

Neighborhood Social Vulnerability and Oral Health Outcomes in California: A Census-Tract Ecological Analysis

Anna-Lena Asiedu¹

anna-lena.asiedu@ucsf.edu

University of California, San Francisco School of Dentistry

Collins Gaba²

Boston University

Research Article

Keywords: Social Vulnerability Index, oral health disparities, edentulism, dental care utilization, census tract

Posted Date: July 28th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10453462/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Background

Neighborhood social vulnerability may influence oral health through socioeconomic disadvantage and barriers to care, yet evidence at the census-tract level remains limited, and the independent contributions of different dimensions of social vulnerability remain poorly understood. We examined the association between the Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry (CDC/ATSDR) Social Vulnerability Index (SVI) and two tract-level oral health outcomes across California census tracts.

Methods

We conducted a cross-sectional ecological study of 9,019 California census tracts representing 39.2 million residents. Tract-level 2022 SVI data were linked to CDC PLACES estimates of edentulism among adults aged ≥ 65 years and past-year dental visits among adults aged ≥ 18 years. Census tracts with populations below 500 were excluded. Associations were estimated using fractional logistic regression with county-clustered standard errors. The four SVI domains were evaluated in mutually adjusted models, and robustness was assessed using the Area Deprivation Index, Social Deprivation Index, and independent county-level estimates from the California Health Interview Survey.

Results

Each 0.10-unit increase in SVI was associated with 20% higher odds of edentulism (odds ratio [OR], 1.195; 95% confidence interval [CI], 1.183–1.207) and 13% lower odds of a past-year dental visit (OR, 0.873; 95% CI, 0.868–0.877). A monotonic dose-response relationship was observed across SVI quartiles: edentulism increased from 5.6% in the least vulnerable quartile to 18.1% in the most vulnerable quartile, whereas past-year dental visits declined from 72.4% to 48.8%. Socioeconomic status demonstrated the strongest independent association with both outcomes, whereas the minority status and language domain remained independently associated with dental visits but not edentulism. Findings were robust across alternative disadvantage indices and independent survey estimates.

Conclusions

Higher neighborhood social vulnerability was strongly associated with both edentulism and dental care utilization across California census tracts. Tract-level analyses identified socioeconomic vulnerability as the dominant dimension associated with oral health disparities and revealed geographic patterns that may not be apparent in county-level analyses. These findings support the use of tract-level social vulnerability measures to guide more equitable allocation of preventive and clinical dental resources.

Trial registration

Not applicable. This study used publicly available, de-identified data and did not involve human participants.

Background

Oral health inequities remain a major public health challenge despite substantial advances in preventive and therapeutic dental care (1, 2). Although oral diseases are largely preventable, they continue to disproportionately affect socially and economically disadvantaged populations, contributing to persistent disparities in oral health outcomes both globally and within the United States (3, 4). These inequities are reflected in higher rates of untreated dental caries, periodontal disease, edentulism, and unmet dental care needs among populations experiencing social disadvantage (5, 6). Edentulism and routine dental visits are widely used population-level indicators of oral health status and access to care, respectively, with edentulism reflecting the cumulative burden of oral disease over the life course (5, 7) and routine dental visits representing access to preventive and restorative dental care (8).

Growing evidence indicates that oral health is shaped not only by individual behaviors and clinical care but also by the social determinants of health and the broader environments in which people live (9, 10). Neighborhood characteristics, including socioeconomic conditions, housing, transportation, and access to healthcare, influence both the development of oral disease and the ability to obtain preventive dental services (11). Consequently, increasing attention has focused on neighborhood-level measures that capture these complex social and structural influences (12).

Among the most widely used measures is the Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry (CDC/ATSDR) Social Vulnerability Index (SVI), which incorporates 16 variables across four domains: socioeconomic status; household composition and disability; racial and ethnic minority status and language; and housing type and transportation. By integrating multiple dimensions of vulnerability into a single measure while retaining information on its individual domains, the SVI provides a comprehensive framework for evaluating neighborhood context beyond socioeconomic deprivation alone (13). Accordingly, the SVI has been widely applied in epidemiologic and health services research, where greater neighborhood social vulnerability has consistently been associated with poorer health outcomes, including cardiovascular disease, heart failure, diabetes, adverse maternal and child health outcomes, cancer, infectious diseases, and premature mortality (13–16).

Although the application of neighborhood social vulnerability measures to oral health research remains comparatively limited, emerging evidence suggests that greater social vulnerability is associated with poorer oral health outcomes, greater reliance on emergency dental services, and reduced access to dental providers (17–19). In a California census tract-level ecological study, Chong and Gansky reported that neighborhood social and environmental conditions, measured using the Healthy Places Index and

residential segregation indices, were associated with higher edentulism prevalence among adults aged 65 years and older (17). Similarly, Gaskin et al. found that socially vulnerable areas experienced substantially higher emergency dental care utilization and that greater dental provider availability was associated with lower emergency service use (18). Collectively, these findings underscore the importance of neighborhood social conditions in shaping oral health and access to dental care (17–19).

Despite these advances, important knowledge gaps remain. Existing studies provide limited insight into which dimensions of neighborhood social vulnerability are most strongly associated with oral health outcomes, limiting the ability to identify the specific neighborhood characteristics that may be most relevant for intervention. Relatively few studies have examined neighborhood social vulnerability and oral health at the census-tract level, where substantial within-county variation in neighborhood vulnerability and oral health exists. Few investigations have simultaneously examined complementary indicators of oral health status and dental care utilization at the census-tract level. California represents an ideal setting for this investigation because of its large, socioeconomically and demographically diverse population and substantial variation in neighborhood social vulnerability (17–19).

Therefore, this study aimed to examine the association between neighborhood social vulnerability, measured using the Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry (CDC/ATSDR) Social Vulnerability Index (SVI), and two census tract-level oral health outcomes—edentulism among adults aged 65 years and older and past-year dental visits among adults aged 18 years and older—across California. We further examined the associations of the overall SVI and the independent contributions of its four domains, evaluated in mutually adjusted models, and assessed the robustness of our findings using alternative measures of area-level disadvantage and independently derived survey estimates. We hypothesized that greater neighborhood social vulnerability would be associated with higher edentulism prevalence and lower prevalence of past-year dental visits.

Methods

Study design and setting

We conducted a cross-sectional ecological study of census tracts in California, United States. Census tracts are relatively permanent statistical subdivisions of counties that average approximately 4,000 residents and represent the most granular geographic level at which both the exposure and outcome measures used in this study are publicly available (20). All data sources used 2020 census tract boundaries, allowing direct linkage using the 11-digit Federal Information Processing Standards (FIPS) tract identifier without the need for geographic crosswalks. The study used publicly available, aggregate, de-identified data and therefore did not constitute human subjects research.

Outcome measures

Two primary tract-level oral health outcomes were obtained from the Centers for Disease Control and Prevention (CDC) PLACES: Local Data for Better Health, 2025 release (21): the prevalence of edentulism (complete tooth loss) among adults aged 65 years and older and the prevalence of a dental visit within the past year among adults aged 18 years and older. PLACES provides model-based small-area estimates derived from the 2022 Behavioral Risk Factor Surveillance System (BRFSS) using multilevel regression and poststratification. The estimation process incorporates tract-level sociodemographic characteristics from the American Community Survey (ACS) and census population data (22, 23). Tract-level PLACES estimates are crude (not age-standardized) prevalence estimates expressed as percentages.

To support validation and supplementary analyses, county-level 2022 estimates of three oral health indicators were obtained from AskCHIS Neighborhood Edition – UCLA Center for Health Policy Research (24): a dental visit within the past year among adults aged 18 years and older, lack of dental insurance among adults, and teeth in fair or poor condition among adults. These model-based small-area estimates are derived from the California Health Interview Survey (CHIS) using a survey and estimation framework independent of both BRFSS and PLACES. The CHIS-based dental visit indicator, which measures the same construct as the PLACES dental visit outcome, was included to assess agreement between county-aggregated PLACES estimates and independently derived estimates. The two additional indicators—lack of dental insurance among adults and teeth in fair or poor condition among adults—were included to descriptively examine county-level associations with social vulnerability. Estimates were available for 57 of California's 58 counties; estimates for Alpine County were suppressed because the county population was below 1,000.

Exposure: Social Vulnerability Index

The primary exposure was the 2022 CDC/Agency for Toxic Substances and Disease Registry (ATSDR) Social Vulnerability Index (SVI) (25). The SVI summarizes 16 ACS-derived variables (2018–2022 five-year estimates) into four thematic domains: socioeconomic status; household composition and disability; racial and ethnic minority status and language; and housing type and transportation, together with an overall composite index (13). We used the state-based ranking, in which each California census tract is assigned a percentile rank ranging from 0 (least vulnerable) to 1 (most vulnerable) relative to all other California tracts, for both the overall SVI and each of the four subthemes. Census tracts assigned a value of – 999 by the CDC, indicating insufficient data for ranking, were excluded. For clarity of interpretation, subthemes are reported herein as vulnerability domains (e.g., 'socioeconomic vulnerability' for the CDC theme labeled 'socioeconomic status'); higher percentile values indicate greater vulnerability on each dimension.

Alternative area-level disadvantage indices

We performed two prespecified sensitivity analyses to evaluate the robustness of the primary findings to alternative measures of area-level socioeconomic disadvantage.

First, we used the 2024 Area Deprivation Index (ADI, version 4.0.1), a 17-variable measure of socioeconomic deprivation available at the census block-group level (26, 27). Because the ADI national percentile is strongly influenced by housing values expressed in dollar terms and is less well calibrated in high-housing-cost states such as California (28, 29), we used the state-specific decile ranking. Block groups with suppression codes assigned by the data distributor were treated as missing, and block-group values were aggregated to the census tract level using an unweighted mean.

Second, we used the Social Deprivation Index (SDI), a seven-variable measure of socioeconomic deprivation originally developed by the Robert Graham Center (30). Because the developer's tract-level releases are based on 2010 census boundaries, we used the Stanford Population Health Sciences (SEPI) implementation, which was constructed from 2016–2020 ACS estimates using 2020 census tract boundaries (31). To facilitate direct comparison with the state-ranked SVI, both alternative indices were converted to within-California percentile ranks ranging from 0 to 1. Sensitivity analyses were conducted using the complete-case sample of census tracts with values available for all three indices, ensuring that estimates were compared using an identical analytic sample.

Comparison with independent survey estimates

Because both the PLACES outcome estimates and the SVI incorporate ACS data, we compared the PLACES-derived estimates with the independently derived AskCHIS estimates. Tract-level PLACES dental visit estimates were aggregated to the county level using population-weighted means. Agreement between county-level PLACES and CHIS dental visit estimates was assessed using Pearson, population-weighted, and Spearman correlation coefficients, together with the mean paired difference. Given the limited number of counties, associations between county-level SVI, computed as the population-weighted mean of tract-level SVI, and the AskCHIS oral health indicators were summarized descriptively using correlation coefficients and mean values across county SVI tertiles rather than formal regression models.

Analytic sample

PLACES outcome estimates were linked to SVI data using census tract FIPS codes. Census tracts with populations below 500 were excluded because they fall well below the Census Bureau's recommended minimum population size for census tracts and may disproportionately represent special-use or group-quarters areas, where model-based residential prevalence estimates are less reliable (20). We also excluded tracts with missing values for either oral health outcome or the overall SVI.

Statistical analysis

Because the outcomes were tract-level prevalence proportions bounded between 0 and 1, associations were estimated using fractional logistic regression implemented as generalized linear models with a quasibinomial family and logit link (32). Fractional logistic regression is well suited for modeling proportion outcomes because it accommodates fractional response variables while ensuring predicted values remain within the 0–1 interval. To account for clustering of census tracts within counties, standard errors were estimated using cluster-robust variance estimators at the county level.

Results are presented as odds ratios (ORs) with 95% confidence intervals (CIs) for each 0.10-unit increase in index percentile. To facilitate interpretation, we also calculated average marginal effects (AMEs), expressed as changes in prevalence percentage points associated with each 0.10-unit increase in SVI.

Dose-response relationships were examined by dividing census tracts into within-California SVI quartiles and comparing the distribution of each oral health outcome across quartiles. The independent associations of the four SVI subthemes with each outcome were evaluated using mutually adjusted models that included all four subthemes simultaneously.

As an additional supporting analysis, we fitted county random-intercept linear mixed models on the logit scale to quantify the proportion of between-tract variation attributable to county-level differences using the intraclass correlation coefficient (ICC). All statistical analyses were performed using R version 4.5.1.

Results

Sample characteristics

The 2022 CDC/ATSDR SVI dataset contained 9,109 California census tracts. Of these, 68 tracts were unranked by the CDC (coded – 999) and excluded. Among the remaining 9,041 tracts, 4 lacked corresponding PLACES estimates, 1 was missing an oral health outcome estimate, and 17 had populations below 500. The final analytic sample comprised 9,019 California census tracts across all 58 counties, representing approximately 39.2 million residents (Table 1). The median tract population was 4,207 (interquartile range [IQR], 3,160–5,359). The mean tract-level prevalence of edentulism among adults aged 65 years and older was 10.9% (standard deviation [SD], 6.2), with a median of 9.5% (IQR, 6.3–14.1). The mean prevalence of a past-year dental visit among adults aged 18 years and older was 61.6% (SD, 10.5), with a median of 63.1% (IQR, 54.2–69.8). The mean overall SVI percentile was 0.50 (SD, 0.29). ADI values were available for 8,975 census tracts (99.5%), while SDI values were available for 9,014 tracts (99.9%).

Table 1
Characteristics of the analytic sample of California census tracts (n = 9,019)

Characteristic	Mean (SD)	Median	IQR
Edentulism, adults ≥ 65 years, %	10.9 (6.2)	9.5	6.3–14.1
Past-year dental visit, adults ≥ 18 years, %	61.6 (10.5)	63.1	54.2–69.8
Overall SVI (within-California percentile)	0.50 (0.29)	0.50	0.25–0.75
Tract population	4,351 (1,695)	4,207	3,160–5,359

SD, standard deviation; IQR, interquartile range; SVI, Social Vulnerability Index. Prevalence values are CDC PLACES model-based estimates derived from the 2022 Behavioral Risk Factor Surveillance System.

Association between social vulnerability and oral health outcomes

Higher tract-level social vulnerability was consistently associated with poorer oral health outcomes (Table 2). For every 0.10-unit increase in the overall SVI percentile, the odds of edentulism among adults aged 65 years and older increased by 20% (OR, 1.195; 95% CI, 1.183–1.207), corresponding to an average increase of 1.69 percentage points in edentulism prevalence. Conversely, each 0.10-unit increase in SVI was associated with a 13% reduction in the odds of a past-year dental visit among adults aged 18 years and older (OR, 0.873; 95% CI, 0.868–0.877), corresponding to an average decrease of 3.11 percentage points in dental visit prevalence.

County random-intercept models produced nearly identical estimates, indicating that the observed associations were robust to between-county variation. Approximately 17% of the variation in edentulism prevalence and 16% of the variation in dental visit prevalence was attributable to differences between counties.

Table 2
Association between overall Social Vulnerability Index and tract-level oral health outcomes, California census tracts (n = 9,019)

Outcome	Adjusted OR per 0.10 SVI (95% CI)	AME (percentage points per 0.10 SVI)
Edentulism, adults ≥ 65 years	1.195 (1.183–1.207)	+ 1.69
Past-year dental visit, adults ≥ 18 years	0.873 (0.868–0.877)	–3.11

OR, odds ratio; CI, confidence interval; AME, average marginal effect; SVI, Social Vulnerability Index. Estimates were obtained from fractional logistic regression models with county-clustered standard errors.

Dose-response relationship across the SVI distribution

A clear monotonic dose-response relationship was observed across SVI quartiles for both oral health outcomes (Fig. 1). Mean edentulism prevalence increased more than threefold, from 5.6% in the least vulnerable quartile to 18.1% in the most vulnerable quartile. In contrast, the prevalence of a past-year dental visit declined from 72.4% to 48.8%, representing an absolute difference of 23.6 percentage points.

For dental visits, the interquartile ranges of adjacent SVI quartiles showed minimal overlap, and the distribution in the most socially vulnerable quartile lay almost entirely below that of the least vulnerable quartile. Examination of the continuous association confirmed that these gradients were not an artifact of categorization (Fig. 2). The relationship between SVI and edentulism became steeper at higher levels of social vulnerability, whereas the association with dental visits remained approximately linear across the full SVI distribution.

The analysis included 9,019 California census tracts, with 2,255, 2,255, 2,255, and 2,254 tracts in SVI quartiles 1–4, respectively. Quartile 1 included tracts with SVI percentiles ≤ 0.25 , quartile 2 > 0.25 to ≤ 0.50 , quartile 3 > 0.50 to ≤ 0.75 , and quartile 4 > 0.75 . Boxes represent the interquartile range, with the horizontal line indicating the median. Whiskers extend to 1.5 times the interquartile range, and points represent outlying census tracts.

Each point represents one California census tract ($n = 9,019$). The Social Vulnerability Index (SVI) is expressed as the within-California percentile rank, ranging from 0 (least vulnerable) to 1 (most vulnerable). Solid lines represent locally estimated scatterplot smoothing (LOESS) curves with 95% confidence bands, illustrating the observed relationship without assuming linearity. Dashed lines represent fitted linear regression lines for comparison.

Associations of SVI subthemes with oral health outcomes

In mutually adjusted models including all four SVI subthemes (Table 3), socioeconomic vulnerability exhibited the strongest independent association with both oral health outcomes. For every 0.10-unit increase in socioeconomic vulnerability, the odds of edentulism increased by 17% (OR, 1.168; 95% CI, 1.153–1.184), while the odds of a past-year dental visit decreased by 10% (OR, 0.901; 95% CI, 0.895–0.908).

Minority status and language vulnerability remained independently associated with lower odds of a past-year dental visit (OR, 0.963; 95% CI, 0.960–0.966) but showed no independent association with edentulism (OR, 0.998; 95% CI, 0.993–1.004). Household composition and disability vulnerability demonstrated modest associations with both outcomes, whereas housing type and transportation vulnerability showed comparatively weak associations with inconsistent directions of effect. Together, these findings indicate that the overall SVI–oral health association was driven predominantly by the socioeconomic dimension, with minority status and language vulnerability contributing independently to the access-related outcome but not to cumulative disease burden.

Table 3

Mutually adjusted associations between Social Vulnerability Index subthemes and tract-level oral health outcomes (n = 9,019)

SVI subtheme	Edentulism, Adjusted OR per 0.10 (95% CI)	Past-year dental visit, Adjusted OR per 0.10 (95% CI)
Socioeconomic vulnerability	1.168 (1.153–1.184)	0.901 (0.895–0.908)
Household composition & disability vulnerability	1.040 (1.029–1.052)	0.983 (0.978–0.987)
Minority status & language vulnerability	0.998 (0.993–1.004)	0.963 (0.960–0.966)
Housing type & transportation vulnerability	1.009 (1.005–1.013)	0.996 (0.993–0.999)

Subthemes correspond to the four CDC/ATSDR SVI themes (socioeconomic status; household characteristics and disability; racial and ethnic minority status and language; housing type and transportation), expressed as within-California percentile ranks; higher values indicate greater vulnerability. All four SVI subthemes were entered simultaneously into a single fractional logistic regression model for each outcome. Standard errors were clustered at the county level. All subthemes are expressed as within-California percentile ranks.

Sensitivity analyses using alternative disadvantage indices

The primary findings remained robust when alternative area-level disadvantage indices were used (Supplementary Table S1). In the complete-case sample of 8,975 census tracts, both the SDI and the state-ranked ADI demonstrated associations that were consistent in direction and similar in magnitude to those observed for the primary SVI analysis.

For edentulism, the OR per 0.10-unit increase was 1.182 (95% CI, 1.171–1.193) for the SDI and 1.148 (95% CI, 1.137–1.158) for the ADI. For past-year dental visits, the corresponding ORs were 0.879 (95% CI, 0.874–0.883) and 0.905 (95% CI, 0.898–0.913), respectively. Associations were consistent in direction and magnitude across all three indices, indicating that the primary findings were robust to the choice of area-level disadvantage measure.

Comparison with independent survey estimates

County-aggregated PLACES estimates of past-year dental visits demonstrated strong agreement with independently modeled CHIS estimates across the 57 counties included in the comparison (Pearson $r = 0.81$; population-weighted $r = 0.88$; Spearman $\rho = 0.79$). PLACES estimates were, on average, 4.8 percentage points lower than CHIS estimates (SD, 3.1), indicating strong agreement in county-level rankings despite systematic differences in absolute prevalence estimates.

County-level social vulnerability was associated with all three CHIS-derived oral health indicators in the expected direction. Higher county SVI was correlated with lower prevalence of past-year dental visits ($r =$

– 0.74), higher prevalence of teeth in fair or poor condition ($r = 0.66$), and higher prevalence of dental uninsurance ($r = 0.39$). Across county SVI tertiles, the mean prevalence of past-year dental visits declined from 69.5% in the least vulnerable counties to 62.5% in the most vulnerable counties. Over the same gradient, the prevalence of teeth in fair or poor condition increased from 23.8% to 30.0%, while dental uninsurance increased from 29.8% to 35.5% (Supplementary Table S2).

Discussion

In this statewide census tract-level ecological analysis, greater neighborhood social vulnerability was strongly and consistently associated with both higher edentulism prevalence among older adults and lower prevalence of past-year dental visits among adults. A clear dose-response relationship was observed across the full distribution of social vulnerability, with census tracts in the most vulnerable quartile experiencing more than three times the prevalence of edentulism and nearly 24 percentage points lower prevalence of past-year dental visits than those in the least vulnerable quartile. These marked gradients indicate meaningful geographic inequalities in cumulative oral disease burden and access to preventive dental care. Importantly, these findings highlight substantial within-county heterogeneity that may be obscured by broader geographic analyses (17).

Among the four SVI domains, socioeconomic vulnerability demonstrated the strongest independent association with both outcomes, suggesting that material deprivation may be a principal pathway linking neighborhood social vulnerability to oral health inequities. Financial barriers and delayed preventive care may contribute to the cumulative progression of oral disease over the life course (33), and transportation challenges may further compound access difficulties in socioeconomically vulnerable neighborhoods (34). In contrast, the minority status and language domain remained independently associated with dental visits but not edentulism, suggesting that language and related structural barriers primarily influence access to dental care rather than cumulative disease burden (35). These findings indicate that different dimensions of social vulnerability may require different public health approaches.

Our findings build upon and extend previous studies linking neighborhood disadvantage with oral health by simultaneously examining cumulative disease burden, routine dental care utilization, and the independent contributions of the four SVI domains across more than 9,000 California census tracts. The consistency of the findings across the SVI, SDI, and ADI, together with the strong agreement between PLACES-derived dental visit estimates and independently derived CHIS estimates, strengthens confidence that the observed associations are robust and unlikely to reflect a particular deprivation measure or shared reliance on American Community Survey data alone. Taken together, these findings suggest that neighborhood social vulnerability captures multiple dimensions of oral health inequity, making the Social Vulnerability Index a useful framework for identifying communities where preventive interventions and dental resources may have the greatest impact.

These findings have important implications for oral health planning and resource allocation. County-level measures alone may overlook neighborhoods with substantial oral health needs, whereas tract-level

social vulnerability measures could support more precise oral health surveillance, needs assessments, and targeting of preventive services and dental workforce resources (17). The domain-specific findings further suggest that interventions should address the predominant drivers of vulnerability, including reducing financial barriers in socioeconomically vulnerable communities (33) and improving language access and culturally responsive care in communities with high minority status and language vulnerability (35).

Strengths and limitations

Strengths of this study include statewide coverage of more than 9,000 California census tracts, fine geographic resolution, simultaneous evaluation of complementary measures of oral disease burden and dental care utilization, examination of the four SVI domains, and confirmation of findings using alternative deprivation indices and independent CHIS estimates.

Some limitations should also be considered. As an ecological, cross-sectional study, the findings describe neighborhood-level associations and cannot establish causality or be interpreted at the individual level (36). The oral health outcomes were model-based PLACES estimates, and both PLACES and the SVI incorporate American Community Survey data, although the consistency of findings across alternative indices and CHIS estimates reduces concern that shared inputs fully explain the observed associations. In addition, edentulism reflects cumulative lifetime disease whereas neighborhood social vulnerability was measured contemporaneously, limiting inference regarding the timing of exposure. Residual confounding by unmeasured neighborhood characteristics—including fluoridation, dental insurance (37), provider participation (38), rurality, and local policy—is also possible. Because the four SVI domains are correlated, the mutually adjusted domain-specific estimates should be interpreted as relative associations rather than fully independent effects. Finally, because SVI percentiles were ranked within California, the observed gradients reflect relative vulnerability within the state and may not directly generalize to other settings.

Conclusion

Neighborhood social vulnerability was strongly associated with both cumulative oral disease burden and dental care utilization across California census tracts, with socioeconomic vulnerability emerging as the dominant independent dimension. These findings suggest that neighborhood social vulnerability is an important contextual influence on oral health and that examining its individual domains provides additional insight beyond the overall composite index. By identifying high-need communities that may be overlooked using broader geographic measures, tract-level social vulnerability measures have the potential to support more equitable and data-informed oral health policy and resource allocation. Future studies should evaluate whether interventions targeting socially vulnerable communities can reduce oral health disparities and improve access to dental care (39).

Abbreviations

ACS

American Community Survey

ADI

Area Deprivation Index

AME

Average Marginal Effect

ATSDR

Agency for Toxic Substances and Disease Registry

BRFSS

Behavioral Risk Factor Surveillance System

CDC

Centers for Disease Control and Prevention

CHIS

California Health Interview Survey

CI

Confidence Interval

FIPS

Federal Information Processing Standards

ICC

Intraclass Correlation Coefficient

IQR

Interquartile Range

LOESS

Locally Estimated Scatterplot Smoothing

OR

Odds Ratio

PLACES

PLACES: Local Data for Better Health

SD

Standard Deviation

SDI

Social Deprivation Index

SVI

Social Vulnerability Index

Declarations

Ethics approval and consent to participate

This study used publicly available, aggregate, de-identified data and did not involve human participants or identifiable private information. Therefore, it did not constitute human subjects research and ethics

committee approval and informed consent were not required.

Consent for publication

Not applicable.

Availability of data and materials

All data used in this study are publicly available: census tract-level oral health estimates from the Centers for Disease Control and Prevention (CDC) PLACES 2025 release; the 2022 CDC/Agency for Toxic Substances and Disease Registry (ATSDR) Social Vulnerability Index; the 2024 Area Deprivation Index (Neighborhood Atlas); and the Stanford Population Health Sciences Social Deprivation and Vulnerability Indices dataset. County-level oral health estimates were obtained through the publicly accessible AskCHIS Neighborhood Edition query platform (UCLA Center for Health Policy Research). The corresponding URLs are provided in the reference list. The R code used for data management and statistical analyses is available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

No external funding was received for this study.

Authors' contributions

ALA: Conceptualization, investigation, visualization, interpretation of data, writing of original draft–review and editing.

CG: Conceptualization, methodology, data analysis, data curation, visualization, writing–review and editing. Both authors read and approved the final manuscript.

Acknowledgements

The authors gratefully acknowledge the University of California, San Francisco Library for its guidance and support in journal selection.

References

1. Peres MA, Macpherson LMD, Weyant RJ, Daly B, Venturelli R, Mathur MR, et al. Oral diseases: a global public health challenge. *Lancet*. 2019;394(10194):249–60. 10.1016/S0140-6736(19)31146-8.
2. World Health Organization. Oral health [Internet]. Geneva: World Health Organization. 2025 [cited 2026 Jul 15]. Available from: <https://www.who.int/news-room/fact-sheets/detail/oral-health>

3. Watt RG. Social determinants of oral health inequalities: implications for action. *Community Dent Oral Epidemiol.* 2012;40(Suppl 2):44–8. 10.1111/j.1600-0528.2012.00719.x.
4. National Institutes of Health. *Oral Health in America: Advances and Challenges.* Bethesda, MD: US Department of Health and Human Services, National Institutes of Health, National Institute of Dental and Craniofacial Research; 2021.
5. Griffin SO, Jones JA, Brunson D, Griffin PM, Bailey WD. Burden of oral disease among older adults and implications for public health priorities. *Am J Public Health.* 2012;102(3):411–8.
6. Centers for Disease Control and Prevention. *Oral Health Surveillance Report. Trends in Dental Caries and Sealants, Tooth Retention, and Edentulism, United States, 1999–2004 to 2011–2016.* Atlanta, GA: Centers for Disease Control and Prevention, US Department of Health and Human Services; 2019.
7. Slade GD, Akinkugbe AA, Sanders AE. Projections of U.S. edentulism prevalence following 5 decades of decline. *J Dent Res.* 2014;93(10):959–65. 10.1177/0022034514546165.
8. U.S. Department of Health and Human Services, Office of Disease Prevention and Health Promotion. Increase use of the oral health care system (OH-08). *Healthy People 2030* [Internet]. Rockville, MD: ODPHP [cited 2026 Jul 15]. Available from: <https://odphp.health.gov/healthypeople/objectives-and-data/browse-objectives/health-care/increase-use-oral-health-care-system-oh-08>
9. Obeidat R, Heaton LJ, Tranby EP, O'Malley J, Timoth   P. Social determinants of health linked with oral health in a representative sample of U.S. adults. *BMC Oral Health.* 2024;24:1518. 10.1186/s12903-024-05257-8.
10. Pourat N, Lu C, Yu-Lefler H, Picillo B, Wendt M. The association of social determinants of health with oral health status among patients of Health Resources and Services Administration funded health centers in the United States. *J Public Health Dent.* 2025;85(1):61–72.
11. Northridge ME, Kumar A, Kaur R. Disparities in access to oral health care. *Annu Rev Public Health.* 2020;41:513–35. 10.1146/annurev-publhealth-040119-094318.
12. Diez Roux AV, Mair C, Ann. *N Y Acad Sci.* 2010;1186:125–45. 10.1111/j.1749-6632.2009.05333.x.
13. Agency for Toxic Substances and Disease Registry. CDC/ATSDR Social Vulnerability Index (SVI) [Internet]. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention; 2024 [cited 2026 Jul 15]. Available from: <https://www.atsdr.cdc.gov/place-health/php/svi/index.html>
14. Bevan G, Pandey A, Griggs S, Dalton JE, Zidar D, Patel S, et al. Neighborhood-level social vulnerability and prevalence of cardiovascular risk factors and coronary heart disease. *Curr Probl Cardiol.* 2023;48(8):101182. 10.1016/j.cpcardiol.2022.101182.
15. Brush JE Jr, Kim C, Liu Y, Xin X, Huang C, Lundy IJ, et al. Association between neighborhood-level social vulnerability and hypertension outcomes. *JACC Adv.* 2025;4(8):101912. 10.1016/j.jacadv.2025.101912.
16. Higginbotham JK, Segovia LM, Rohm KL, Anderson CM, Breitenstein SM. Social Vulnerability Index and health outcomes in the United States: a systematic review. *Fam Community Health.*

- 2025;48(2):81–96. 10.1097/FCH.0000000000000421.
17. Chong GTF, Gansky SA. Census tract geospatial analysis comparing social determinants of health with tooth loss in California seniors: an ecologic study. *Community Dent Oral Epidemiol*. 2024;52(6):889–99. 10.1111/cdoe.12995.
 18. Gaskin DJ, Kanwar O, McCleary R, Davis AL, Weatherspoon DJ, Fleming E, et al. Spatial patterns of emergency dental care utilization: assessing the influence of social vulnerability and dental provider availability. *Healthc (Basel)*. 2024;12(21):2191. 10.3390/healthcare12212191.
 19. Benavidez GA, Crouch E, Nelson J, Martin A. Congruence between county dental health provider shortage area designations and the Social Vulnerability Index. *Prev Chronic Dis*. 2024;21:E48. 10.5888/pcd21.230315.
 20. U.S. Census Bureau. Glossary: census tract [Internet]. Washington, DC: U.S. Census Bureau [cited 2026 Jul 8]. Available from: <https://www.census.gov/programs-surveys/geography/about/glossary.html>
 21. Centers for Disease Control and Prevention. PLACES: Local Data for Better Health, Census Tract Data, 2025 release [dataset]. Atlanta, GA: Centers for Disease Control and Prevention; 2025 [cited 2026 Jul 8]. Available from: <https://data.cdc.gov/500-Cities-Places/PLACES-Local-Data-for-Better-Health-Census-Tract-D/cwsq-ngmh>
 22. Greenlund KJ, Lu H, Wang Y, Matthews KA, LeClercq JM, Lee B, et al. PLACES: Local Data for Better Health. *Prev Chronic Dis*. 2022;19:E31. 10.5888/pcd19.210459.
 23. Zhang X, Holt JB, Lu H, Wheaton AG, Ford ES, Greenlund KJ, et al. Multilevel regression and poststratification for small-area estimation of population health outcomes: a case study of chronic obstructive pulmonary disease prevalence using the Behavioral Risk Factor Surveillance System. *Am J Epidemiol*. 2014;179(8):1025–33. 10.1093/aje/kwu018.
 24. UCLA Center for Health Policy Research. AskCHIS Neighborhood Edition: 2022 California Health Interview Survey small-area estimates [Internet]. Los Angeles, CA: UCLA Center for Health Policy Research [cited 2026 Jul 8]. Available from: <https://askchisne.ucla.edu>
 25. Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry/Geospatial Research, Analysis, Program S. CDC/ATSDR Social Vulnerability Index 2022 Database, California [dataset] [cited 2026 Jul 9]. Available from: https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html
 26. Kind AJH, Buckingham WR. Making neighborhood-disadvantage metrics accessible – the Neighborhood Atlas. *N Engl J Med*. 2018;378(26):2456–8. 10.1056/NEJMp1802313.
 27. University of Wisconsin School of Medicine and Public Health. 2024 Area Deprivation Index, version 4.0.1 [dataset]. Madison, WI: University of Wisconsin; 2024 [cited 2026 Jul 8]. Available from: <https://www.neighborhoodatlas.medicine.wisc.edu>
 28. Hannan EL, Wu Y, Cozzens K, Anderson B. The Neighborhood Atlas Area Deprivation Index for measuring socioeconomic status: an overemphasis on home value. *Health Aff (Millwood)*. 2023;42(5):702–9. 10.1377/hlthaff.2022.01406.

29. Rehkopf DH, Phillips RL Jr.. The Neighborhood Atlas Area Deprivation Index and recommendations for area-based deprivation measures. *Health Aff (Millwood)*. 2023;42(5):710–4. 10.1377/hlthaff.2023.00282.
30. Robert Graham Center — Policy Studies in Family Medicine & Primary Care. Social Deprivation Index (SDI) [Internet]. Washington, DC: Robert Graham Center. 2018 Nov 5 [cited 2026 Jul 10]. Available from: <https://www.graham-center.org/evidence-based-research/featured-work/social-deprivation-index>
31. Stanford Center for Population Health Sciences. Social Deprivation and Vulnerability Indices [dataset]. Redivis [cited 2026 Jul 10]. Available from: <https://redivis.com/datasets/6qpr-bt8vmp4h4>
32. Papke LE, Wooldridge JM. Econometric methods for fractional response variables with an application to 401(k) plan participation rates. *J Appl Econ*. 1996;11(6):619–32.
33. Amedari MI, Atanda AJ, Amedari IK, Monger M, Walker BH. The association between predisposing, enabling and need factors and oral health care utilization among U.S. working age adults. *BMC Oral Health*. 2025;25:501. 10.1186/s12903-025-05821-w.
34. Rahman MS, Kawachi I, Sommers BD, Tipirneni R, Blossom JC, Elani HW. Driving and public transit barriers to dental care in the United States. *SSM Popul Health*. 2026;33:101907. 10.1016/j.ssmph.2026.101907. . Epub 2025 Jul 7.
35. Marcus K, Balasubramanian M, Short S, Sohn W. Barriers and facilitators to dental care among culturally and linguistically diverse carers: a mixed-methods systematic review. *Community Dent Oral Epidemiol*. 2023;51(2):327–44. 10.1111/cdoe.12745.
36. Wakefield J. Ecologic studies revisited. *Annu Rev Public Health*. 2008;29:75–90. 10.1146/annurev.publhealth.29.020907.090821.
37. Elani HW, Rahman MS, Wallace J, Rosenthal MB, Sommers BD. Availability of adult dental plans in the Affordable Care Act Marketplaces, 2016–23. *Health Aff (Millwood)*. 2024. 10.1377/hlthaff.2024.00307
38. Nasseh K, Fosse C, Vujcic M. Dentists who participate in Medicaid: who they are, where they locate, how they practice. *Med Care Res Rev*. 2023;80(2):245–52. 10.1177/10775587221108751.
39. Stennett M, Dawson E, Hijryana M, Cannon P, Daly B, Macpherson L, Watt RG. Upstream interventions to promote oral health and reduce oral health inequalities: a scoping review. *Community Dent Oral Epidemiol*. 2026;54(2):146–62. 10.1111/cdoe.70049.

Figures

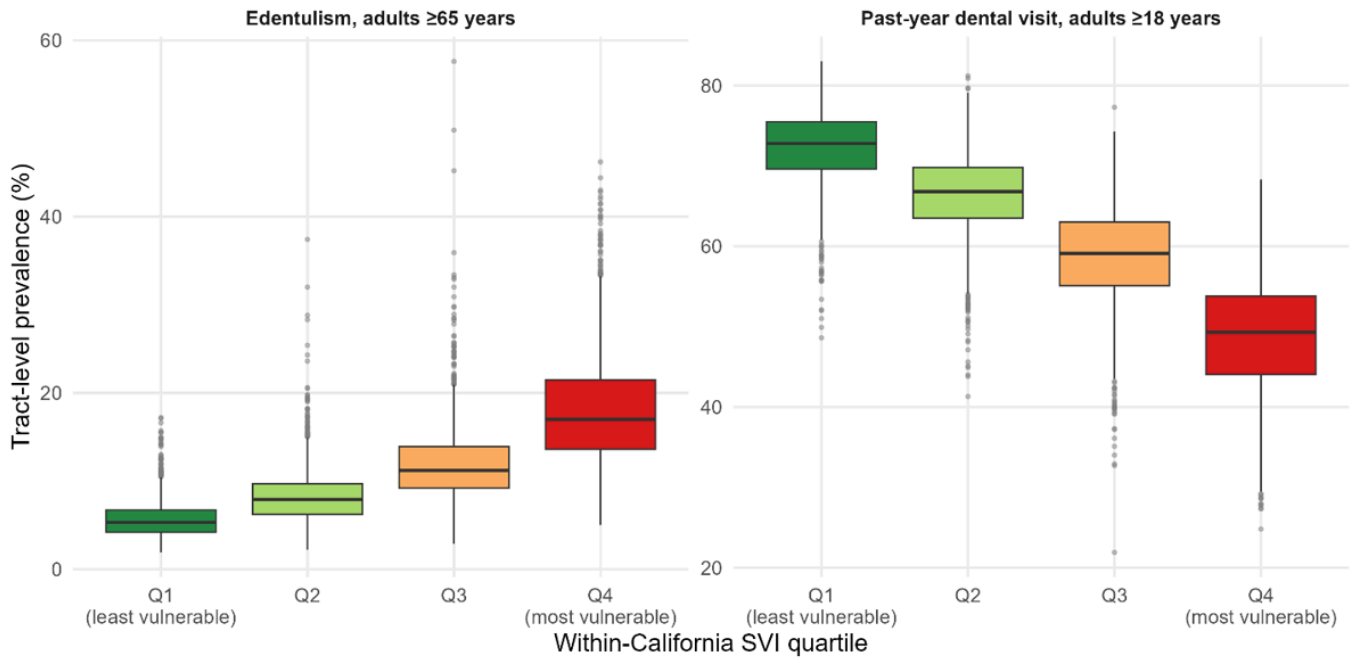


Figure 1

Distribution of tract-level prevalence of edentulism among adults aged ≥65 years and past-year dental visits among adults aged ≥18 years across within-California Social Vulnerability Index quartiles.

The analysis included 9,019 California census tracts, with 2,255, 2,255, 2,255, and 2,254 tracts in SVI quartiles 1–4, respectively. Quartile 1 included tracts with SVI percentiles ≤ 0.25 , quartile 2 > 0.25 to ≤ 0.50 , quartile 3 > 0.50 to ≤ 0.75 , and quartile 4 > 0.75 . Boxes represent the interquartile range, with the horizontal line indicating the median. Whiskers extend to 1.5 times the interquartile range, and points represent outlying census tracts.

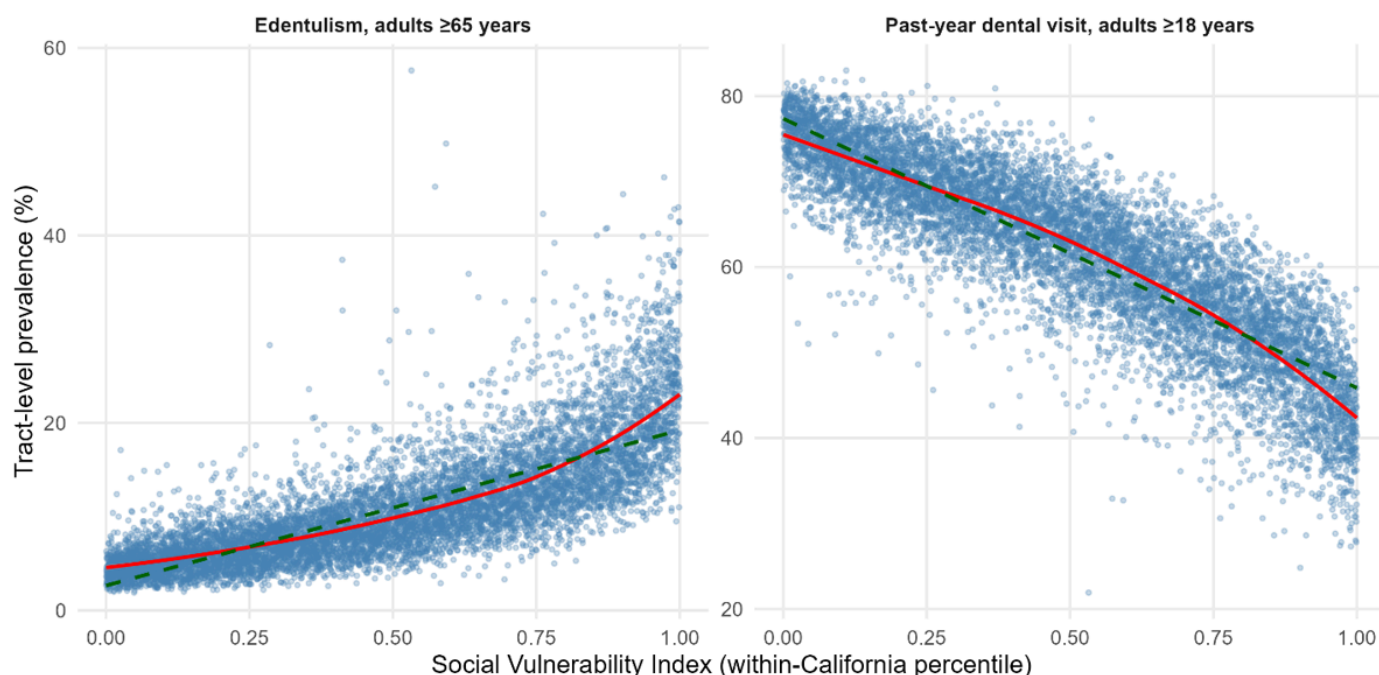


Figure 2

Association between tract-level Social Vulnerability Index percentile and the prevalence of edentulism among adults aged ≥ 65 years and past-year dental visits among adults aged ≥ 18 years.

Each point represents one California census tract ($n = 9,019$). The Social Vulnerability Index (SVI) is expressed as the within-California percentile rank, ranging from 0 (least vulnerable) to 1 (most vulnerable). Solid lines represent locally estimated scatterplot smoothing (LOESS) curves with 95% confidence bands, illustrating the observed relationship without assuming linearity. Dashed lines represent fitted linear regression lines for comparison.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SupplementaryTableS.docx](#)