Association of Income Inequality With Orthodontic Use

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Scholarly Report

Submitted in Partial Fulfillment of the

MD Degree at Harvard Medical School

Association of income inequality with orthodontic use

by

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3 February 2020

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Citation: Simon L, Choi SE, Ticku S, Fox K, Barrow J, Palmer N. Association of income inequality with orthodontic use. *Journal of the American Dental Association*. 2020;In Press.

Abstract:

Background: Income inequality has also been associated with worse oral health outcomes and reduced dental utilization. It is unknown whether income inequality may motivate individuals to seek orthodontic treatment.

Methods: This was a logistic mixed-effects model of deidentified claims from a private insurer in the United States with members having at least one orthodontic visit in the calendar year as the dependent variable. Total number of dental visits, age, and gender were individual-level covariates. Median household income, GINI coefficient, female population proportion, number of practicing dentists and orthodontists, population size, and population density were ZIP code-level covariates.

Results: 1,860,709 individuals had at least one orthodontic claim. Adjusting for population demographics, Gini index was significantly positively associated with orthodontic utilization for children but not for adults (OR 1.69 for children, $p<0.0001$). Female gender was the strongest predictor of orthodontic utilization for adults and was also a significant predictor of utilization for children (OR 1.50 and 1.45, respectively, $p<0.0001$).

Conclusions: Gini index is associated with orthodontic utilization in children in a privately insured population. Individual characteristics are more predictive of orthodontic utilization among privately insured adults.

Table of Contents

Glossary of Abbreviations:

CDT – Current Dental Terminology

CI – Confidence Interval (95%)

ICC – Intraclass Correlation

IRB – Institutional Review Board

OR – Odds Ratio

Statement of Scholarly Project Question:

Oral health plays a critical role in overall health, and untreated dental disease can cause untold suffering that is disproportionately experienced by vulnerable people. Yet the status of someone's teeth can also affect their ability to navigate the social world, including their employability and perceived attractiveness. Orthodontic treatment in the United States is increasingly perceived as a necessity, even though it is almost entirely paid for out-of-pocket at considerable expense. The purpose of this project was to determine the impact of income inequality on rates of orthodontic utilization in a privately insured population.

Contribution to the Work:

I was primarily responsible for this project. I developed the research question and identified the data needed from both the claims database and publicly available datasets. I developed the SQL queries necessary to extract the data from the claims database, and isolated and downloaded necessary publicly available data from much larger datasets (e.g. the American Community Survey, the National Plan and Provider Enumeration System). I conducted all statistical analyses in Stata and wrote the manuscript and all revisions. I submitted the manuscript for review and responded to reviewers.

My mentor and co-authors provided feedback and guidance throughout the project. Dr. Palmer provided expert feedback on my SQL query code and the use of the claims database. Dr. Choi and Dr. Palmer collectively provided suggestions and feedback on my statistical analysis strategy. Dr. Fox is a content expert on the claims database and provided feedback on my choice of covariates and search strategy. Dean Barrow was responsible for obtaining access

to the claims database and generating the umbrella IRB approval under which this research was possible. Dean Barrow, Dr. Ticku, Dr. Choi, Dr. Palmer, and Dr. Fox all provided feedback on each iteration of the manuscript and responses to reviewers.

Citation:

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Appendix: In-Press Manuscript

Proof of article begins on the next page.

Original Contributions

Association of income inequality with orthodontic treatment use

Lisa Simon, DMD; Sung Eun Choi, PhD; Shenam Ticku, BDS, MPH; Kathe Fox, PhD; Jane Barrow, MS; Nathan Palmer, PhD

ABSTRACT

Background. Income inequality has been associated with worse oral health outcomes and reduced dental care use. It is unknown whether income inequality may motivate people to seek orthodontic treatment.

Methods. This was a logistic mixed-effects model of deidentified claims from a private insurer in the United States with enrolled members having at least 1 orthodontic visit in the calendar year as the dependent variable. Total number of dental visits, age, and sex were individual-level covariates. Median household income, Gini coefficient, female population proportion, number of practicing dentists and orthodontists, population size, and population density were zip code-level covariates.

Results. A total of 1,860,709 people had at least 1 orthodontic claim. Adjusting for population demographics, the Gini index was significantly positively associated with orthodontic use for children but not for adults (odds ratio, 1.69 for children; $P < .0001$). Being female was the strongest predictor of orthodontic use for adults and was a significant predictor of use for children (odds ratio, 1.50 and 1.45, respectively; $P < .0001$).

Conclusions. The Gini index is associated with orthodontic use in children in a privately insured population. Individual characteristics are more predictive of orthodontic use among privately insured adults.

Practical Implications. Demographic and economic traits of communities can affect oral health care use; effects on orthodontic use may be more dramatic than on other forms of oral health care.

Key Words. Oral health; income inequality; orthodontic care; oral health care; health care use; Gini coefficient.

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At both the population and person levels, income dramatically affects oral health. Income is associated with numerous social determinants of health such as education, living conditions, and community resources, as well as determining whether people can afford health care, including out-of-pocket expenses as well as associated transportation costs and lost time from work.[1] As oral health care represents disproportionately higher out-of-pocket expenses, inequity in oral health is particularly affected by income.[2,3]

However, income inequality may also play a large role in determining the health of people in a society. More unequal societies tend to have reduced investment in social supports and services that otherwise optimize health and reduce economic and social mobility, leading to worse health outcomes.[4] In addition to predicting health behaviors (such as smoking, diet, or substance use), income inequality may also increase the chronic stress associated with living in a less socially connected and more competitive society, which can further reduce health.[5,6] Income inequality is worsening over time, and in the United States wealth has become almost twice as concentrated among the top 1% of earners over the past 4 decades.[7] Better understanding the impact of this inequality on health outcomes is quickly becoming an imperative.

Previous studies have found that higher income inequality is associated with lower oral health–related quality of life,[8] increased tooth loss,[9] and lower rates of dental use.[10] The impact of income inequality on oral disease is more pronounced in higher income countries such as the

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United States and can be mediated by the availability of dentists, which may be lower in communities with higher income inequality.[11,12]

Although income inequality has consistently predicted lower dental health care use, its impact on orthodontic treatment has not been well explored. Orthodontic treatment can prevent some negative dental outcomes, yet treatment is likely to be motivated by potential cosmetic benefit.[13,14] Although dental care use in general is more affected by financial considerations than other forms of medical treatment,[15] orthodontic treatment use is even more sensitive to economic pressures, declining with economic downturns[16] as well as with changes in insurance coverage for orthodontic treatment.[17]

Demand for orthodontic treatment is increasing globally among both adults and children.[18-20] In the United States, it is common, with about 10% of all children and 1% of all adults receiving some orthodontic treatment.[21] Nonetheless, such treatment represents a significant out-of-pocket expenditure for families, with cost estimates ranging from $1,000 through $5,000 annually per person and with limited-to-no coverage by most dental insurance plans.[21,22] In addition to out-of-pocket expenses, adults undergoing orthodontic treatment miss an average of 1.7 hours of work annually.[23] Thus, families and people may choose to defer orthodontic treatment unless they perceive it to be highly beneficial. One commonly expressed motivation for pursuing orthodontic treatment is the potential cosmetic or social benefit of orthodontically treated teeth, the value of which may be affected by perceptions about its contribution to social mobility and future advancement.[24] Such considerations may be affected by the income inequality within a person's community.

The purpose of this study was to evaluate the contribution of income inequality to orthodontic treatment use in a population with primary medical coverage through a major private insurer in the United States.

METHODS

We conducted a retrospective analysis of a large deidentified claims database of privately insured people. The database includes all medical and dental claims for people enrolled with a major private national insurer encompassing self-employment and small and large employer groups. The most recent full calendar year of available data, 2016, was used for this analysis. Exemption was obtained from an institutional review board blinded to the identity of human patients (IRB14-0171).

Dental and orthodontic claims data, as well as enrolled members' ages, sexes, and zip codes, were obtained using unidentifiable claims data from a nationwide US health insurance plan. Only members who were enrolled in the insurance plan for the entirety of 2016 and had at least 1 dental visit were included in the analysis. Dental visits and orthodontic visits were identified by Current Dental Terminology (CDT) codes in the database. By using CDT codes, we were able to include orthodontic visits to both orthodontists and nonorthodontists in our analysis. To avoid overestimates of use owing to people with a high number of total annual orthodontist visits, we selected having at least 1 orthodontic visit in the calendar year, rather than total number of visits, as the dependent variable.

As the claims data did not include notations of the number of subscribers with dental benefits, only people with at least 1 dental visit were included in the analysis. The number of discrete dental visits was selected as a covariate to account for differences in use rates in the study population owing to variation in market penetration of the insurer across different zip codes, as well as potential variation in dental insurance rates among subscribers.

The Gini coefficient is a standardized measure of income inequality, in which a value of 0 indicates a completely equal society and a value of 1 indicates a completely unequal society. The proportion of the population that was female, Gini estimates by zip code, and median household income by zip code were obtained using publicly available data from the American Community Survey.[25] Owing to difficulty defining area boundaries for zip codes, population density was calculated on the basis of zip code tabulation area, rather than zip code, using the 2017 Census Gazetteer area estimates and 2016 population estimates from the American Community Survey.[26] Dentist and orthodontist density was calculated using the National Plan and Provider Enumeration System file for October 2019, using the business zip code for all providers with a National Provider Identifier registered as of January 1, 2016.[27] For all other variables, data from 2016 were used, as 2016 was the most recent full calendar year for which claims data were available in the database.

ABBREVIATION KEY

CDT: Current Dental Terminology.

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Table 1. Age and sex of adult and child enrolled members seeking dental and orthodontic health care.

AGE (y)	DENTAL, ORTHODONTIC VISITS, NO.	PATIENTS, NO.	FEMALE, %	MEAN AGE (SD*)y	P VALUE
18 and Younger	Members with ≥ 1 dental visit, no orthodontic visit	2,379,798	47.61	11.42 (3.79)	$P < .0001^{\dagger}$
	Members with ≥ 1 orthodontic visit	932,058	55.62	14.62 (2.53)	$P < .0001^{\dagger}$
19 and Older	Members with ≥ 1 dental visit, no orthodontic visit	12,160,066	52.00	44.83 (15.10)	$P < .0001^{\dagger}$
	Members with ≥ 1 orthodontic visit	928,651	61.00	30.81 (13.00)	$P < .0001^{\dagger}$

* SD: Standard deviation. † Statistical significance $P < .05$.

We analyzed orthodontic visits by those 18 years or younger and those age 19 years and older as 2 separate subgroups. These age ranges were selected because children aged 8 through 18 years are the most frequent users of orthodontic treatment, and this age cutoff had been used in the literature to evaluate orthodontic treatment use.[16] In addition, we hypothesized that orthodontic treatment use by those 18 years or younger would be more likely to be affected by parental or guardian considerations of the perceived desirability of orthodontic treatment, whereas those 19 year and older would be more likely to seek orthodontic treatment independently, and thus may have different predictors of use.

Because our analysis included both group-level (that is, zip code-level) covariates and individual-level covariates, we used a mixed-effects model to evaluate the contribution of these predictors. This approach has been described and involves fitting a series of logistic regression models to the data, using maximum likelihood to account for random effects at the zip-code level.[28]

Mixed-effects logistic regressions with random intercept for zip code were conducted with the Stata Statistical Analysis Package Version 15 (StataCorp). The need for a mixed-effects model was evaluated using the residual intraclass correlation (ICC). We included as individual-level covariates enrolled member's age, sex, and number of annual dental visits. We included as zip code-level covariates median household income, population size, population density, number of dentists, number of orthodontists, and proportion of the population estimated to be female within each zip code. We excluded members younger than 5 years and older than 90 years from the analysis.

RESULTS

Among active enrolled members 18 years and younger, 3,311,856 had at least 1 dental visit and 932,058 had an orthodontic visit (28.14% of the sample). For members 19 years and older, 13,088,717 had a dental visit and 928,651 had an orthodontic visit (7.10% of the sample). Demographic information about those seeking dental and orthodontic treatment among these age groups is listed in Table 1. Children with an orthodontic visit were significantly older than those with a dental visit but no orthodontic visit (14.62 [2.53] versus 11.42 [3.79] years, respectively; $P < .0001$). Adults with an orthodontic visit were significantly younger than those with a dental visit (30.81 [13.00] versus 44.83 [15.10] years, respectively; $P < .0001$). Members with an orthodontic visit in both age groups were significantly more likely to be female (61.00% versus 52.00% of those 19 years and older, $P < .0001$; 55.62% versus 47.61% of those 18 years and younger, $P < .0001$).

A total of 27,215 zip codes had at least 1 orthodontic claim during 2016. Average demographics of zip codes with at least 1 member with an orthodontic visit are displayed in Table 2. Including all covariates, a total of 2,788,510 people were included in the regression for members 18 years and younger, and 10,942,203 people were included in the regression for members 19 years and older. For both logistic mixed-effects regressions, the residual ICC was greater than 0, indicating a need for mixed-effects modeling rather than traditional logistic regression (ICC, 0.063 for those 18 years and younger; ICC, 0.067 for those 19 years and older). Regression results are presented in Table 3.

For adults, being female was the largest contributor to orthodontic use (odds ratio [OR], 1.50; 95% confidence interval [CI], 1.50 to 1.51; $P < .0001$). The Gini index was the largest contributor for children (OR, 1.69; 95% CI, 1.38 to 2.08; $P < .0001$). The proportion of the population that was female was not a significant contributor to orthodontic use for those 19 years and older (OR, 0.95; 95% CI, 0.74 to 1.22; $P = .689$) but was significantly associated with reduced orthodontic use among children (OR, 0.25; 95% CI, 0.19 to 0.32; $P < .001$).

FLA 5.6.0 DTD ■ ADAJ1659_proof ■ 22 January 2020 ■ 12:31 am ■ ce

Table 2. Average demographics for zip codes with at least 1 enrolled member orthodontic visit.*

DEMOGRAPHIC	VALUE (95% CONFIDENCE INTERVAL)
Median Household Income	$54,500 ($31,400 to $106,000)†
Gini Coefficient	0.429 (0.428 to 0.438)
Female Proportion of Population	0.505 (0.504 to 0.506)
Median Member Age, y	38 (30 to 56)†
Mean Number of Dentists (N = 16,811)	18.9 (18.5 to 19.28)
Mean Number of Orthodontists (N = 16,811)	0.98 (0.95 to 1.01)
Population	9,819 (125 to 40,732)
Population Density (Population per Square Mile)	2,390 (2,270 to 2,510)

* N = 27,215 except as specified. † Fifth and 95th percentile values shown.

For adults, although all individual-level covariates (younger age, higher number of dental visits, and being female) were significantly associated with orthodontic use, several zip code-level covariates were not significantly associated with use. This included the Gini index, number of dentists (OR, 1.0001; 95% CI, 0.999 to 1.001; $P = .863$) and orthodontists (OR, 0.996; 95% CI, 0.99 to 1.02; $P = .217$), and proportion of the overall population that was female.

DISCUSSION

This study of orthodontic and dental claims found that the median household income and Gini index for a given zip code were significantly associated with rates of orthodontic use among privately insured children. Whereas median income contributed to use rates among adults, the Gini index was not significantly associated with orthodontic use in this population.

Higher income was associated with increased orthodontic use among both children and adults in our sample, a finding replicated in other studies.[21,29] Higher income can make treatment feasible for patients, but living in higher income areas may also make people more aware of (and desirous of) orthodontic treatment. In addition to predicting use,[21,29] community wealth has been found to predict demand for orthodontic treatment, independent of need.[30]

Overall, 28.14% of children 18 years or younger in our data set had at least 1 orthodontist visit. This is much higher than the national average of 10% of all US children, as well as that for privately insured children of 13.6% per year.[21] This high rate of use suggests that our cohort was likely relatively affluent and had a high demand for orthodontic services. With income inequality increasing over time and the Gini coefficient contributing most strongly to orthodontic treatment use in this group, it is possible that the increased demand for orthodontic treatment use over time in this age group (the largest cohort of orthodontic treatment users nationally)[29] could be due to perceived advantages of orthodontic treatment in more unequal communities.

Whereas a prior study has found higher rates of unmet dental need in areas of higher income inequality,[31] our results found that orthodontic treatment use by children was higher in zip codes with higher Gini indexes. This discrepancy could be because our sample included only privately insured patients, who are more likely to be among the more advantaged within their communities. These people may be more motivated to seek health care in more unequal communities, especially health care that results in a more esthetic outcome, such as orthodontic treatment, a finding that has been replicated for other forms of self-presentation.[32] That this pattern does not hold true for adults could be due to individual-level factors that are more predictive of orthodontic treatment among adults, such as extent of malocclusion, sex, and marital status.[22] It is also possible that families are more willing to invest in perceived future esthetic or dental advantages for their children.[24] Caregivers may also be more responsive to recommendations for orthodontic treatment from dental professionals for their children.[13,24]

Population density has been shown to be a negative predictor of orthodontic use among children receiving Medicaid, a finding significantly, but not substantially, replicated in our study.[33] Although lower population density areas often have a lower density of practicing dentists and lower rates of

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Table 3. Results of logistic mixed-effects regression for those 19 years and older and those 18 years and younger.

VARIABLE	ODDS RATIO	95% CI*	*P* VALUE
Individual-Level Covariates			
Member age			
≤ 18	1.33	1.328 to 1.331	< .0001†
≥ 19	0.92	0.922 to 0.922	< .0001†
Total dental visits			
≤ 18	1.21	1.209 to 1.216	< .0001†
≥ 19	1.20	1.195 to 1.199	< .0001†
Sex (female)			
≤ 18	1.45	1.44 to 1.46	< .0001†
≥ 19	1.50	1.50 to 1.51	< .0001†
Zip code-level covariates			
Gini Index			
≤ 18	1.69	1.38 to 2.08	< .0001†
≥ 19	0.93	0.76 to 1.22	.487
Median household income			
≤ 18	1.00001	1.00001 to 1.00001	< .0001†
≥ 19	1.000008	1.000007 to 1.000008	< .0001†
Number of dentists			
≤ 18	1.0008	1.0002 to 1.001	.007†
≥ 19	1.0001	0.999 to 1.001	.863
Number of orthodontists			
≤ 18	1.012	1.006 to 1.019	< .0001†
≥ 19	0.996	0.99 to 1.002	.217
Proportion of population			
≤ 18	0.25	0.19 to 0.32	< .0001†
≥ 19	0.95	0.74 to 1.22	.689
Population density			
≤ 18	1.00	0.999997 to 0.9999998	.025†
≥ 19	1.00	0.999994 to 0.999997	< .0001†
Population size			
≤ 18	1.00	0.999 to 1.00	.241
≥ 19	1.000004	1.000004 to 1.000005	< .0001†

* CI: Confidence interval. † Statistical significance, $P < .05$.

dental care use overall, an inverse relationship with orthodontic treatment suggests that families in these areas are highly motivated to seek orthodontic treatment. International studies have also found that patients are more likely to elect to travel farther when seeking out specialty health care.[34] As we examined only whether patients had at least 1 orthodontic visit, it is unknown whether these patients are more or less likely to successfully complete orthodontic treatment, especially given the potential for travel times for routine recall visits can be prohibitive; however, research suggests that this is unlikely to be the case.[35]

Although women and girls in our data set were individually more likely to have an orthodontic visit, zip codes with a higher proportion of women were significantly associated with lower rates of orthodontic treatment use among children in our data set. Residence in areas with higher income inequality has also been associated with increased rates of depression among women but not among men, suggesting that, as women are already more likely to face systematic discrimination, they may be even more affected by the unfavorable impact of income inequality.[36] Both women and girls are more likely to desire orthodontic treatment than men and boys with the same severity of malocclusion.[18,19] It is possible that women perceive their physical appearance to

FLA 5.6.0 DTD ■ ADAJ1659_proof ■ 22 January 2020 ■ 12:31 am ■ ce

be more important when competing with men for employment. The unequal benefit of an "attractiveness premium" for women compared with men has been described.[37] It is also consistent with prior findings that women with worse oral health earn less than women with better oral health.[38]

Limitations

Our study had a number of limitations. First, our data set included only enrolled members of a single private insurer, and we are unable to conclude whether these patterns apply to publicly insured people, especially given known differences in orthodontic use by income. Second, we were not able to determine which members had dental insurance through the insurer. Although we used the presence of at least 1 annual dental visit as a proxy for dental access, the role of dental insurance coverage in orthodontic use rates remains unknown. We were unable to include a measure of orthodontic need as an individual-level covariate, although it is likely an important contributor to peoples' desires to seek orthodontic treatment. However, previous studies have found that desire for orthodontic treatment may not be exclusively due to unmet need,[20] and that successful orthodontic treatment completion is not associated with malocclusion.[35]

Whereas privately insured people are most likely to pay out-of-pocket for orthodontic expenses even with dental insurance,[29] Medicaid orthodontic coverage likely plays a large role in determining use for low-income children.[17,39] Last, mail-order and "DIY" orthodontics are becoming increasingly popular and face limited regulation in the market[40,41]; the use of these more affordable services could not be factored into our analyses and may be less affected by income.

CONCLUSIONS

When corrected for individual-level factors and population-level factors including population and provider density and sex distribution within the population, the Gini index was a positive predictor of orthodontic use among children but not among adults, and income was a significant contributor to both adult and child orthodontic use. Women were significantly more likely to seek orthodontic treatment than other types of dental health care, and use rates by adult women were the most disproportionate. In spite of this, orthodontic use among children was significantly higher in zip codes with a higher proportion of men. Further study should explore whether these patterns hold among publicly insured populations, as well as the relationship between desire for orthodontic treatment and use rates. Improved dental esthetics obtained through orthodontic treatment may be related to competitiveness within more unequal communities. ■

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FLA 5.6.0 DTD ■ ADAJ1659_proof ■ 22 January 2020 ■ 12:31 am ■ ce

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