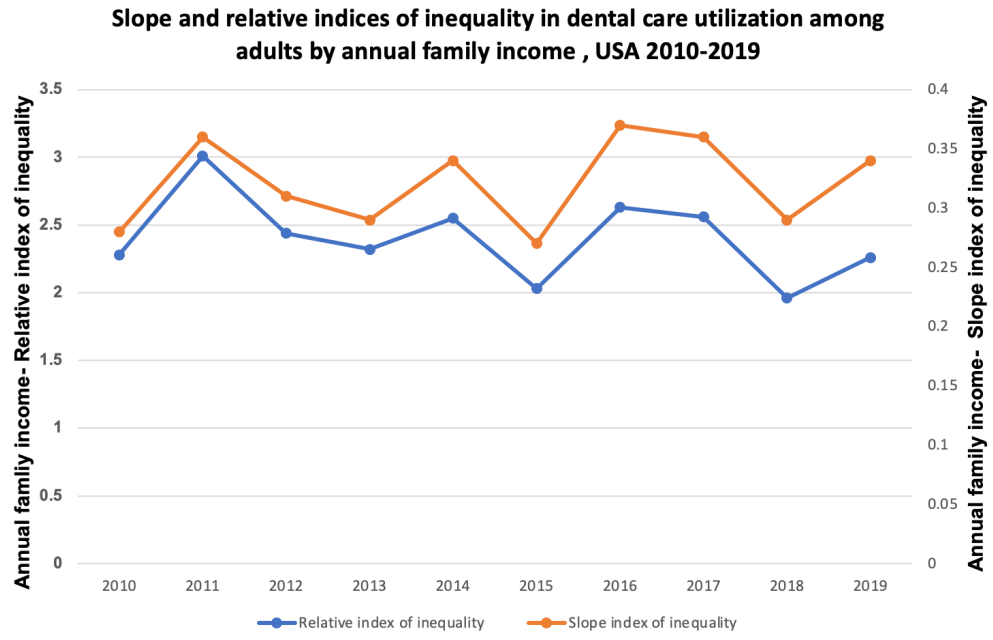

Figure 6: Slop and relative indices of inequality in dental care utilization by annual family income, USA 2010-2019

Manuscript 2: Socio-Economic Inequalities in Dental Care Utilization Among the U.S. Children: A Study of Trends From 2010 to 2019

Abstract

Objectives:

Over the past couple of decades, different policy initiatives have increased health care coverage among US children.[1] However, oral health disparities continue to exist for certain racial and ethnic groups. The poorest oral health for any racial and ethnic groups is found among non-Hispanic Blacks, Hispanics, and American Indians and Alaska Natives.[2] In this study, we assessed dental care utilization among US children aged less than 18 years using the National Health Information Survey (NHIS) data from 2010 to 2019.

Methods:

This analysis included 113,347 respondents. Six socioeconomic indicators (SEI) were analyzed to assess their associations with past-year utilization of dental care. The Slope Index of Inequality (SII) and Relative Index of Inequality (RII) were used to measure inequality for ordinal variables. Risk difference and risk ratio were calculated to measure inequality for variables that lack natural ordering. Logistic regression was used to assess trends.

Results:

Among the respondents, a significant increase in last year's dental visit was observed from 2010 to 2019 (74.75 % to 83.77 %; *p*-trend<.001). Within the pooled analyses, the adjusted odds of

visiting the dentist were higher among children aged 6-11 (OR:7.46, 95%CI:7.04-7.90) and children aged 12-17 (OR:5.56, 95%CI:5.92-5.84) compared to younger children aged 0-5. Lower odds of visiting a dentist were seen among uninsured children compared to children with private insurance (OR:0.26, 95%CI:0.24-0.28). Children with annual family income ≥ 400% FPL (OR:1.98, 95%CI:1.82-2.15) had higher odds of visiting the dentist compared to children less than 100% FPL. On the absolute scale of inequality, children who live with the most educated adults and older children were more likely to have a dental visit during the past year. Moreover, children living in families with higher annual income were more likely to have a dental visit during past year.

Conclusion:

Inequalities in dental care utilization still exist for children, although it has diminished within society across all indicators of oral health. Children with private insurance or who were living in families with higher annual income were more likely to have has a dental visit during past year. Policy makers should take into consideration the significance of oral health and its integral relationship to everyone's overall health when implementing new policies or modifying existing policies.

Introduction

The Surgeon General's report sent a clear message that oral health is part of general health and well-being and can be achieved by everyone.[3] Despite the progress in oral health since the publication of the report, it is estimated that dental caries affects 46% of US children ages 2 to 19, making it the most common chronic disease of childhood.[4] The prevalence of untreated dental caries is 20% among children aged 5-11 and 13% among adolescents aged 12 to 19 years.[5] The pain and infection caused by dental caries can hinder the ability to chew and talk or be productive in school.[3, 6, 7] Therefore, it is important to utilize dental services in order to prevent and treat dental disease. In fact, the American Academy of Pediatric Dentistry recommends that the first dental visit for children should be no later than their first birthday.[8]

Over the past several decades, different policy initiatives increased health care coverage among US children.[1] Medicaid and the Children's Health Insurance Program (CHIP) helped many US children to gain public health insurance.[9-12] This resulted in a decline from 15% in 1997 to 5% in 2015 in the percentage of children aged 17 years or less who don't have health insurance.[13] There has also been an increase in the percentage of children who visit dentists, which rose from 42.2% in 2000 to 47.8% in 2014.[14] While the gap in utilizing dental care between high- and low-income adults increased, it has narrowed dramatically for children.[14, 15] The difference in the use of dental care among low- and high-income children was 29% in 2000, and it was 21.2% in 2014.[14]

Oral health disparities exist for different racial and ethnic groups, even though there has been an overall improvement in oral health.[3] In the United States, the poorest oral health of any racial

and ethnic groups is found among non-Hispanic Blacks, Hispanics, and American Indians and Alaska Natives. Compared to children from high-income families, the prevalence of dental caries is twice as high among children aged 5 to 19 in low-income families.[2] Child age is also an important factor. An analysis of the 2016 National Survey of Children's Health and found that the likelihood of receiving a preventive dental visit was lower among children aged 2-5 years. Further, they found that the likelihood of having dental caries was higher among children aged 6-9 years. Their conclusion was that preventive dental services are lagging for younger children and causing caries that progressed into older ages.[16]

One of the leading health indicators for Healthy People 2020 is to increase the proportion of children, adolescents, and adults who use the oral health care system from 44.5% in 2007 to 49% in 2020. While the percentage of patients utilizing the oral health care system for children age 5-11 years and 12-17 years in 2016 was 58%, it was 39% for children aged 2-4 years.[17] The goal of this study was to examine trends in annual dental visit rates among different age groups of children and to assess any inequalities, utilizing both relative and absolute measures.

Methods

Data source and Measures

Our main source of data was the 2010 - 2019 National Health Interview Survey (NHIS).[18] The NHIS is conducted annually and is nationally representative of the civilian non-institutionalized US population. Between 2010 and 2019, 113,347 individuals were interviewed for NHIS. The analyses in this study were restricted to children aged <18 years. The annual sample size for the population averaged 11,335 (8,269 in 2018 (lowest) to 13,380 in 2014(highest)).

Dental care Utilization Among during the past 12 months

The primary outcome is dental care utilization which defined as the percentage of persons who self-reported visiting the dentist during the past year.

Indicator variables

Six indicator variables were analyzed in our study: sex, education; annual family income; race/ethnicity; dental insurance; and past-year health insurance coverage. The selection of the six indicators variables was based on whether it was a social determinant health associated with social disadvantage status, or relevance to the public or clinical health. Detailed descriptions are presented in the table1.

Data analyses

To obtain nationally representative estimates, all data used were weighted to account for the complex design of the NHIS. Analyses were conducted using Stata V.15 (Stata Corporation,

College Station, TX). Prevalence estimates were computed for each year in the period examined. Trends during the entire study period were assessed using estimates of relative percentage change (RPC) between the first and last survey years. To determine if the observed changes were statistically significant, age and sex adjusted slope estimates expressed as log-odds in a binary logistic model were measured.

Assessment of Inequalities

The absolute inequality measures were used to quantify the differences across all levels of socioeconomic positions rather than measuring the differences relative to a specific referent group (i.e., a global measure).[19] A single number was used to describe the overall inequality for each indicator within a specific year. For ordinal variables, such as education, age, and income, the Slope Index of Inequality (SII) and relative index of inequality (RII) were calculated. However, other variables that lack natural ordering, pairwise comparisons (risk difference (RD) and risk ratio (RR) were calculated.

SII and RII for each year were calculated by regressing the outcome (dental utilization; 0=no dental visit during the past year, 1= dental visit during the past year), against an individual's relative rank in the cumulative distribution of socio-economic position that is weighted based on the group size (ridit score). The interaction variable (year*ridit score) was utilized as a trend test at $p<0.05$. We assumed that dental care utilization is distributed equally among all socio-economic groups if SII had a value of zero and RII had a value of one. On the other hand, it was

assumed that the utilization of dental care is more among socially advantage groups if SII had a positive value and RII had a value above one. If dental care utilization increased by the same amount in all socio-economic groups, the SII would increase while the RII would not change. For that, both measures were analyzed to present a complete picture of inequalities.

RR and RD for each year were calculated by comparing the risk of dental care utilization between two subgroups. To calculate RD and RR, logistic regression was used to model the log odds of using dental care the coefficients was transformed into marginal predicted risks.

Results

Trends among US children

The analysis included 113,347 respondents under the age of 18. Among this study population, dental care utilization increased significantly between 2010 and 2019 (74.75 % to 83.77 %; *p*-trend<.001).

Pooled analysis

Within the pooled analyses, the adjusted odds of visiting the dentist were higher among 6-11-year-old children (OR:7.46, 95%CI:7.04-7.90) and 12-17-year-old children (OR:5.56, 95%CI:5.92-5.84) compared to younger children aged 0-5 (**Table 2**). Compared to Whites, the adjusted odds of visiting the dentist were higher for Hispanics (OR:1.22, 95%CI:1.15-1.30) and Blacks (OR:1.19, 95%CI:1.11-1.27) and were lower among Asian children (OR:0.79, 95%CI:0.72-0.86). Compared to children with private insurance, those with public insurance had higher odds of visiting a dentist (OR:1.18, 95%CI:1.11-1.25) while uninsured children had lower odds of visiting a dentist (OR:0.26, 95%CI:0.24-0.28). Lower odds of visiting a dentist were seen among children with parents who had less than a high school education (OR:0.82, 95%CI:0.74-0.89), those with high school diplomas (OR:0.79, 95%CI:0.74-0.84), or with some college education (OR:0.79, 95%CI:0.74-0.84) compared to respondents whose parents had a college degree or higher. Children between 200%-399% FPL (OR:1.31, 95%CI:1.21-1.42) or more than 400% FPL (OR:1.98, 95%CI:1.82-2.15) had higher odds of visiting the dentist compared to children with less than 100% FPL.

Trends among population subgroups

Education

Between 2010 and 2019, a significant increase in dental care utilization was detected among all educational levels (*p*-trend<0.05): less than high school diploma (67.98% to 82.65%); high school diploma (69.72% to 78.94%); some college (72.01% to 81.73%); or more than or equal to a college degree (79.38% to 85.83%) (**Table 3 & Figure 1**). In the most disadvantaged group (<high school diploma; RPC = 21.58), the percentage increase in dental care utilization was 2.65 times greater than those with ≥college degree (RPC = 8.13), 1.63 times greater those with a high school diploma (RPC =13.22), and 1.60 times greater than those with some college (RPC =13.5).

Annual family income

From 2010 to 2019, a significant increase in dental care utilization was detected among all annual family income categories (*p*-trend<0.05): <100% (68..58% to 81.01%); 100-199% (70.25% to 80.64%); 200-399% (74.85% to 83.37%); and ≥ 400 (83.83% to 88.29%) (**Table 3 & Figure 1**). Among the most disadvantaged group (<100%; RPC = 18.12), the percentage increase in dental care utilization was 1.23 times greater compared to 100-199% level group (RPC = 14.79), 1.59 times greater compared to 200-399% level group (RPC = 11.38), and 3.48 times more compared to >400% level group (RPC = 5.32)

Sex

Between 2010-2019, there was a significant increase in dental care utilization among both boys (73.91% to 83.97%) and girls (75.64%–83.55%) (p-trend <0.001) (**Table4**). The percentage

increase in dental care utilization was 1.3 times more among boys compared to girls (RPC=13.61 vs 10.46, respectively).

Race/ethnicity

A significant increase in dental care utilization was detected among all race/ethnic groups: Whites (76.88% to 83.76%); Blacks (75.52% to 86.00%); Asians (70.93% to 82.51%); and Hispanics (70.54% to 82.95%); (p-trend <0.05) (**Table 4 & Figure 1**). Among the most disadvantaged group (Hispanics; RPC = 17.59), the percentage increase in dental care utilization was 1.97 times larger than Whites (RPC = 8.95) , 1.27 times larger than Blacks (RPC = 13.88), and 1.08 times larger than Asians (RPC = 16.33).

Age

A significant increase in dental care utilization was observed for all age groups: 0-5 (50.65% to 64.67%); 6-11 (86.98% to 92.46%); and 12-17 (84.08% to 90.33%) (**Table 4**). Among the most disadvantaged group (0-5; RPC = 27.68), the percentage increase in dental care utilization was 4.39 times more than those aged 6-11 (RPC = 6.3), and 3.73 times more than those aged 12-17 (RPC= 7.43).

Health Insurance

A significant increase in dental care utilization was observed for all insurance groups: private (79.30% to 85.39%); public (73.81% to 84.17%); and uninsured (49.36% to 61.06%) (**Table 5 & Figure 1**). For the uninsured group (RPC = 23.7), the percentage increase in dental care utilization

was 3.09 times larger than for those with private insurance (RPC = 7.68) and 1.69 times larger than for those with public insurance (RPC= 14.04).

Assessment of Inequalities

Race/ Ethnicity

Measured inequalities by race/ethnicity decreased during the past 10 years for White children compared to Hispanics (2010 RR: 1.09, RD:0.06 - 2019 RR:1.01, RD:0.01) and Asians (2010 RR:1.08, RD:0.06 - 2019 RR:1.02, RD:0.01) (**Table 7**). In 2019, White children were 1 percentage-point higher compared to Hispanics (95% CI -0.02, 0.03) and Asians(95% CI: -0.03, 0.05). On the relative scale, White children were 1.01 times higher in utilizing dental services compared to Hispanics (95% CI: 0.98, 1.04) and 1.02 times higher compared to Asians (95% CI: 0.96, 1.07).

Insurance

On both the relative and absolute scales, the inequality decreased between private-public insurance (2010 RR: 1.07, RD:0.05 - 2019 RR:-1.01, RD:0.01) and private-uninsured (2010 RR: 1.61, RD:0.30 - 2019 RR:1.40, RD:0.24) (**Table 8**). In 2019, children with private insurance was 1 percentage-points higher compared to children with public insurance (95% CI: -1.01, RD:0.03) and 24 percentage-points higher compared to uninsured children (95% CI: 0.19, RD:0.30). On the relative scale, children with private insurance were 1.01 times higher compared to children with private insurance (95% CI: 0.99, 1.04) and 1.40 times higher compared to uninsured children (95% CI: 1.27, 1.53).

Education

Between the highest and the lowest education groups, there was a decrease in inequality for both the SII and RII from 2010 (SII:0.17, RII:1.26) to 2019 (SII:0.10, RII:1.12) (**Table 9**). In 2019, the SII for education was 0.10 (95% CI: 0.06, 0.13) indicating that dental care utilization is on average 10 percentage points higher at the top vs. the bottom of the education distribution. On the relative scale, children who lived with more educated adults were 1.12 times more likely to have dental services in the past year than children who lived with the less educated adults (95% CI: 1.07, 1.17)

Age

Measured inequalities by age deceased during the 10 years of the study (2010 SII:0.49, RII:2.10 - 2019 SII:0.37, RII:1.64) (**Table 9**). In2019, the SII was 0.37 (95% CI: 0.33, 0.42) indicating that dental care utilization is on average 37 percentage points higher at the top vs. the bottom of the age distribution. On the relative scale, older children were 1.64 times more likely to have dental services in the past year than younger children (95% CI: 1.53, 1.75).

Annual family income

On both relative and absolute scales, the inequalities by annual family income decreased during the study period (2010 SII:0.20, RII: 1.32 - 2019 SII:0.10, RII:1.13) (**Table 9**). The SII for Annual family income in 2019 was 0.10 (95% CI: 0.07, 0.14) indicating that dental care utilization is on average 10 percentage points higher at the top vs. the bottom of the annual family income distribution. On the relative scale, the children living in families with higher annual income were

1.13 times more likely to have dental services in the past year than children living in families with lower annual income (95% CI: 1.09, 1.18).

Discussion

Utilization of dental care during the past year increased for U.S. children across all socio-economic indicator variables. However, there was a disproportionately lower prevalence of dental care utilization among younger children ages 0–5, Asians, uninsured, those with parents with less than a high school education, and who had annual family income below 100% FPL.

Nasseh and Vujicic reported similar findings in their article published in 2016 in which they used the Medical Expenditure Panel Survey (MEPS). In 2014, 39.9% of children ages 2–18 who were below 100% FPL had a dental visit in the past year, while 61.1% children who were >400% had a dental visit. Furthermore, only 22.6% of uninsured children had a dental visit compared with 41.0% of children who had public insurance.[14]

For each indicator from 2010 to 2019, there was an increase in the relative percentage change (RPC) for the most disadvantaged groups compared to the most advantaged groups. The RPC increased by 23.7% for uninsured children compared to 7.68% for children with private insurance. The RPC for children who lived in a family with an annual income of < 100% FPL increased by 18.12%, while it increased only by 5.32% for children who lived in a family with an annual income of >400% FPL.

During the study period, the RPC increased more for children whose parents had less than a high school education (21.6%) compared to children whose parents had a college degree or higher (8.1%). In the same study that analyzed the MEPS data between 2000 and 2014 among children

ages 2–18, the RPC increased by 50.9% for poor children (<100% FPL) and increased by 11.9% for high-income children (400%+ FPL). On the other hand, the RPC decreased for the uninsured children (-23.65%) and increased for the children with private insurance (13.8%).[14]

Inequalities in dental care utilization still exist, although they are diminishing within society across all indicators for children. On the absolute scale of inequality, children who live with the most educated adults and older children were more likely to have a dental visit during the past year. Moreover, children living in families with higher annual income were more likely to have a dental visit during past year. Inequalities in dental care were diminished on both relative and absolute scales between children who had private and public insurance. However, children with private insurance were more likely to visit a dentist compared to uninsured children.

Poor oral health can lead to increased risks for systemic diseases, such as diabetes, cardiovascular, and respiratory diseases.[20-22] It also compromises major functions, such as chewing, breathing, and speaking.[23] Oral disease contribute to lost school days as well as loss of self-confidence.[24, 25] Therefore, policy makers should take into consideration the significance of oral health and its integral relationship to overall health when implementing new policies or modifying existing policies.

Our study has several limitations. First, it is not feasible to compare states that expanded Medicaid and those that did not, due to the lack of state-level data in NHIS. Second, our outcome variable is self-reported, which is more likely to lead to a recall bias the participants may have

their own interpretations of the need for dental treatment. Finally, due to the cross-sectional nature of the collected data, it is not possible to assess the outcomes among longitudinal in the same population.

Conclusion

Inequalities in dental care utilization still exist for children, although it has diminished within society across all indicators of oral health. Children with private insurance or who were living in families with higher annual income were more likely to have has a dental visit during past year. Policy makers should take into consideration the significance of oral health and its integral relationship to everyone's overall health when implementing new policies or modifying existing policies.

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Tables and graphs

Table 1: Socio-Demographic characteristics of U.S. children in 2010 and 2019. National Health Information Survey.

		2010		2019	
	Category	n	Weighted %	n	Weighted %
Sex	Male	5,838	51.1	4,705	51.05
	Female	5,439	48.9	4,484	48.95
Age	0-5	3,909	34.5	2,861	32.29
	6-11	3,354	32.61	2,765	33.25
	12-17	4,014	32.89	3,567	34.46
Race/Ethnicity	Hispanic	3,518	23.00	2,173	25.7
	White (non-Hispanic)	4,911	55.87	4,921	51.63
	Black (non-Hispanic)	2,020	15.4	1,022	12.73
	Asian (non-Hispanic)	740	04.58	511	04.38
	Other	88	01.15	566	05.56
Education	<High school diploma high	1,335	10.58	465	06.75
	High school diploma	2,398	20.17	1,596	18.17
	Some college	2,279	19.67	1,313	14.48
	≥college degree	5,248	49.58	5,806	60.6
Poverty Level	Less than 100%	2,371	21.04	1,250	17.42
	100- 199%	2,386	20.85	1,947	23.13
	200%- 399%	2,832	25.57	2,894	30.35
	More than 400%	2,643	23.68	3,102	29.1
	Unspecified	1,045	08.86	-	-
Dental coverage	Yes	2,486	44.86	2,215	44.5
	No	2,983	55.14	2,933	55.5
Insurance Type	Private	5,655	53.76	5,396	55.59
	Public	4,226	35.47	3,036	36.39
	Other	299	02.66	284	02.94
	Uninsured	1,063	08.11	436	05.08

Table 2 Multivariable logistic regression of socio-economic indicators and dental care utilization during the past year among US children. National Health Information Survey, 2010–2019

Characteristics	OR* of dental care utilization	95% CI**	P-value
Sex (Referent group: female)			
Male	0.97	0.93-1.01	0.158
Age (Referent group: 0-5)			
6-11	7.46	7.04-7.90	<0.001
12-17	5.56	5.29- 5.84	<0.001
Race/ethnicity (Referent group: White)			
Hispanic	1.22	1.15-1.30	<0.001
Black	1.19	1.11- 1.27	<0.001
Asian	0 .79	0.72-0.86	<0.001
Other	1.28	1.04-1.57	0.021
Poverty level (Referent group: Less than 100%)			
100- 199%	1.06	0.98-1.13	0.146
200%- 399%	1.31	1.21-1.42	<0.001
More than 400%	1.98	1.82-2.15	<0.001
Unspecified	1.36	1.23-1.51	<0.001
Education (Referent group: ≥college degree)			
<High school diploma	0.82	0.74-0.89	<0.001
High school diploma	0.79	0.74-0.84	<0.001
Some college	0.79	0.74-0.84	<0.001
Insurance (Referent group: Private)			
Public	1.18	1.11-1.25	<0.001
Other	0.95	0.82-1.10	0.510
Uninsured	0.26	0.24-0.28	<0.001

*OR = Odd ratio *95%CI= 95% Confidence interval

Table 3 Mean dental care utilization and 95% CI among children by education and annual family income groups. National Health Information Survey, 2010–2019 (RPC: Relative Percentage Change)

	Education				Annual family income				
	<High School diploma	High School diploma	Some College	≥College degree	< 100%	100- 199%	200%- 399%	> 400%	unspecified
2010	67.98 (64.31-71.66)	69.72 (67.40-72.04)	72.01 (69.72-74.30)	79.38 (78.02-80.74)	68.58 (66.04-71.11)	70.25 (68.10-72.39)	74.85 (72.62-77.07)	83.83 (82.30-85.36)	75.29 (72.20-78.38)
2011	73.75 (70.62-76.88)	74.10 (71.83-76.36)	76.28 (74.12-78.44)	80.21 (79.08-81.34)	71.24 (68.87-73.61)	75.16 (72.89-77.43)	77.32 (75.51-79.13)	85.08 (83.53-86.64)	79.36 (76.43-82.30)
2012	75.44 (72.38-78.50)	75.77 (73.75-77.78)	75.39 (73.04-77.75)	81.69 (80.49-82.90)	72.73 (70.37-75.10)	75.49 (73.26-77.72)	78.46 (76.61-80.30)	86.06 (84.52-87.60)	80.90 (78.00-83.80)
2013	74.59 (7.16-77.60)	76.30 (73.90-78.70)	76.81 (74.64-78.97)	82.61 (81.33-83.88)	74.93 (72.69-77.17)	75.14 (72.94-77.34)	81.38 (79.72-83.03)	84.86 (83.25-86.47)	80.38 (77.43-83.34)
2014	76.76 (73.56-79.99)	76.83 (74.68-78.99)	76.19 (73.76-78.61)	81.74 (80.41-83.07)	75.03 (72.69-77.38)	75.00 (72.71-77.29)	80.15 (78.46-81.84)	85.96 (84.36-87.55)	79.56 (75.83-83.30)
2015	81.15 (78.22-84.07)	76.91 (74.45-79.36)	78.01 (75.79-80.24)	84.18 (82.88-85.48)	79.37 (77.04-81.70)	77.96 (75.72-80.20)	80.57 (78.73-82.41)	86.60 (85.14-88.06)	82.37 (78.38-86.36)
2016	75.44 (71.10-79.77)	78.28 (75.89-80.67)	80.21 (77.85-82.58)	82.70 (81.30-84.10)	76.93 (74.22-79.64)	76.44 (74.00-78.87)	81.06 (79.16-82.95)	86.53 (84.75-88.31)	83.05 (79.14-86.95)
2017	76.81 (71.97-81.66)	77.61 (74.66-80.57)	76.90 (74.01-79.79)	83.96 (82.61-85.31)	77.77 (74.51-81.03)	76.29 (73.78-78.80)	79.46 (77.47-81.45)	88.24 (86.73-89.74)	82.36 (77.94-86.77)
2018	79.55 (74.91-84.19)	79.55 (76.90-82.20)	80.72 (78.07-83.38)	84.49 (83.20-85.79)	78.58 (75.22-81.94)	79.98 (77.48-82.48)	82.18 (80.25-84.11)	87.00 (85.43-88.58)	82.26 (77.58-86.94)
2019	82.65 (78.14-87.16)	78.94 (76.39-81.50)	81.73 (78.98-84.47)	85.83 (84.75-86.90)	81.01 (78.29-83.74)	80.64 (78.34-82.95)	83.37 (81.66-85.08)	88.29 (87-89.57)	-
RPC	**21.58**	**13.22**	**13.5**	**8.13**	**18.12**	**14.79**	**11.38**	**5.32**	**9.62**
Trend	↑	↑	↑	↑	↑	↑	↑	↑	↑
P-Trend	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.008**

Table 4 Mean dental care utilization and 95% CI among children by race/ethnicity, age, and sex. National Health Information Survey, 2010–2019
(RPC: Relative Percentage Change)

	Race/ethnicity				Age			Sex	
	Hispanic	White	Black	Asian	0-5	6-11	12-17	Male	Female
2010	70.54 (68.49-72.59)	76.88 (75.36-78.39)	75.52 (73.08-77.97)	70.93 (66.42-75.45)	50.65% (48.56-52.72.86)	86.98% (85.52-88.43)	84.08% (82.61-85.55)	73.91% (72.44-75.38)	75.64% (74.18-77.09)
2011	76.53 (74.77-78.29)	78.59 (77.31-79.87)	76.96 (74.75-79.17)	73.42 (69.68-77.17)	54.72% (52.74-56.71)	89.85% (88.70-90.99)	85.39% (84.03-86.75)	77.56% (76.23-78.88)	77.65% (76.36-78.93)
2012	77.10 (75.42-78.78)	79.39 (78.07-80.72)	79.00 (78.07-80.72)	75.73 (72.10-79.37)	55.58% (53.40-57.00)	90.05% (88.97-91.14)	86.45% (85.18-87.73)	79.00% (77.68-80.31)	78.34% (77.03-79.65)
2013	77.72 (76.05-79.40)	81.09 (79.79-82.39)	77.94 (75.23-80.65)	76.60 (73.07-80.12)	58.53% (56.33-60.73)	89.39% (88.17-90.62)	86.61% (85.37-87.85)	79.18% (77.84-80.52)	79.94% (78.58-81.31)
2014	78.32 (76.39-80.25)	80.33 (79.03-81.64)	78.68 (76.45-80.92)	74.16 (70.56-77.78)	57.55% (55.35-59.76)	89.50% (88.26-90.75)	86.93% (85.66-88.20)	78.93% (77.63-80.24)	79.73% (78.40-81.06)
2015	80.30 (78.56-82.04)	81.78 (80.42-83.14)	82.67 (80.21-85.13)	79.78 (76.14-83.43)	60.15% (57.82-62.49)	91.56% (90.34-92.80)	88.40% (87.13-89.67)	81.07% (79.74-82.40)	81.76% (80.41-83.11)
2016	79.84 (77.72-81.97)	80.87 (79.46-82.29)	83.48 (81.06-85.90)	78.74 (74.03-83.44)	60.30% (57.64-62.97)	91.33% (90.00-92.66)	87.43% (85.97-88.90)	80.53% (79.11-81.96)	81.16% (79.65-82.67)
2017	80.84 (78.44-83.25)	82.33 (81.01-83.65)	77.83 (74.12-81.55)	80.68 (76.64-84.73)	60.57% (58.07-63.08)	90.58% (89.26-91.90)	87.98% (86.39-89.58)	80.52% (79.06-81.99)	81.85% (80.25-83.44)
2018	82.51 (80.20-84.83)	82.01 (80.53-83.50)	84.36 (81.64-87.09)	83.01 (78.94-87.09)	61.70% (59.19-64.21)	92.17% (90.96-93.40)	89.63% (88.28-91.04)	82.74% (81.30-84.19)	82.59% (80.99-84.18)
2019	82.95 (80.91-85)	83.76 (82.47-85.06)	86.00 (83.08-88.93)	82.51 (78.49-86.53)	64.67% (62.34-67.00)	92.46% (91.26-93.66)	90.33% (89.05-91.60)	83.97% (82.67-85.27)	83.55% (82.13-84.97)
RPC	**17.59**	**8.95**	**13.88**	**16.33**	**27.68**	**6.3**	**7.43**	**13.61**	**10.46**
Trend	↑	↑	↑	↑	↑	↑	↑	↑	↑
P-Trend	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**

Table 5 Mean dental care utilization and 95% CI among children by health insurance status. National Health Information Survey, 2010–2019 (RPC: Relative Percentage Change)

	Health insurance status			
	Private	Public	Other	Uninsured
2010	79.30 (77.92-80.68)	73.81 (72.13-75.50)	73.03 (66.30-79.76)	49.36 (45.32-53.40)
2011	81.35 (80.12-82.59)	76.12 (74.51-77.74)	79.45 (73.39-85.51)	56.60 (52.48-60.72)
2012	82.39 (81.26-83.53)	77.37 (75.75-78.99)	77.43 (71.88-82.98)	56.79 (52.22-61.36)
2013	83.65 (82.50-84.80)	78.67 (77.05-80.30)	78.20 (71.99-84.41)	52.71 (48.31-57.11)
2014	82.98 (81.76-84.20)	77.26 (75.76-78.76)	78.71 (71.81-85.62)	57.75 (53.10-62.41)
2015	83.54 (82.31-84.79)	81.05 (79.51-82.60)	81.66 (74.67-88.64)	59.09 (54.08-64.11)
2016	83.89 (82.48-85.30)	80.12 (78.35-81.89)	83.88 (78.96-88.80)	54.67 (48.88-60.46)
2017	84.57 (83.30-85.84)	79.03 (76.84-81.23)	81.51 (74.51-88.52)	61.58 (55.59-67.58)
2018	85.37 (84.06-86.69)	81.87 (79.97-83.78)	81.77 (79.97-83.77)	62.64 (56.82-68.47)
2019	85.39 (84.15-86.62)	84.17 (82.50-85.85)	84.95 (80.22-89.68)	61.06 (55.45-66.67)
RPC	**7.68**	**14.04**	**16.32**	**23.7**
Trend	↑	↑	↑	↑
P-Trend	**<0.001**	**<0.001**	**0.005**	**<0.001**

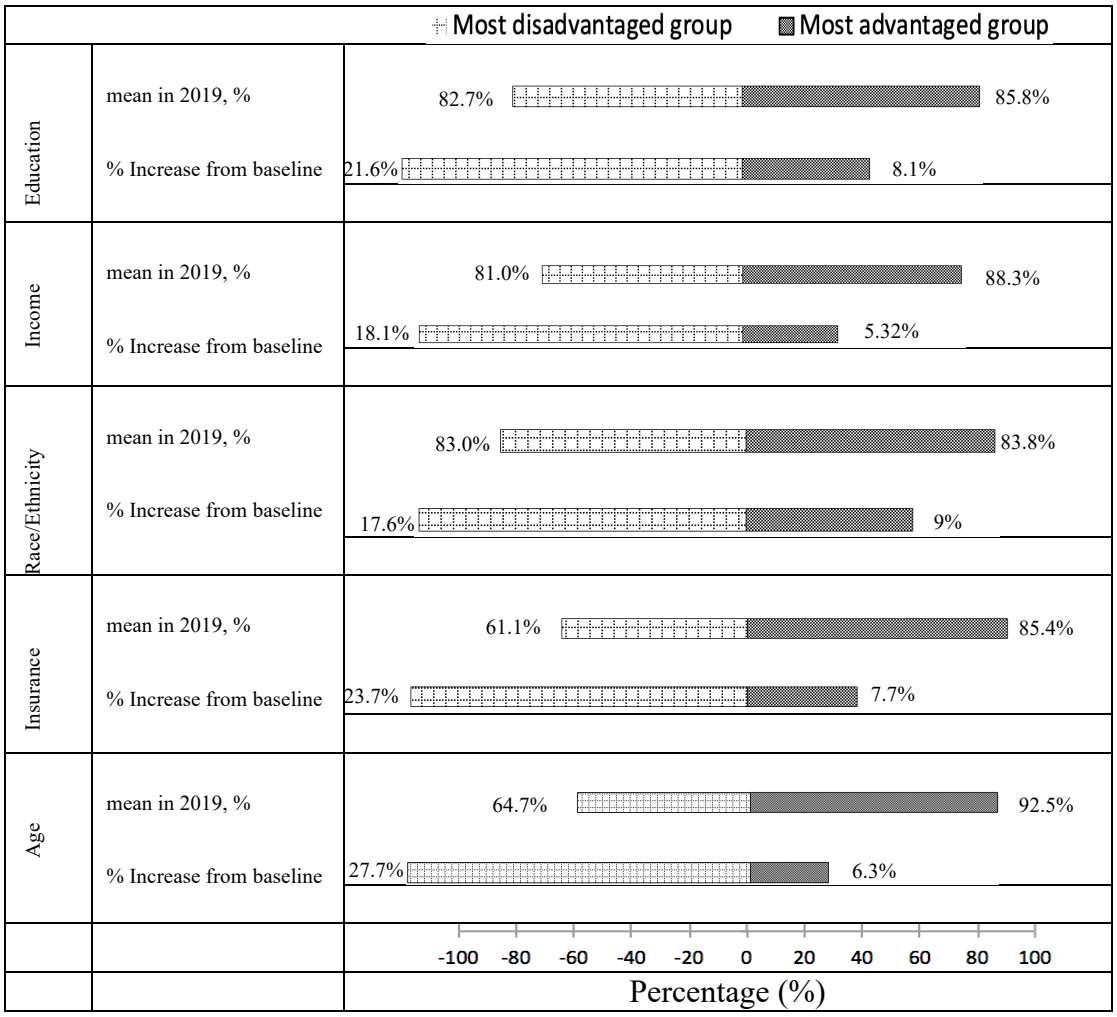

Figure1: The RPC and the mean of dental care utilization in 2019 among the most advantaged and disadvantaged groups of children by different socio-economic indicators. National Health Information Survey, 2010–2019 (RPC: Relative Percentage Change)

Table 6 Estimates and 95% CI of inequality in dental care utilization among children by sex. National Health Information Survey, 2010–2019

Reference	Female Male	
	RR 95% CI	RD 95% CI
2010	1.02 (1.00,1.05)	0.02 (-.002,.04)
2011	1.00 (.98,1.02)	0.001 (-.02,.02)
2012	0.99 (.97,1.02)	-0.01 (-.03,.01)
2013	1.01 (.99,1.03)	0.01 (-.01,.03)
2014	1.01 (.99,1.03)	0.01 (-.01,.03)
2015	1.01 (.99,1.03)	0.01 (-.01,.03)
2016	1.01 (.98,1.03)	0.01 (-.01,.03)
2017	1.02 (.99,1.04)	0.01 (-.01,.03)
2018	1.00 (.97,1.02)	-0.002 (-.02,.02)
2019	1.00 (.97,1.02)	-0.004 (-.02,.01)

95% CI: 95% Confidence Interval
RR: Risk Ratio RD: Risk Difference.

Table 7 Estimates and 95% CI of inequality in dental care utilization among children by race/ethnicity. National Health Information Survey, 2010–2019

Reference	White Hispanic		White Black		White Asian	
	RR 95% CI	RD 95% CI	RR 95% CI	RD 95% CI	RR 95% CI	RD 95% CI
2010	1.09 (1.05,1.13)	0.06 (.04,.09)	1.02 (.98,1.06)	0.01 (-.01,.04)	1.08 (1.01,1.16)	0.06 (.01,.11)
2011	1.03 (1.00,1.05)	0.02 (.0002,.04)	1.02 (.99,1.05)	0.02 (-.01,.04)	1.07 (1.01,1.13)	0.05 (.01,.09)
2012	1.03 (1.00,1.06)	0.02 (.002,.04)	1.00 (.97,1.04)	0.004 (-.02,.03)	1.05 (.99,1.10)	0.04 (-.002,.08)
2013	1.04 (1.02,1.07)	0.03 (.01,.05)	1.04 (1.00,1.08)	0.03 (.0001,.06)	1.06 (1.01,1.11)	0.04 (.01,.08)
2014	1.03 (1.00,1.06)	0.02 (-.003,.04)	1.02 (.99,1.05)	0.02 (-.01,.04)	1.08 (1.03,1.14)	0.06 (.02,.10)
2015	1.02 (.99,1.05)	0.01 (-.01,.04)	0.99 (.96,1.02)	-0.01 (-.04,.02)	1.03 (.98,1.07)	0.02 (-.02,.06)
2016	1.01 (.98,1.04)	0.01 (-.01,.04)	0.97 (.94,1.001)	-0.03 (-.05,.001)	1.03 (.96,1.09)	0.02 (-.03,.07)
2017	1.02 (.98,1.05)	0.01 (-.01,.04)	1.06 (1.00,1.11)	0.04 (.01,.08)	1.02 (.97,1.07)	0.02 (-.03,.06)
2018	0.99 (.96,1.03)	-0.01 (-.03,.02)	0.97 (.94,1.00)	-0.02 (-.05,.01)	0.99 (.94,1.04)	-0.01 (-.05,.03)
2019	1.01 (.98,1.04)	0.01 (-.02,.03)	0.97 (.94,1.01)	-0.02 (-.05,.01)	1.02 (.96,1.07)	0.01 (-.03,.05)

95% CI: 95% Confidence Interval
RR: Risk Ratio RD: Risk Difference.

Table 8 Estimates and 95% CI of inequality in dental care utilization among children by insurance. National Health Information Survey, 2010–2019

Reference	Private Public		Private Other		Private Uninsured	
	RR 95% CI	RD 95% CI	RR 95% CI	RD 95% CI	RR 95% CI	RD 95% CI
2010	1.07	0.05	1.09	0.06	1.61	0.30
	(1.04,1.10)	(.03,.08)	(.99,1.19)	(-.01,.13)	(1.47,1.74)	(.26,.34)
2011	1.07	0.05	1.02	0.02	1.44	0.25
	(1.04,1.10)	(.03,.07)	(.95,1.10)	(-.04,.08)	(1.33,1.54)	(.20,.29)
2012	1.06	0.05	1.06	0.05	1.45	0.26
	(1.04,1.09)	(.03,.07)	(.99,1.14)	(-.01,.11)	(1.33,1.57)	(.21,.30)
2013	1.06	0.05	1.07	0.05	1.59	0.31
	(1.04,1.09)	(.03,.07)	(.98,1.16)	(-.01,.12)	(1.45,1.72)	(.26,.35)
2014	1.07	0.06	1.05	0.04	1.44	0.25
	(1.05,1.10)	(.04,.08)	(.96,1.15)	(-.03,.11)	(1.32,1.55)	(.20,.30)
2015	1.03	0.02	1.02	0.02	1.41	0.24
	(1.01,1.05)	(.01,.04)	(.93,1.11)	(-.05,.09)	(1.29,1.54)	(.19,.30)
2016	1.05	0.04	1.00	0.00005	1.53	0.29
	(1.02,1.08)	(.01,.06)	(.94,1.06)	(-.05,.05)	(1.37,1.70)	(.23,.35)
2017	1.07	0.06	1.04	0.03	1.37	0.23
	(1.04,1.10)	(.03,.08)	(.95,1.13)	(-.04,.10)	(1.24,1.51)	(.17,.29)
2018	1.04	0.04	1.04	0.04	1.36	0.23
	(1.01,1.07)	(.01,.06)	(.95,1.14)	(-.04,.11)	(1.23,1.49)	(.17,.29)
2019	1.01	0.01	1.01	0.004	1.40	0.24
	(.99,1.04)	(-.01,.03)	(.95,1.06)	(-.05,.05)	(1.27,1.53)	(.19,.30)

95% CI: 95% Confidence Interval
RR: Risk Ratio RD: Risk Difference.

Table 9 Slope and relative indices of inequality in dental care utilization among children by age, education, and annual family income groups. National Health Information Survey, 2010–2019

	Age		Education		Annual family income	
	SII 95% CI	RII 95% CI	SII 95% CI	RII 95% CI	SII 95% CI	RII 95% CI
2010	0.49 (.45,.52)	2.10 (1.95,2.25)	0.17 (.13,.21)	1.26 (1.19,1.33)	0.20 (.16,.24)	1.32 (1.25,1.39)
2011	0.45 (.42,.48)	1.92 (1.80,2.04)	0.10 (.07,.13)	1.14 (1.09,1.19)	0.17 (.14,.21)	1.25 (1.19,1.31)
2012	0.44 (.41,.48)	1.89 (1.77,2.01)	0.11 (.07,.14)	1.14 (1.10,1.19)	0.17 (.14,.20)	1.25 (1.19,1.30)
2013	0.40 (.37,.44)	1.75 (1.64,1.85)	0.12 (.09,.15)	1.16 (1.11,1.21)	0.15 (.11,.18)	1.20 (1.15,1.26)
2014	0.42 (.38,.46)	1.81 (1.69,1.93)	0.09 (.05,.12)	1.12 (1.07,1.17)	0.15 (.12,.19)	1.22 (1.16,1.27)
2015	0.41 (.37,.45)	1.75 (1.63,1.86)	0.10 (.06,.13)	1.13 (1.08,1.18)	0.10 (.07,.14)	1.14 (1.09,1.18)
2016	0.39 (.35,.43)	1.71 (1.59,1.83)	0.09 (.05,.13)	1.12 (1.06,1.17)	0.14 (.10,.18)	1.19 (1.13,1.25)
2017	0.39 (.35,.43)	1.70 (1.58,1.82)	0.12 (.08,.16)	1.16 (1.10,1.22)	0.15 .(17,.19)	1.21 (1.15,1.27)
2018	0.40 (.36,.45)	1.73 (1.60,1.86)	0.08 (.04,.12)	1.11 (1.05,1.16)	0.11 (.08,.15)	1.15 (1.09,1.21)
2019	0.37 (.33,.42)	1.64 (1.53,1.75)	0.10 (.06,.13)	1.12 (1.07,1.17)	0.10 (.07,.14)	1.13 (1.09,1.18)

95% CI: 95% Confidence Interval RII: Relative Index of Inequality
SII: Slope Index of Inequality

Manuscript 3: The impact of the implementation of Medicaid expansion under the ACA on dental care utilization.

Abstract

Objectives:

The Affordable Care Act (ACA) helped to reduce health inequalities by reducing the number of uninsured which could generally lead to an improvement in health outcomes.[1, 2] However, dental benefits for adults are not included as an essential health benefit under the ACA.[3] In this study, we assessed the effect of Medicaid expansion on dental care use by stratifying data from the 2012 and 2018 Behavioral Risk Factor Surveillance System (BRFSS) by individual's income levels and by the state in which they live. Sates were categorized by whether they provided adult dental benefits or not.

Methods:

The analysis included 555,981 respondents. Eight socioeconomic indicators (SEI) were analyzed to assess their associations with past-year utilization of dental care. Logistic regression was used to assess the dental care utilization among of each state's population before and after the Affordable Care Act reform. A single number was used to describe the overall inequality for each indicator within a specific year. The Slope Index of Inequality (SII) and Relative Index of Inequality (RII) were used to measure inequality.

Results:

The overall prevalence of dental care use significantly increased among U.S. adults aged 25-64 years (P-value <0.05) during the study period (2012 to 2018). Those reporting a dental visit in the past 12 months increased from 65.67% to 66.34% (RPC = 1.02) while those with a dental visit in the past 24 months rose from 78.18% to 79.12% (RPC = 1.2). The percentage respondents using dental services in the past 12 and 24 months increased for low income adults regardless of the Medicaid expansion status of the state and whether or not the state offered dental benefits. On both relative and absolute scales, the inequalities in dental care utilization decreased during the study period for all the states. The lowest inequality was seen among adults in expanded states that provided dental benefit. After the implementation of the ACA, low income adults had higher odds of using dental services (OR: 1.39, 95% CI (1.30-1.47)) compared to before the implementation of the ACA.

Conclusion:

Low-income adults were the only group who had an increase in the percentage of individuals visiting the dentist in the past 12- and 24-months regardless of the state classification. However, inequality still exist and people with a high-income level are utilizing dental services more than those with a low-income level. Comprehensive dental benefits for adults are offered only in 19 states among 35 states that offer adult Medicaid dental benefits beyond emergency service.[3] Extending dental coverage to include Medicaid-eligible adults may increase the utilization of dental services for the most disadvantaged populations.

Introduction

Oral care is recognized as a leading unmet health need that has implications for overall health.[4, 5] However, the prevalence of untreated dental caries among non-elderly, low-income adults aged 20-64 is 44%, and approximately 5% have lost all of their teeth.[3, 6] Compared to high-income adults, low-income adults were 40% less likely to have had a dental visit in the past 12 months.[7] An estimated 130 million Americans didn't have dental coverage in 2009.[8] In the U.S., a study reported $2.7 billion in dental-related hospital emergency department visits over a three-year period.[9] Over 40% of the emergency patients were uninsured, and an additional 30% of them were Medicaid-enrolled adults.[9]

The Affordable Care Act (ACA) expanded Medicaid coverage to all U.S. residents with a family income of 138% or below of the federal poverty level (FPL).[10] The expansion also included non-disabled adults without children who were, in most states, not eligible for Medicaid.[10, 11] Researchers suggest that the ACA helped to reduce health inequalities by reducing the uninsured rate and improving different health outcomes.[1, 2] However, dental benefits are not included as an essential health benefit under the ACA.[3, 12] There are three different categories for dental benefits that are covered by state Medicaid programs, ranging from limited emergency services such as relieving pain under defined situations, limited dental services, and extensive dental services, including more than 100 diagnostic, preventive, and minor and major restorative procedures.[3, 13] There are 35 states that cover dental services beyond emergency situations.[3]

Although cost has been cited by adults as the primary reason for not visiting a dentist, the ACA expansion had little effect on the utilization of dental services, and its impact on access to dental care was only assessed by a few studies.[14-18] One recently published study examined the effect of the Medicaid expansion under the ACA on dental coverage. The researchers found an association between the improvement of dental coverage and Medicaid expansion. Furthermore, there was an increase in patients seeing a dentist within the past year, which was associated with the Medicaid expansion among non-Hispanic White adults, but not among the full sample size. This might be due to the persistent barriers among racial/ethnic minority groups.[17]

In this study, our aim was to assess the effect of Medicaid expansion on dental care utilization by stratifying the Behavioral Risk Factor Surveillance System (BRFSS) 2012 and 2018 data by income level and the availability of adult dental benefits in each state.[19] We also examined inequality by family income level on both the relative and the absolute scales.

Methods

Data source and Measures

Our main source of data was the 2012 and 2018 Behavioral Risk Factor Surveillance System (BRFSS).[19] The Centers for Disease Control and Prevention conducts BRFSS annually by telephone survey to monitor state trends in health-related risk behaviors, chronic health conditions, and use of preventive services. The analyses in this study were restricted to adult persons aged 25-64 years. Adults aged 19-24 were excluded because they might be impacted by dependent coverage policy by the ACA.[20] The sample size for the adult population was 299,407 in 2012 and 257,251 in 2018.

Dental care Utilization Among during the past 12 months

Our primary outcome was dental care utilization and included responses to one item: "Including all types of dentists, such as orthodontists, oral surgeons, and all other dental specialists, as well as dental hygienists, how long has it been since you last visited a dentist or a dental clinic for any reason?"

Our sample size was stratified into 4 categories based on state Medicaid expansion under ACA and the provision of dental services beyond emergency dental coverage for adults. We excluded Connecticut, Minnesota, and District of Columbia because they expanded before 2012.

States that Expanded Medicaid and with Adult Dental Benefits	States that did not expand Medicaid and with Adult Dental Benefits.	States that Expanded Medicaid and without Adult Dental Benefits.	States that did not expand Medicaid and without Adult Dental Benefits
Alaska	Missouri	Arizona	Alabama
Arkansas	Nebraska	Delaware	Florida
California	North Carolina	Hawaii	Georgia
Colorado	North Dakota	Louisiana	Idaho
Connecticut	South Carolina	Maryland	Kansas
District of Columbia	South Dakota	Nevada	Maine
Illinois	Wisconsin	New Hampshire	Mississippi
Indiana	Wyoming	West Virginia	Oklahoma
Iowa			Tennessee
Kentucky			Texas
Massachusetts			Utah
Michigan			Virginia
Minnesota			
Montana			
New Jersey			
New Mexico			
New York			
Ohio			
Oregon			
Pennsylvania			
Rhode Island			
Vermont			
Washington			

Indicator variables

Eight indicator variables were analyzed in our study: sex, age, education, family income, race/ethnicity, marital, past week employment status, and health plans. The selection of the eight indicators variables was based on whether each was a social determinant health associated with social disadvantage, or relevance to public or clinical health. Detailed descriptions are presented in Table1.

Data analyses

To obtain nationally representative estimates, all data used were weighted to account for the complex design of the BRFSS. Analyses were conducted using Stata V.15 (Stata Corporation, College Station, TX). Prevalence estimates were computed for each period examined. Trends during the entire study period were assessed using estimates of relative percentage change (RPC) between the first (2012) and last (2018) survey years. To determine if the observed changes were statistically significant, age and sex adjusted slope estimates expressed as log-odds in a binary logistic model were measured.

Logistic regression was used also to assess the dental care utilization before and after the Affordable Care Act reform. Our estimate of interest was the interaction term between the classification of the state (expanded: yes=1 / provided adult dental benefits: yes=1) and the post expansion indicator. We adjusted all models for age and sex. We first examined the full sample size and then repeated the analysis separately for states that do and do not provide Medicaid adult dental benefits. We also conducted subgroup analyses comparing low-income adults with all other income groups.

Results

The overall prevalence of dental care use significantly increased among U.S. adults aged 25-64 years (P-value <0.05) during the study period (2012 to 2018) from 65.67% to 66.34% (RPC = 1.02) for past 12 months dental visit and from 78.18% to 79.12% (RPC = 1.2) for past 24 months dental visit (**Table 2**). There was a significant increase in dental care use among adults aged 25-34 (RPC= 2.43) who visited the dentist during the past 12 months and among adults aged 25-34 (RPC= 1.84) and 45-54 (RPC= 1.77) who visited the dentist during the past 24 months. In this study period, a significant increase in dental care use during the past 12 and 24 months was observed among both Blacks (past 12: RPC 4.5) (past 24 months: RPC= 4.42) and Hispanics (past 12: RPC=3.95) (past 24 months: RPC= 3.98). Adults with an education level of less than high school were the only group that showed a significant increase in dental care use during the past 12 months (RPC= 6.17) and 24 months (RPC= 5.3). A significant decrease was seen among adults who were on a health plan in both past 12 (RPC= -3.29) and 24 (RPC= -2.02) months dental care use. However, there was a significant increase in dental care use in the past 12 (RPC=7.31) and 24 months (RPC=6.00) for adults who didn't have health plan. Regarding marital status, the only group who didn't have a significant increase in dental care use was the married group (12 months: RPC= -0.85 , 24 months: RPC= -0.35). By income level, adults with annual income levels less than $15,000 had the highest significant increase in dental care use in past 12 months (RPC= 7.16) and past 24 months (RPC= 5.28). States that had both Medicaid expansion and adult dental benefits had a significant increase in dental care use in the past 12 months (RPC= 1.48) and the past 24 moths (RPC= 1.93).

A sub analysis was done to assess dental care utilization before and after the implementation of Affordable Care Act among U.S. adults by income level (**Table 3**). The prevalence of individuals using dental services in the past 12 and 24 months increased only for low income adults regardless of the expansion status of the state and whether or not the state offered dental benefits. Both middle- and high-income adults had lower prevalence of using dental services after implementation of the ACA in all states.

On both relative and absolute scales, the inequalities in dental care utilization among adults decreased during the study period in all states (**Table 4**). The lowest inequality was seen among adults in expanded states that provided dental benefits. The SII was 0.38 (95% CI 0.36, 0.40) indicating that dental care utilization is on average 38 percentage points higher at the top vs. the bottom of the income distribution. On the relative scale, adults with higher annual incomes were 1.81 times more likely to have dental services in the past year than adults with lower incomes (RII = 1.75, 95% CI 1.09, 1.86). The highest inequality was seen among adults in Medicaid expanded states that didn't provide dental benefits. The SII was 0.45 (95% CI 0.42, 0.48) indicating that dental care utilization was on average 45 percentage points higher at the top vs. the bottom of the income distribution. On the relative scale, adults with higher annual incomes were 2.14 times more likely to have dental services in the past year than adults with lower incomes (RII = 2.14, 95% CI 2.00, 2.29).

After the implementation of the ACA, the odds of utilizing dental services for all adults were 1.26 times higher compared to before the implementation of the ACA, holding other variables

constant, and low income adults had higher odds of using dental services (OR: 1.39, 95% CI (1.30-1.47)). While the odds of using dental services after the implementation of the ACA were not significantly changed for middle income adults (OR: 1.01, 95% CI (0.94-1.08)), the odds were lower for high income adults (OR: 0.93, 95% CI (0.87-0.98)). In states without adult dental benefits, the odds of using dental services in the past 12 months were not significant for all adults (OR: 1.05, 95% CI (1.00-1.10)) and for adults with low incomes (OR: 1.11, 95% CI (1.00-1.23)). On the other hand, middle- and high-income adults had lower odds of utilizing dental services after the implementation of the ACA (OR: 0.84, 95% CI (0.75-0.94)) (OR: 0.84, 95% CI (0.78-0.92)), respectively. In states with adult dental benefits, the odds of using dental services were higher for all adults (OR: 1.15, 95% CI (1.11-1.20)) and especially for adults with low incomes (OR: 1.34, 95% CI (1.24-1.45)) after the ACA implementation. However, middle- and high-income adults had lower odds of utilizing dental services (OR: 0.95, 95% CI (0.87-1.04)) (OR: 0.83, 95% CI (0.77-0.89)), respectively (**Table 5**)**.**

Discussion

The overall prevalence of utilizing dental care significantly increased among U.S. adults aged 25-64 years between 2012 and 2018. We found that after the ACA expansion, the most disadvantaged groups, such as people with less than a high school education, Blacks and Hispanics, those with an income less than $15,000, and those who were unemployed had a higher increase in dental care utilization in the past 12 and 24 months compared to the most advantaged groups. Furthermore, there was a decrease in dental care use during the past year for people with high incomes, employed, married, with a health plan, and who lived in states that expanded Medicaid but didn't include adult dental benefits.

In our study, we analyzed the BRFSS data by stratifying the states into four groups based on the expansion status of the state and whether the state provided adult dental benefits or not. We also stratified our sample size by income level into low-, middle-, and high-income adults. We found that after the expansion, there was a significant increase in the percentage of past 12- and 24-months dental visit among low-income adults in all states, except states that had an expansion but didn't include adult dental benefits. After the expansion, the odds of visiting the dentist among low-income adults in states with a dental benefit was 1.34 times compared to before the expansion. For both middle- and high-income adults, there was a decline in utilizing dental services in the past 12 and 24 months after implementing the expansion.

A study published in November 2020 examined the access to dental care after the expansion by analyzing the National Health Interview Survey. They divided the states into those with and

without an adult benefit. They found that there was a higher increase in seeing a dentist in the past year for low-income adults in states that had an expansion compared to low-income adults in states that didn't expand. However, the increase was not significant, and they point to many barriers that might interfere with the use of dental services, such as health literacy.[17]

Inequality in dental care use by income level decreased for all states on both the relative and absolute scales and the lowest inequality was seen in states that expanded Medicaid and provided dental benefits. However, inequality still exists and people with a high-income level are utilizing dental services more than those with low incomes. Comprehensive dental benefits for adults are offered only in 19 states among 35 states that offer for adults who have Medicaid services beyond emergency situations.[3] Not extending dental coverage to include Medicaid-eligible adults may deprive the most disadvantaged populations from obtaining oral health-care services.

Our study had several limitations. The BRFSS is a telephone interview survey and the response rate in 2018 was relatively low (53.3%). The outcome variable is self-reported and subject to recall bias and to various interpretations of the need for dental treatment. Due to the cross-sectional nature of the collected data, it is not possible to assess the outcome among the same population in a longitudinal fashion. Finally, the income variable in the BRFSS data was categorized into five groups and we couldn't use the threshold of 125% FPL to define the low-income adults.

Conclusion

In our study, low-income adults were the only group who had an increase in the reporting of visiting the dentist in the past 12- and 24-months regardless of the state classification between 2012 and 2018. Inequality still persists as evidenced by the fact that those with a high-income level utilized dental services more than people with low-income levels. Comprehensive dental benefits for adults are offered only in 19 states among 35 states that offer for adults who have Medicaid services beyond emergency situations.[3] Our conclusion from this study is that extending dental coverage to include Medicaid-eligible adults may increase the utilization of dental services for the most disadvantaged populations.

Tables and graphs

Table 1: Socio-Demographic characteristics of adult respondents (aged 25-64) and low-income adult respondents (aged 25-64) in 2012 and 2018. Behavioral Risk Factor Surveillance System.

		All Adult respondent				Low income adult respondent (<25,000$)			
		Pre-Affordable Care Act Reform		Post Affordable Care Act Reform		Pre-Affordable Care Act Reform		Post Affordable Care Act Reform	
	Category	n	Weighted %	n	Weighted %	n	Weighted %	n	Weighted %
Sex	Male	126,109	49.73	121,413	49.81	27,614	47.1	22,445	44.18
	Female	173,298	50.27	135,161	50.19	43,878	52.9	30,134	55.82
Age	25 to 34	66,791	36.68	66,038	37.64	20,197	45.42	15,159	42.32
	35 to 44	55,473	20.71	47,513	20.59	11,177	18.38	8,737	18.52
	45 to 54	77,871	2248	61,213	20.72	17,155	18.98	11,249	17.55
	55 to 64	99,272	19.83	82,487	21.05	22,963	17.22	17,581	21.62
Race/Ethnicity	White (non-Hispanic)	221,999	63.81	180,512	59.05	42,212	45.04	29,214	42.16
	Black (non-Hispanic)	28,123	12.61	23,567	12.89	11,739	18.76	7,718	18.75
	Hispanic	23,843	17.24	26,308	18.88	10,213	28.81	9,158	31.04
	Multiracial	6,628	01.57	5,972	01.43	2,204	1.81	1,568	1.57
	Other	15,314	06.77	15,822	07.75	4,394	5.58	4,197	6.47
Education	<High school diploma high	22,426	14,33	19,342	12.75	12,851	29.79	9,547	28.1
	High school diploma	82,066	28.04	69,318	27.80	27,650	34.25	20,405	35.23
	Some college	84,487	31.34	71,475	31.14	20,968	27.61	15,128	27.86
	≥college degree	109,252	26.29	96,104	28.30	9,928	8.35	7,483	8.81
Poverty Level	<15,000$	31,004	13.41	21,054	09.96				
	15,00-0<25,000	40,488	17.16	31,672	15.26				
	25,000-<35,000$	26,288	10.22	19,808	09.35				
	35,000-<50,000$	37,131	13.46	27,351	12.11				
	>50,000	130,644	45.74	118,654	53.33				
Health plan	Yes	248,849	77.50	225,132	84.96	45,463	55.94	40,724	72.39
	No	49,497	22.50	30,748	15.04	25,758	44.06	11,719	27.61
Employment	Employed	167,783	55.85	147,687	58.14	23,595	36.73	17,339	37.4
	Unemployed	107,905	39.56	89,021	37.27	43,136	59.92	31,756	58.57
	Retired	22,051	4.59	17,076	04.59	4,514	3.34	3,206	4.03
Marital status	Married	166,089	4885	133,631	49.46	18,716	25.13	12,660	25.95
	Wid/Div/Sep	62,498	15.27	49,866	14.87	26,311	24.61	18,372	25.48
	Never Married	58,526	30.07	59,582	29.98	22,593	41.44	18,118	40.76
	Unmarried couple	10,271	05.81	12,073	05.69	3,512	8.82	3,227	7.8
Expansion	Expansion/adult benefit	141,495	52.46	118,080	51.69	33,013	50.48	23,900	49.83
	No expansion/Adult benefit	49,631	09.85	35,436	09.69	11,826	9.7	6,899	9.22
	No expansion/No adult	39,749	08.27	36,172	08.26	9,036	8.03	7,350	8.29
	No expansion/No adult benefit	68,532	29.41	67,563	30.22	17,617	31.8	14,577	32.66

Table 2: Trends in in dental care utilization among adult respondents (aged 25-64) (BRFSS, United States, 2012 & 2016-2018)

		Proportion of respondents with a Dental visit in the past 12 months				Proportion of respondents with a Dental visit in the past 24 months			
		Pre ACA 2012 %(95% CI)	Post ACA 2016-2018 %(95% CI)	RPC (%)	P - value	Pre ACA 2012 %(95% CI)	Post ACA 2016-2018 % (95% CI)	RPC (%)	P - value
Overall		65.67 (65.27-66.08)	66.34 (66.05-66.63)	1.02	<0.05	78.18 (77.82-78.54)	79.12 (78.88-79.37)	1.2	<0.05
Sex	Male	62.49 (61.87-63.10)	63.38 (62.96-63.80)	1.42	<0.05	75.67 (75.12-76.22)	76.47 (76.10-76.85)	1.06	<0.05
	Female	68.77 (68.23-69.30)	69.23 (68.84-69.62)	0.67	0.171	80.63 (80.16-81.09)	81.72 (81.39-82.04)	1.35	<0.05
Age	25 to 34	63.39 (62.62-64.17)	64.93 (64.42-65.44)	2.43	<0.05	77.79 (77.11-78.46)	79.22 (78.78-79.66)	1.84	<0.05
	35 to 44	65.84 (64.94-66.74)	66.14 (65.49-66.80)	0.46	0.593	79.07 (78.28-79.87)	79.17 (78.60-79.74)	0.12	0.85
	45 to 54	66.61 (65.81-67.40)	67.26 (66.67- 67.85)	0.98	0.195	77.83 (77.12-78.55)	79.21 (78.69-79.73)	1.77	<0.05
	55 to 64	68.58 (67.89-69.28)	68.09 (67.56-68.62)	-0.71	0.273	78.38 (77.75-79.00)	78.82 (78.37-79.27)	0.56	0.262
Race/ Ethnicity	White	69.05 (68.62-69.48)	69.10 (68.80-69.41)	0.07	0.837	80.15 (79.78-80.53)	80.28 (80.02-80.54)	0.15	0.577
	Black	59.99 (58.74-61.24)	62.69 (61.87-63.51)	4.5	<0.05	75.04 (73.90-76.17)	78.00 (77.31-78.70)	3.95	<0.05
	Hispanic	57.05 (55.62-58.49)	59.57 (58.56-60.57)	4.42	<0.05	72.68 (71.40-73.96)	75.57 (74.69-76.46)	3.98	<0.05
	Multiracial	60.88 (57.90-63.86)	60.32 (58.27-62.36)	-0.92	0.764	75.89 (73.28-78.50)	73.80 (71.88-75.72)	-2.75	0.207
	Other	65.95 (64.02-67.88)	67.51 (66.21-68.81)	2.37	0.167	79.22 (77.51-80.92)	81.42 (80.37-82.47)	2.78	<0.05
Education	less than HS	44.74 (43.25-46.22)	47.50 (46.40-48.61)	6.17	<0.05	59.90 (58.45-61.35)	62.98 (61.93-64.02)	5.13	<0.05
	HS/GD	60.42 (59.65-61.18)	60.49 (59.93-61.06)	0.12	0.809	74.11 (73.43-74.80)	74.67 (74.17-75.17)	0.75	0.194
	Some College	67.49 (66.77-68.21)	67.47 (66.97-67.98)	-0.03	0.921	80.37 (79.76-80.98)	80.53 (80.11-80.94)	0.19	0.591
	College +	79.51 (78.98-80.04)	78.99 (78.61-79.34)	-0.65	0.150	89.02 (88.60-89.44)	88.91 (88.62-89.20)	-0.12	0.699
Health plan	Yes	72.73 (72.32-73.14)	70.34 (70.05-70.63)	-3.29	<0.05	84.06 (83.72-84.40)	82.36 (82.12-82.61)	-2.02	<0.05
	No	40.35 (39.35-41.36)	43.30 (42.37-44.24)	7.31	<0.05	57.01 (55.98-58.03)	60.42 (59.53-61.32)	6.00	<0.05
Marital status	Married	72.10 (71.60-72.60)	71.49 (71.10-71.88)	-0.85	<0.05	83.08 (82.66-83.51)	82.79 (82.47-83.12)	-0.35	<0.05
	Wid/Div/Sep	54.93 (53.99-55.87)	57.24 (56.54-57.94)	4.21	<0.05	.68.59 (67.71-69.47)	70.70 (70.06-71.34)	3.08	<0.05
	Never Married	62.55 (61.67-63.43)	64.06 (63.49-64.63)	2.41	<0.05	76.59 (75.81-77.38)	78.48 (78.00-78.97)	2.47	<0.05
	unmarried couple	54.57 (52.39-56.76)	56.73 (55.37-58.09)	3.96	<0.05	69.55 (67.53-71.57)	72.26 (71.00-73.52)	3.90	<0.05
Employment status	Employed for wages	70.03 (69.52-70.55)	69.52 (69.15-69.88)	-0.73	0.218	81.96 (81.53-82.40)	81.62 (81.31-81.93)	-0.42	0.318
	unemployed	58.38 (57.66-59.09)	60.55 (60.04-61.05)	3.72	<0.05	72.21 (71.55-72.87)	74.79 (74.35-75.23)	3.57	<0.05

	Retired	74.06 (72.74-75.38)	71.79 (70.71-72.87)	-3.07	<0.05	82.66 (81.49-83.82)	81.77 (80.84-82.71)	-1.07	0.220
Income	<15,000$	44.15 (42.82-45.49)	47.31 (46.23-48.39)	7.16	<0.05	59.77 (58.45-61.08)	62.92 (61.88-63.97)	5.28	<0.05
	15,000<25,000	49.60 (48.47-50.72)	51.81 (50.96-52.67)	4.46	<0.05	65.24 (64.16-66.31)	68.17 (67.39-68.95)	4.49	<0.05
	25,000-<35,000$	56.91 (55.45-58.37)	56.00 (54.90-57.09)	-1.60	0.248	72.82 (71.51-74.13)	71.82 (70.84-72.80)	-1.38	0.162
	35,000-<50,000$	66.78 (65.66-67.90)	63.44 (62.54-64.35)	-5.00	<0.05	79.76 (78.78-80.74)	77.36 (76.56-78.16)	-3.01	<0.05
	>50,000	79.85 (79.33-80.37)	77.28 (76.90-77.66)	-3.22	<0.05	89.21 (88.79-89.62)	87.43 (87.13-87.74)	-1.99	<0.05
Expansion	Expansion/adult benefit	68.86 (68.24-69.48)	69.88 (69.50-70.26)	1.48	<0.05	80.79 (80.25-81.33)	82.35 (82.04-82.67)	1.93	<0.05
	No expansion/Adult benefit	66.52 (65.69-67.34)	66.55 (65.85-67.25)	0.05	0.961	77.67 (78.39-79.11)	78.03 (77.42-78.65)	0.47	0.47
	Expansion/ No adult benefit	66.33 (65.40-67.25	64.58 (63.95-65.22)	-2.64	<0.05	78.24 (79.05-79.85)	77.54 (76.98-78.11)	-0.89	<0.05
	No expansion/No adult benefit	62.01 (61.27-62.76)	63.22 (62.66-63.77)	1.95	<0.05	74.58 (75.24-75.91)	76.60 (76.11-77.08)	2.71	<0.05

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Table 3: Dental Care Utilization Among Adults 25-64 by income level. Pre- and Post-Affordable Care Act Reform in expansion and non-expansion states

		12-month dental visit			24-month dental visit		
		Low income	**Middle income**	**High income**	**Low income**	**Middle income**	**High income**
Expansion with adult benefit	Pre	50.05 (48.96,51.14)	62.97 (61.85,64.09)	80.45 (79.84,81.06)	82.08 (80.58,83.57)	92.36 (90.93,93.78)	98.28 (97.60,98.97)
	Post	53.18 (52.07,54.29)	62.36 (61.20,63.53)	77.78 (77.16,78.40)	88.57 (87.06,90.09)	91.88 (90.44,93.32)	98.02 (97.31,98.72)
RPC %		6.25	-0.97	-3.32	7.91	-0.52	-0.26
P -value		<0.05	0.483	<0.05	<0.05	0.464	<0.05
No expansion with adult benefit	Pre	45.91 (44.36,47.47)	63.37 (61.77,64.96)	81.08 (80.09,82.07)	75.95 (73.78,78.12)	89.84 (87.84,91.84)	98.00 (96.90,99.10)
	Post	49.19 (47.01,51.38)	58.10 (55.99,60.22)	78.06 (76.86,79.25)	80.41 (77.48,83.33)	86.45 (83.67,89.23)	95.69 (94.33,97.04)
RPC %		7.14	-8.23	-3.72	5.87	-3.77	-2.36
P -value		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Expansion with no adult benefit	Pre	45.25 (43.38,47.13)	60.32 (58.47,62.17)	79.25 (78.22,80.29)	79.30 (76.62,81.99)	91.05 (88.68,93.42)	98.87 (97.69,100.00)
	Post	46.06 (43.95,48.16)	56.36 (54.20,58.52)	75.08 (74.00,76.17)	79.60 (76.71,82.50)	86.60 (83.73,89.48)	96.04 (94.78,97.30)
RPC %		1.79	-6.56	-5.26	.38	-4.89	-2.86
P -value		0.539	<0.05	<0.05	0.646	<0.05	<0.05
No expansion with no adult benefit	Pre	43.54 (42.10,44.97)	60.28 (58.66,61.89)	78.17 (77.17,79.18)	74.58 (72.51,76.66)	89.23 (87.15,91.30)	98.57 (97.40,99.73)
	Post	46.93 (45.01,48.86)	58.11 (56.08,60.15)	75.11 (73.97,76.25)	77.7 (75.21,0.24)	87.93 (85.34,90.52%	97.42 (96.05,98.78
RPC %		7.79	-3.6	-3.91	4.18	-1.46	-1.17
P -value		<0.05	0.100	<0.05	<0.05	0.140	<0.05

Table 4: Slope and relative indices of inequality in dental care utilization by income group (5 categories) among adults 25-64. Pre- and Post-Affordable Care Act Reform in expansion and non-expansion states

		SII	RII
Expansion with adult benefit	Pre	0.46	2.11
		(0.44,0.48)	(2.04,2.18)
	Post	0.38	1.81
		(0.36,0.40)	(1.75,1.86)
No expansion with adult benefit	Pre	0.51	2.40
		(0.49,0.54)	(2.27,2.53)
	Post	0.45	2.08
		(0.42,0.48)	(1.95,2.21)
Expansion with no adult benefit	Pre	0.51	2.40
		(0.48,0.53)	(2.25,2.55)
	Post	0.45	2.14
		(0.42,0.48)	(2.00,2.29)
No expansion with no adult benefit	Pre	0.52	2.54
		(0.50,0.54)	(2.40,2.68)
	Post	0.44	2.10
		(0.41,0.47)	(1.97,2.23)

Table 5 : Results from logistic regression models examining the impact of ACA on dental visits, BRFSS 2012 and 2018

	All OR (95% CI)	Low income OR (95% CI)	Middle income OR (95% CI)	High income OR (95% CI)
Overall	1.26 (1.22-1.30)	1.39 (1.30-1.47)	1.01 (0.94-1.08)	0.93 (0.87-0.98)
Without adults' dental benefit	1.05 (1.00-1.10)	1.11 (1.00-1.23)	0.84 (0.75-0.94)	0.84 (0.78-0.92)
With adults' dental benefit	1.15 (1.11-1.20)	1.34 (1.24-1.45)	0.95 (0.87-1.04)	0.83 (0.77-0.89)

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