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ORIGINAL ARTICLE

Income-based inequalities in dental service utilization: A multiple mediation analysis

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Abstract

Objectives: With elimination of the financial burden of dental services, one can expect an increase in utilization of dental services. This study aimed to investigate the effective mechanisms of financial barriers to the utilization of dental services in an Australian adult population.

Methods: South Australian survey data from the Dental Care and Oral Health Study (2015) were analysed. Following the flexible mediation approach, the direct effect of income and indirect effect of income through mediators (insurance, concession card and service sector) on the outcomes (visit avoidance and treatment prevention due to the cost) were calculated.

Results: Findings showed that around half of the low-income people and one-third of the high-income South Australians experienced a financial burden on receiving a dental visit or service. The indirect effect of income on both outcomes of financial burden was negligible, while the direct effect was significant. By changing the potential outcome distribution to their counterfactual exposure distribution and if the mediators are drawn from their counterfactual exposure (lower/higher income) distribution, the odds of visit avoidance and treatment prevention due to the cost were almost twice (Odds Ratio: 2.13, 95% CI 1.72–2.60) and 98% (Odds Ratio: 1.98, 95% CI 1.67–2.35) than in the lower-income individuals, respectively.

Conclusions: It can be concluded that the level of household income, directly and regardless of insurance status, concession card ownership and whether the service sector was public or private, affected the financial burden on utilization of dental services.

KEYWORDS
Australia, dental health services, healthcare disparities, insurance, private sector, public sector, socioeconomic factors

1 | INTRODUCTION

Universal Health Coverage (UHC) is one of the sustainable development goals (SDG) demanded by almost all countries.[1,2] Despite the high burden of oral disease, universal coverage of dental services has faced many challenges in most countries.[3]

Ghanbarzadegan et al.[4] introduced the conceptual framework of the '*triangle of inequality*' in dental services, which includes

access to services, utilization and provision of services. In this conceptual framework, determinants such as insurance coverage, distribution of public dental services and dental services tariffs define the availability and affordability of services within the framework of service provision, which eventually defines access to dental services. In this conceptual framework, access itself is aligned with the UHC cube.[5] The UHC cube illustrates how access inequalities should be tackled from different perspectives, such as the amount of financial support, the proportion of eligible services and people covered by the UHC scheme. Together and not separately, these intertwined socioeconomic determinants may promote the utilization of dental services. In contrast, inequality in any of these dimensions, in addition to the individual, sociocultural factors, may lead to inequality in the utilization of dental services.[6] Therefore, eliminating the reasons for not using dental services seems necessary to improve UHC and utilization of dental services. There are several reasons for not using dental services, one of which is financial barriers to the utilization of dental care.[4,6,7]

Policymakers are considering ways to remove financial barriers to utilization of dental services worldwide, including introduction of public insurance, private insurance subsidies, development and extension of public dental services.[6]

In Australia, for example, supportive health policies are primarily limited to insurance rebates for people with private insurance and public dental services for people who have concession cards. However, these services target a small proportion of adults, and around 80 per cent of services in Australia are delivered in the private sector.[8,9]

Various studies have demonstrated a contrast between Australian public and private dental care provision. Although public services cover a wide range of general and specialized services with a small cost, resource constraints within the public sector cause long waiting times.[10] Provision of services within the public sector in Australia leans more towards extractions and emergency care than prevention and tooth maintenance treatments.[11] Considering that prioritizing resource constraints is undeniable, public dental services in Australia only cover people who have a concession card. Eligible concession cards vary in each state and eligible people include vulnerable groups, such as the elderly, low-income or unemployed individuals. However, public dental services are not available to other vulnerable people in the community who do not have a concession card and are not eligible.[12]

Introduction of insurance schemes has been considered another solution in Australia. The government pays a 30% insurance rebate for people who have private insurance. However, only around half of Australians have some sort of private dental health insurance, and therefore, a significant proportion of services and people are not covered.[9,13,14] Hopkins et al. investigated the relationship between utilization of dental services and insurance status in Australia between 1995 and 2001.[15] They found a greater prevalence of dental visits in insured individuals and suggested that Australian private insurance coverage has increased service utilization. However, they declared that this might increase access inequalities among insured and uninsured individuals. This is consistent with Harford and Spencer, who reported that the Australian government's private insurance scheme more favourably targeted higher-income groups.[16]

Due to the lack of studies investigating financial barriers to dental services, the mechanisms of the impact of financial barriers on the avoidance or delay of dental services are still unclear. Notably, a knowledge gap exists on these barring mechanisms in the public and private sectors.

This study aimed to investigate income-related factors that are associated with avoiding or delaying dental service utilization for Australian adults in the public and private sectors. The research question of interest was 'Does income inequality lead to a different choice of service provision sector (Public or private dental service provider) that leads to a decrease in financial burden of dental services (visit/treatment)?' An additional question was whether this mediation would be influenced by other income mediators such as insurance and concession card ownership (Figure 1).

2 | METHODS

This retrospective cross-sectional study utilized baseline data from the Dental Care and Oral Health Study (DCOHS) study, which was conducted in 2015 by the Australian Research Centre for Population Oral Health (ARCPOH) at the University of Adelaide.[17]

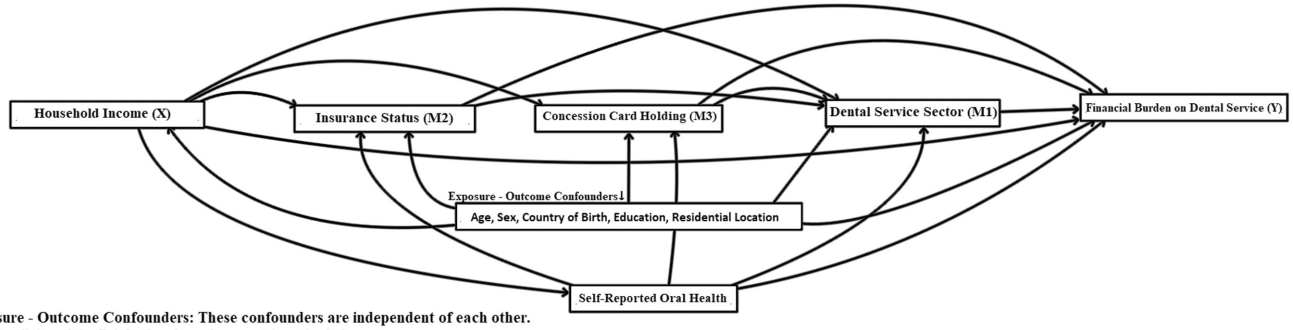

FIGURE 1 Directed Acyclic Graph illustrating the data analysis of the mediation analysis

Questionnaires were sent by email and post to 12 245 South Australians from June to November 2015. A total of 4494 responses were received. After adjusting for out-of-scope participants (not residing at listed addresses), the response rate was 44.6%. Data were weighted based on the distribution of age by sex and according to South Australia residential population estimates in 2015 provided by the Australian Bureau of Statistics.

The identity of participants and their information remained confidential. Ethical approval was obtained from the University of Adelaide HREC (H-288-2011).

2.1 | Variables of interest

Household income (Exposure variable)

Participants were asked about their sum of untaxed income from all persons in the household including a range of ten categories (coded as 1–10) with the interval between each category being 20 000 Australian Dollars (AUD). Categories were from less than 20 000 AUD (initial code was 1) to more than 180 000 AUD (initial code was 10). In the analysis, income was dichotomised where ≥80 000 AUD was coded as 0 and <80 000 AUD coded as 1.

Dental service sector (Mediator 1)

Participants were asked about the sector of the last dental visit choosing between private dental practice (=1) and public dental clinics (=2, including dental hospitals and community clinics).

Insurance status (Mediator 2)

Participants were asked if they had a private insurance coverage excluding the public social health coverage (i.e., Medicare). They responded no (=1) and yes (=2) to this question.

Concession card ownership (Mediator 3)

Participants were asked if they owned any concession cards (including Health Care Card, Pensioner Concession Card, Commonwealth Seniors Card or any other card). From their responses, a new variable named Concession Card Holding (CCH) status was created. If their answer to any of the questions asked was yes, CCH Status was considered to be positive (yes = 2) and otherwise negative (no = 1).

In South Australia, CC holders are the only eligible group to use public adult dental services. However, for several reasons, they may choose to visit the private sector. This current variable is their concession card holding status, while information about which dental sector they actually attended (public or private) was gathered through the Dental Service Sector variable.

Delayed/Avoided dental visits (Outcome for Model 1)

Participants were asked if they had avoided or delayed visiting a dental professional because of cost during the past 12 months (yes = 1, no = 0).

Prevented Treatments (Outcome for Model 2)

Participants were asked whether they had been prevented from accepting a dentist's recommended dental treatment due to cost (yes = 1 and no = 0).

Confounders

Age

Year of birth was collected, with participants' age in 2015 calculated and categorized into three ordinal groups including 18–39 years old (=0), 40–59 years old (=1) and greater than or equal to 60 years old (=2).

Sex

Participants were recorded as male (=0) or female (=1).

Country of birth

Participants were asked about their county of birth, whether Australia (=0) or another country (=1).

Education

Participants were asked about their highest level of education. Options included from no schooling to completed a university degree or tertiary education. If the participant had a university degree, it was coded as university degree/ tertiary education (=1), with other levels of education coded as less than or equal to 12 years of studying (=0).

Residential location

Recorded postcodes were divided into two major categories: greater Adelaide area (Capital area = 0) and the rest of South Australia (Non-capital areas = 1).

Self-reported oral health

Participants were asked to rate their oral health on a 5-point Likert scale (very poor, poor, good, very good, excellent). Responses

were dichotomised as poor (=0, including very poor and poor responses) and good to excellent (=1, including the remaining responses).

As shown in Figure 1, previous confounders were adjusted in all exposure, mediator and outcome paths. However, self-reported health status was considered an induced mediator outcome confounder and was adjusted in mediators' models.

2.2 | Statistical Analysis

To study the effects of income on the financial burden of dental services, we assumed the following simplistic view of the data generating mechanism shown in Figure 1. The directed acyclic graph (DAG) in Figure 1 is usually referred to as the mediation DAG. Confounders included in the analyses and Figure 1 were independent of each other, and only for a simplistic visualization, were they collated into a single box.

Mediation analysis allows studying mechanisms in which exposure affects the outcome through mediators. Following the counterfactual theory proposed by Greenland and Robins[18] and using the Ratio of Mediator Probability Weighting (RMPW) approach,[19,20] we decomposed the effects of income on the financial burden of dental services into the direct and indirect effects (through multiple mediators).

In the counterfactual theory, the total causal effect of the exposure on the outcome (Model 1: avoided dental visits by costs and Model 2: Dental treatments prevented or delayed due to the cost) can be decomposed into the direct and indirect effects. The direct effect expresses the effect of income (changing from high income to low income) on the risk of financial burden on dental services, as it would have been observed if the distribution of the mediators resembled the higher-income people. The indirect effect would express the change in financial burden on dental services when the distribution of the mediators changed to what it would be for lower-income people.

To estimate these direct and indirect effects, we used Marginal Structural Models (MSMs) using the *geeglm* function (family: *'binomial'*) from the *Geepack* package and for the mediators model, we used Generalized Linear Models and *glm* function (family: *'binomial'*) in R.

This mediation analysis was carried out under four assumptions of unmeasured confounding: a) there should be no unmeasured confounding between exposure and the outcome, b) there should be no unmeasured confounding between the mediator and the exposure, c) there should be no unmeasured confounding between the outcome and the mediator, and d) there should be no exposure induced mediator outcome confounder.

The analysis is not free from the issues of missing data. To handle missing data, we used multiple imputations using the *Mice* package in R. Most of the variables of interest were initially dichotomised. Household income (less/greater than or equal to 80000 AUD), education (year 12/ having a diploma or a degree) and self-reported oral health (bad/good to excellent) were also dichotomised to reduce bias due to individuals' misclassifications.

For double robustness, our models included confounders, including age, sex, country of birth, education, residential location and self-reported oral health. To achieve the bootstrap assessment of estimation uncertainty and repeated measurement of the participants, the code was run with 1000 repetitions. All the estimates were calculated with 95% confidence intervals. All analyses were conducted using RStudio version 1.3.1056 and R version 4.0.4. The R code used in this paper is available in the Appendix S1.

2.3 | Sensitivity Analysis

Sensitivity analysis was performed to determine whether the presence of unmeasured confounders violated the conclusion of inference and the findings. The weighting-based approach introduced by Hong et al.[21] was adopted for conducting the sensitivity analysis. As their method and R package were designed for a single mediator mediation, we have modified it to suit multiple mediation approach by calculating the total mediators' weights and the weight discrepancy between the new weight after omitting an observed confounder and the initial calculated weight. The consequent *'sensitivity bias'* due to omitting currently observed confounders (age, sex, education, country of birth, residential location and education oral health interaction) is comparable to some potential unmeasured confounders. In this approach, three sensitivity parameters were calculated: σ is the standard deviation of mediators' weights discrepancy; ρ is the correlation between the mediators' weights discrepancy and the outcome. Consequently, the sensitivity bias is the multiplication of σ and ρ.

3 | RESULTS

Results are reported based on the weighted imputed sample. Distribution details of all variables are given in Table A of the Appendix S1. The mean age of the population was 48.1 ± 18.2 years, with 51.0% being female. Almost 60% of the population had an income of less than 80000 AUD. The rate of delayed visits (Model 1) and prevented treatments (Model 2) due to cost was 36.3% and 44.0%, respectively, in the population. An unadjusted bivariate analysis depicted a significant association between the exposure and outcomes in both models (Pearson Correlation of the chi-square table: −0.12 and −0.15, *p*-value <0.001 for Model 1 and 2, respectively). To clarify, 29.2% of high-income individuals reported an avoided dental visit (Model 1) because of cost; in contrast, it was 41.6% in the lower-income group. In Model 2, with a similar pattern, 34.5% of higher-income individuals compared to 50.7% of lower-income individuals, reported prevented dental treatments due to cost. More details of the bivariate analysis are available in Table B in the Appendix S1. Table C in the Appendix S1 also includes cross-tabulationa between the exposure and the mediators.

Table 1 shows that the mediators' total indirect effects were small in both models. However, the direct effect of income was evidently significant in both models. The odds ratio (OR) of the direct effect was 2.13 (95% CI 1.72, 2.60) for avoided or delayed dental visits (Model 1) and 1.98 (95% CI 1.67, 2.35) for prevented treatments (Model 2). According to these findings, if the potential outcome distribution of each individual changes to their counterfactual exposure distribution and their mediators are drawn from their counterfactual exposure (lower/higher income) distribution, then the odds of experiencing financial burden on receiving dental visits or services will be almost twice (lower compared to the higher-income group).

Table 2 shows the total effect and effect decomposition of mediation effects. The total effect was 2.01 (95% CI 1.70, 2.37) for Model 1 and 1.89 (95% CI 1.63, 2.22) for Model 2. Decomposing the total indirect shows that the odds ratio for each mediator is very close to 1 in both models. According to these findings, most of the total effect results from the total direct effect of income. Figure A in the Appendix S1 illustrates the odds ratios as shown in Table 2.

Bias due to omitting the currently adjusted confounders was measured for both models. Based on the sensitivity analysis, omitting any of the observed confounders did not change the conclusion of statistical inference. Hence, the mediation analysis is not sensitive to any single unmeasured confounder bias (Table D & E in the Appendix S1). There is a possibility that the results could be biased for a cumulative unmeasured confounder bias. However, the interaction with the two measured confounders with higher biases (Education * Oral Health Status) did not change the statistical inference.

4 | DISCUSSION

According to the research question, these findings support that income status reduces the financial burden on the utilization of dental services. However, the analysis found no effect of insurance and concession cards on the financial burden of dental service utilization.

Other researchers have reported various factors associated with the utilization of dental services.[14,15,22] For example, Srivastava et al.[23] using the 2004–06 Australian National Survey of Oral Health, declared that dental service use was 43% higher in insured individuals than uninsured Australians.

The findings of the study showed that the indirect effect was negligible (OR≈1), which means that in the studied population, the level of household income through mediators is ineffective in avoidance or prevention of dental visits and treatments. In fact, regardless of the status of the mediators (i.e., insurance status, CCH status and service sector), the status of the outcomes will be the same among groups with different levels of income.

This is a challenging finding. Individuals with insurance, ownership of a concession card and those attending the public dental sector may be expected to receive more services.[14,15,22,23] However, the findings of this study should be used to determine whether these factors alone or in conjunction with income level are causally influential on the financial burden of dental services. The negligible effect of insurance may be due to the fact that most insurance coverage includes basic hospital services. In addition, governmental benefit packages also include less expensive dental services. With regard to concession card ownership, this analysis is more challenging because a concession cardholder can receive dental services at a lower cost in the public sector. So, the question arises as to why having a card had a negligible effect on the financial burden of dental service utilization? Concession cards may not work correctly for various reasons, such as the fact that the card owners are not adequately targeted or the service coverage is insufficient to reduce the financial burden of dental service utilization. Only around 20% of eligible people actually receive public dental service in Australia. Waiting lists are too long.[22] According to the data in Table B (Appendix S1), around 38.4% of participants had a concession card. These figures were 58.8% for low-income and 10.7% for high-income individuals. Furthermore, 7.0% of higher-income people received public services. This confirms that

TABLE 1 Direct effect of income (direct effect) and the total mediating effect of income through the service sector, concession cards and insurance (total indirect effect) on the financial burden of dental services (avoided or delayed visits and treatments)

	Model 1	Model 2
	OR (95% CI)	
Direct effect of income (Reference: ≥80000 AUD)	2.13 (1.72, 2.60)	1.98 (1.67, 2.35)
Total indirect effect of income through all mediators	0.94 (0.85, 1.06)	0.95 (0.90, 1.03)
Age 40–59 year (Reference: 18–39 year)	1.15 (0.93, 1.42)	1.26 (1.03, 1.56)
Age ≥ 60 year (Reference: 18–39 year)	0.43 (0.35, 0.54)	0.66 (0.53, 0.81)
Sex (Reference: Male)	1.36 (1.15, 1.63)	1.29 (1.09, 1.52)
Education (Reference: ≤Year12/Certificate)	0.86 (0.72, 1.04)	0.74 (0.63, 0.88)
Country of birth (Reference: Australia)	1.18 (0.96, 1.46)	1.55 (1.24, 1.91)
Residential location (Reference: Capital area)	1.18 (0.98, 1.47)	1.11 (0.91, 1.35)

Note: Model 1, Avoided or delayed dental visit by cost; Model 2, Prevented dental treatment by cost.

Abbreviations: CI, confidence intervals; OR, odds ratio.

TABLE 2 Effect decomposition of the total effect income on the financial burden of dental services (avoided or delayed visits and treatments) into the direct effect and the total mediating effect of income through the service sector, concession cards and insurance (total indirect effect)

	OR (95% CI)
Model 1	
Income 2 (High) → 1 (Low)	
Direct effect	2.13 (1.72, 2.60)
Indirect effect of income through dental service sector (M1)	1.00 (0.91, 1.12)
Indirect effect of income through insurance status (M2)	0.97 (0.96, 0.98)
Indirect effect of income through concession card holding status (M3)	0.97 (0.96, 0.98)
Total effect	2.01 (1.70, 2.37)
Model 2	
Income 2 (High) → 1 (Low)	
Direct Effect	1.98 (1.67, 2.35)
Indirect effect of income through dental service sector (M1)	1.00 (0.94, 1.08)
Indirect effect of income through insurance status (M2)	0.97 (0.96, 0.98)
Indirect effect of income through concession card holding status (M3)	0.98 (0.97, 0.99)
Total effect	1.89 (1.63, 2.22)

Note: Model 1, Avoided or delayed dental visit by cost; Model 2, Prevented dental treatment by cost.

Abbreviations: CI, confidence interval; OR, odds ratio.

the distribution and utilization of public dental services were not equitable. In addition, data in support of an existing inequality are the magnitude of the direct effect of income; this shows the odds of a dental visit, or service avoidance is almost twice in lower-income individuals than those in the higher income group.

Findings showed that some high-income individuals had access to the concession cards and utilized public services. Insurance also had insufficient coverage with limited dental services included. These are some of the possible structural factors which show why these mediators could not reduce the financial burden of dental services.

Only one-fifth of eligible people can eventually use public services.[9] This means that besides reviewing the current processes, increasing the efficiency of the public sector and increasing insurance coverage, concession cards may be other effective solutions.[24,25] This transformation would face many challenges, and various factors must be considered. Finland, for example, implemented a health transformation plan in 2001–2002 to include subsidized dental services. Although the plan successfully reduced inequality in the short term, inequality indicators in 2007 returned to pre-2001 levels. In such situations, considering the visiting patterns and norms is essential.[26]

To the best of our knowledge, no similar study has examined the mechanisms of financial barriers to dental services with a similar methodology. Another strength of this counterfactual multiple mediation analysis was the sensitivity analysis using the Ratio of Mediator Probability Weighting (RMPW) approach. Despite the robust method and the sensitivity analysis, this study had some limitations. Dichotomisation may lead to information loss, but it assists researchers and policymakers have a better insight with a direct interpretation when we have potential outcomes. On the contrary, if we have a continuous-valued variable, then the corresponding counterfactual values are a distribution compared to a single value, thus posing a challenge in defining randomized trials in the real world. Moreover, the decomposition effect obtained using a continuous exposure could be difficult to interpret. For these reasons, we dichotomised most of the variables. Hence, the findings should be interpreted with caution as they may be sensitive to the cut point used in exposure dichotomisation.

A second limitation was that the data used in this study are from a single cross-sectional sample survey where some of the measures are self-reports and can be subjected to measurement errors. Currently, there is no software or methods for handling measurement error in natural effect mediation models. Therefore, estimates must be interpreted with caution. For estimating the causal effects, future studies must be designed as longitudinal studies as they will be helpful in capturing the time-varying and time-dependent confounding more appropriately. To establish the true causality, we encourage researchers to investigate these mechanisms in other data if it is similar to the one described in this study.

In conclusion, the level of household income, regardless of the status of insurance status, CCH status and service sector, was the most important factor in dental visits avoidance and treatment prevention in the current analysis. Although the level of government support for adult dental services in Australia compared to other health services is minimal, the amount did not reduce the financial burden of utilizing dental services. These findings indicate that the role of private insurance in the Australian healthcare system, alongside other government subsidies such as concession cards and public dental services eligibility, should be reviewed. According to income significant direct effect, policymakers should review the income distribution and equity within the communities.

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CONFLICT OF INTEREST

LJ is one of the Journal of Community Dentistry and Oral Epidemiology associate editors.

DATA AVAILABILITY STATEMENT

Research data are not shared.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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