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ORIGINAL ARTICLE

The effect of education on dental service utilization patterns in different sectors: A multiple mediation analysis

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Abstract

Objective: The aim of this study was to investigate how education level affects dental service utilization patterns in the Australian adult population. This study tested how education level mediated these service patterns through behavioural mediators such as smoking, tooth brushing and oral health status and investigated these mediation effects in different dental service providers.

Method: Following the flexible mediation approach, the direct and indirect effects of education through behavioural mediators on dental service utilization patterns (time of last dental visit, reason for last dental visit and frequency of seeking dental care) were calculated for the South Australian population from the Dental Care and Oral Health Study.

Results: Participants with lower educational attainment were 33% (Odds Ratio: 0.67, 95% CI 0.56–0.78) and 38% (Odds Ratio: 0.62, 95% CI 0.53–0.74), less likely than their counterparts with higher education to visit a dentist or to receive dental care in the last 12 months, respectively. Low education was associated with a 23% increase in odds of receiving emergency and treatment services (Odds Ratio: 1.23, 95% CI 1.05–1.43) compared to routine dental check-ups or examinations.

Conclusion: Low education, regardless of oral health behaviours and status, reduces the odds of dental service utilization in terms of frequency of seeking dental care and time of last dental visit. There is more tendency towards receiving emergency and treatment services compared to routine dental check-ups or examinations in participants with lower educational attainment.

KEYWORDS
dentistry, education, health literacy, oral health

1 | INTRODUCTION

Dental diseases are among the most well-attended public health issues due to their universal prevalence and direct impact on quality of life.[1] Considering the importance of oral health as a major component of general health, this is also believed to be highly associated with socio-economic status.[2] Several studies have been implemented to outline socio-economic proxy factors affecting oral

health, such as health literacy and education. Many studies have demonstrated the association between education and dental care utilization worldwide.[3–5]

In two comprehensive reviews, Ghanbarzadegan et al. (2021) examined various factors that lead to inequality in dental services. They considered three dimensions of utilization, provision and access as different dimensions of inequality in dental services (*Triangle of Inequality in dental services*). In this model, education level impacts the two dimensions of access and utilization of services. People with lower levels of education have less acceptance of dental services, affecting their service utilization. Therefore, differences in education levels can lead to inequality in utilization and access to dental care.[6,7]

Ju et al. (2021), using a robust methodology, investigated the mediation mechanisms of education and oral health literacy and behaviours on tooth loss among Australian adults. They found a 40% reduction in self-reported missing teeth among lower educated individuals.[8]

These findings show the importance of education in achieving optimal oral health status. However, there is not enough knowledge on the mechanisms by which education may affect dental service patterns through behaviours and attitudes and how these mechanisms may vary in different service provider sectors. Understanding the outcome of these disparities may magnify the importance of education as one of the social determinants of health.

Therefore, the aim of this study was to measure the effect of education level on Australian adults' dental service utilization patterns and investigate how these service patterns may be influenced by other mediating factors such as oral health habits (tooth brushing and smoking) and oral health status. These service patterns were the time of the last dental visit, dental visit reason and the frequency of dental visiting. Also, how these mediation paths may be modified in different dental service provider sectors was tested by testing the effect modification of attending public or private sectors on the mediation paths of education and service utilization patterns.

2 | METHODS

Baseline data collected from the Dental Care and Oral Health Study (DCOHS) were used. DCOHS was a state dental survey conducted from 2015 to 2019 in South Australia. Self-completed questionnaires were collected from randomly selected participants using the Australian Electoral Roll. Data were weighted by age and sex using the Australian Bureau of Statistics' 2015 population estimates to ensure estimates were representative of the South Australian adult population. Out of 12 245 South Australians, with a response rate of 44.6%, 4494 individuals participated in the survey by returning the questionnaire. More information on the DCOHS sampling method, size and power calculation is available in Song's PhD thesis (2020).[9] Ethical approval was provided by the University of Adelaide Human Research Ethics Committee (H-288-2011), and the participants' identity and information were kept confidential.

2.1 | Variables of interest

Figure 1 illustrates the thematic view of data analysis according to the research question. This Interaction Directed Acyclic Graph (IDAG) is a combination of two regular Directed Acyclic Graphs (DAG) in which one modifies the other.[10] IDAGs illustrate how interactions can modify causal mechanisms. To investigate how these mediated mechanisms of education (exposure) and oral health habits (mediators) on dental service utilization (outcomes) differ in different service sectors (public versus private), the interaction of service sectors on these mediated paths (IDAG) was checked. The main DAG

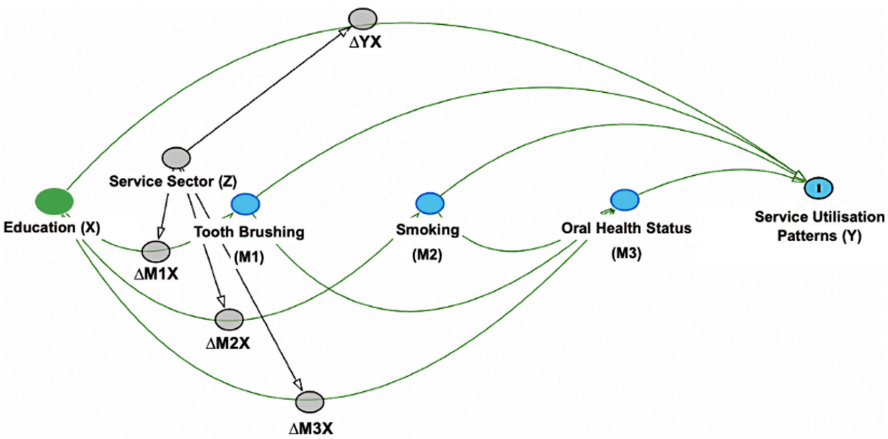

FIGURE 1 Directed Acyclic Graph illustrating the data analysis of the mediation analysis

(i.e. mediation DAG) was drawn to test the direct and indirect effects of education level on dental service utilization patterns (models 1, 2 and 3) through a mediation path. These mediators were tooth brushing habits, smoking and oral health status. In this mediation, it was hypothesized that the first two mediators influence the third (oral health status). How different service sectors modify these mediation effects (IDAG) was tested as well by measuring the effect modification of a baseline confounder (Service sector). According to Figure 1, we elaborate on the variables' definitions and ordering.

2.2 | Education (Exposure)

The highest level of education was recorded. Categories were '*No schooling*', '*Completed primary school*', '*Some high school*', '*Completed High School*', '*Vocational training*' and '*University degree*' (including university degrees, diplomas and tertiary education). From a legal sense, it is compulsory to finish high school in South Australia unless approved in some circumstances (full-time work or starting vocational training, which is also captured in our study). Therefore, education was dichotomized into ≤12 Year/Certificate, including people with any level of high school or vocational training (Coded as 1) and > 12 Year/Diploma (Coded as 0) for individuals with a diploma or university degrees.

2.3 | Mediators

The mediation included three mediators as follows: Tooth Brushing (Mediator one), Smoking (Mediator two) and Oral Health Status (Mediator three). Information regarding tooth brushing habits was collected. Brushing at least once or more daily was coded as 1; if the daily brushing times were less than one, it was coded as 2. Participants were asked about their cigarette smoking status; participants who did not smoke were coded as 1, while those who did smoke were coded as 2. Participants were asked to rate their dental health and choose from each of these categories: '*Very poor*', '*Poor*', '*Good*', '*Very Good' and 'Excellent'*. Self-reported oral health status of participants was dichotomized as poor when their responses were '*Very poor' or 'Poor'* and coded as 2; otherwise, it was recorded as good and coded as 1.

2.4 | Outcomes

Our models include three outcomes related to dental visiting patterns: Last dental visit (Outcome for model one), Reason for visit (Outcome for model two) and Frequency of dental care (Outcome for model three). Participants were asked about the last time they visited a dental professional (including dentist, dental specialist, oral health therapist, dental hygienist, dental therapist, dental technician, denturist or dental prosthetist). When it was less than 12 months ago, responses were coded as 0 and other times were coded as 1. If the main reason for the last dental visit was for an emergency or treatment, it was coded as 1; for examination or check-up, it was coded as 0. Participants were asked how often they seek care from a dental professional; at least once annually, responses were coded as 1 and otherwise coded as 0.

2.5 | Confounders

The confounder variables included in the mediation models were the last dental service sector (private = 0, public =1), Age (18–39 years old =0, 40–59 years old =1 and greater than or equal to 60 years old = 2), Gender (male = 0, female = 1), Country of Birth (Australia = 0, Other = 1), Residential location (greater Adelaide area = 0, other places = 1), Hosehold untaxed income (≥$80 000 = 0, <$80 000 = 1) and self-reported general health status (good = 0, poor = 1).

As education levels influence the households income, we have not adjusted our outcome models for income. However, to calculate the mediators' probability weights, two of the mediators' models, oral health status and smoking, were adjusted for income.

2.6 | Statistical analysis

The counterfactual analysis compares what happened and what would have happened at different levels of exposure. It measures what happened and what would have happened if we went back in time and gave the same person the same or different exposure. Counterfactual meditation analysis is one of the approaches that can be used to analyse the mechanisms between exposure and outcome through mediators. In these analyses, it is necessary to consider a series of cross-world assumptions. These assumptions are described below and are based on the fact that there should not be any unmeasured confounder violating the mediation pathways. In addition to this, when there are several mediators which affect each other (as in Figure 1), these assumptions are violated. Therefore, the flexible mediation method with multiple mediators approach,[11,12] which is an extension of Counterfactual mediation analysis,[13] was used to overcome this problem by not decomposing this as individual pathways but using the joint analogues effects. With this approach, the total effect is decomposed into direct and indirect effects. The direct effect is the change in the outcome when everyone in the population who had their exposure level switched from higher to lower education level, but the distribution of the mediators was set to those of higher educated individuals. In the same way, the indirect effect expresses the change in the dental service utilization patterns when the exposure has been set to that of the lower educated group, but the distribution of the mediators changed to what it would be of the lower educated individuals.[11,12,14]

Finally, the effect modification of different provider sectors as a baseline confounder in our different marginal structural models (*Geeglm* * Provider Sector) was measured. This accounted for the impact of education levels on the mediation paths in the public and private sectors.

Dichotomizing multicategory variables may cause homogeneity and loss of information. Although this study followed a robust methodology, most of the variables were dichotomized for various reasons. Several concepts are hard to visualize when using a continuous-valued exposure with the potential outcome approach. On the contrary, a binary exposure has a clear and direct interpretation as it corresponds to the randomized trials exposed and control groups. For example, suppose that the exposure is a dichotomous variable that takes values 1 and 0; when the patient/individual in the observed data is exposed ($X = 1$), their counterfactual value which the exposure can take is the not exposed state, ($X = 0$). However, if the observed exposure is a continuous-valued variable, then the corresponding counterfactual values are a distribution compared to a single value. Using a whole distribution of potential outcomes can be challenging both in terms of interpretation as well as defining randomized trials corresponding to the distribution. Second, as we are using the mediator weights, these will be from the density functions, which can be unstable. Similar to exposure effect interpretation, the decomposition effect interpretation can be complex too.

Inference from the analysis and findings have no causal interpretation in the presence of unmeasured confounders. Therefore, this study was conducted under the assumption that there should be no unmeasured confounder between exposure-outcome, exposure-mediator, mediator-outcome and no exposure-induced mediator outcome confounder. For this reason, sensitivity analysis was carried out to understand the nature of the unmeasured confounders.[15] Hong et al. (2018) introduced weighting-based sensitivity analysis in causal mediation studies by calculating the propensity weights of mediators. In this approach, bias due to omitting currently adjusted confounders (i.e. observed pre-treatment confounders) can be an approximate prediction of probable unmeasured confounders.[16] This possible bias can be measured by step-by-step elimination of observed confounders and by calculating the difference in the new and previous mediators' distribution weights. They introduced two sensitivity parameters that estimate the bias size. By this bias estimate size, the new effect estimates affected by unmeasured confounders can be calculated. This bias size equals the multiplication of two sensitivity parameters, Sigma (σ: standard deviation of mediators' weights discrepancy) and Rho (ρ: correlation between the mediators' weights discrepancy and the outcome). The original approach and their R package are for models with one mediator. As mediation paths in this study included multiple mediators and interactions, Hong's codes were modified, and the mediators' weight discrepancy was calculated by multiplying each mediator's weight discrepancy and calculating the total mediators' weights.

All analyses were conducted using *RStudio* version 1.3.1056 and *R* version 4.0.4. To handle missingness, a multiple imputation technique was utilized using the *Mice* package. Mediation effects were measured by the *Geepack* package, and all three models were adjusted for confounders (service sector, age, gender, income, general health status, country of birth and residential location). Bootstrap assessment was done with 1000 repetitions, and estimates were reported with 95% confidence intervals. R codes for mediation analysis are available in the Supplement file S1.

3 | RESULTS

Findings are based on the imputed weighted sample. The mean age was 48.1 ±18.2 years, with 49.0% being male. Individuals with a higher education level (having a university degree) were 59.5% of the population. People whose last dental visit was more than 12 months ago or having less than one dental visit in the last year were 41.5% and 44.8%, respectively (Models 1 & 3). Most participants (60.1%) went for an examination or check-up, while 39.9% visited because of an emergency or treatment during their last dental visit (Model 2). Further distribution of variables is given in Table S1.

According to the crosstabulation results, delayed (more than 12 months) last dental visit (Model 1) was more prevalent (45.4%) in the group with low education compared to the highly educated group (35.7%). Similarly, in Model 3, 49.8% of the low education group, compared to 37.3% of the highly educated group, reported a dental visit less than once a year. Investigating the last dental visit frequency reason depicted that 66.6% of highly educated individuals visited a dentist for a dental check-up or an examination, and 33.4% of those visited their dentist because of an emergency or treatment. In comparison, 55.7% of people with low education visited their dentist for a check-up or an examination, and 44.2% visited for an emergency or treatment (Model 3). According to these findings, less educated individuals visited a dentist less frequently and mainly to receive emergency treatments rather than routine dental check-ups.

Table 1 depicts the results of the mediation models with the decomposition of the total indirect effect and is adjusted for confounder variables. In model 1, the direct effect of education on the time of the last dental visit was 0.67 (95% CI 0.56, 0.78), which is interpreted as the odds of a favourable dental visit in the last 12 months would be 33% less if changing the distribution of potential outcomes of individuals to their counterfactual exposure distribution (Changing education level from high to low) and keeping their mediators' distributions at the observed level (high-educated individuals). Considering this interpretation, the odds of the direct effect were 1.23 (95% CI 1.05, 1.43) and 0.62 (95% CI 0.53, 0.74) for model 2 and model 3, respectively. The odds ratios of indirect effect for all models were close to one, and this could be interpreted as no more changes could be expected in favourable visiting patterns after a simultaneous change of the distribution of exposure in observed high-educated individuals to their counterfactual level and the mediators' distributions to their counterfactual mediators' distributions of low education individuals. In other words, lower levels of education, regardless of oral health status, smoking status and brushing, can affect the use of dental services.

In the lower section of Table 1, results show the effect modification of a baseline confounder (i.e. dental service providing sector). This shows how the direct and indirect effects would be in various dental service sectors. In other words, it shows the odds

TABLE 1 Direct effect of education and the total mediating effect of education through various mediators on dental service utilization patterns

	Model 1	Model 2	Model 3
	OR (95% CI)		
(Intercept)	1.66 (1.29–2.09)	0.28 (0.22–0.36)	1.72 (1.37–2.18)
Direct effect of education (Reference: Diploma/Degree)	0.67 (0.56–0.78)	1.23 (1.05–1.43)	0.62 (0.53–0.74)
Total indirect effect of education through all mediators	1.01 (0.96–1.05)	0.99 (0.95–1.03)	1.00 (0.96–1.05)
Indirect effect of tooth brushing (Mediator1)	1.00 (0.96–1.03)	1.00 (0.97–1.03)	1.00 (0.97–1.04)
Indirect effect of smoking Status (Mediator 2)	1.00 (1.00–1.01)	1.00 (0.99–1.00)	1.00 (1.00–1.01)
Indirect effect of oral health status (Mediator 3)	1.01 (0.97–1.04)	0.99 (0.97–1.02)	1.00 (0.96–1.03)
Total Effect (direct + indirect effect)	0.67 (0.57–0.78)	1.22 (1.05–1.40)	0.63 (0.54–0.73)
Service Sector (Reference: Private)	0.28 (0.18–0.43)	1.70 (1.15–2.49)	0.21 (0.13–0.32)
Age 40–59 year (Reference: 18–39 year)	1.26 (1.02–1.54)	2.11 (1.72–2.67)	1.01 (0.82–1.24)
Age ≥ 60 year (Reference: 18–39 year)	2.08 (1.69–2.62)	2.34 (1.87–2.94)	1.73 (1.37–2.16)
Gender (Reference: Male)	1.17 (0.98–1.42)	0.83 (0.71–0.99)	1.35 (1.13–1.60)
General Health Status (Reference: Good Status)	0.56 (0.39–0.77)	2.04 (1.43–2.83)	0.51 (0.36–0.73)
Country of Birth (Reference: Australia)	1.10 (0.88–1.33)	1.22 (0.99–1.52)	0.97 (0.79–1.21)
Residential Location (Reference: Capital Area)	0.65 (0.52–0.79)	1.60 (1.33–1.95)	0.58 (0.47–0.70)
Mediation Effects after Effect Modification of a Baseline Confounder (i.e. Service Sector) (Reference: High-educated individuals who went to private sector)			
Direct Effect of Education: Sector	1.30 (0.78–2.15)	1.24 (0.78–2.03)	1.40 (0.87–2.35)
Indirect effect of tooth brushing (Mediator1): Sector	0.99 (0.95–1.02)	1.00 (0.95–1.06)	0.99 (0.96–1.03)
Indirect effect of smoking status (Mediator 2): Sector	0.99 (0.98–1.00)	1.00 (0.99–1.05)	0.99 (0.98–1.00)
Indirect effect of oral health status (Mediator 3): Sector	0.99 (0.95–1.08)	1.00 (0.94–1.05)	1.00 (0.94–1.12)

Note: Model 1, Time of last dental visit (Reference: More than 12 Months ago); Model 2 (Reference: Examination or Check-up), Reason of the last dental visit; Model 3, Frequency of dental care (Reference: Less than once a year).

Abbreviations: CI, Confidence Intervals; OR, Odds Ratio.

of outcomes for low education individuals who visited the public sector compared to their counterparts with different education and service sector. The odds ratio of indirect effect for all three models with no change kept at close to one, but the odds ratio for the direct effect changed to 1.30 (95% CI 0.77, 2.03) for Model 1, 1.24 (95% CI 0.78, 2.03) for Model 2 and 1.40 (95% CI 0.87, 2.35) for Model 3. In general individuals with low education did not have proper dental service utilization (models 1 and 3); however, those individuals with low education who visited a public sector had higher odds of proper dental service utilization compared to the others.

According to the sensitivity analysis (Table S2), omitting currently adjusted confounders did not change the direct effect estimate. There are some negligible changes for the indirect effect, but new estimates in all models are still very close to one. Although results show no sensitivity to the omission of currently adjusted confounders, there is still a possibility of cumulative unmeasured confounders and measurement biases.

4 | DISCUSSION

This analysis sought to model how education affects dental service utilization patterns in Australian adults and how these education effects were mediated by some measured health behaviours. The findings suggest that low education individuals are less likely to have a dental visit in 1 year or to have received dental services at least once a year, respectively.

According to the findings, low education level was associated with a less favourable utilization of dental services (Models 1 and 3). This inverse association between the use of dental services and low education has been reported in other studies. Listl (2012), in a study of socio-economic inequalities through the lifespan in thirteen European countries, reported that people with less education utilized dental services less than their counterparts with more education.[4] Also, Piotrowska et al. (2018) reported that the use of dental services in people with less education was almost half compared to people with more education.[17] Besides the association with dental visiting frequency, this study showed that low education was associated with more emergency and treatment visits compared to routine dental check-ups (Model 2).

Another notable finding was the results of the effect modification measurement, which indicated a relative improvement of the dental service patterns in the patients referred to the public sector. It can be interpreted that public services, to some extent, reduce this disparity in the use of dental services between people with different levels of education.

These findings provide new information on the impact of education on dental services utilization patterns. Despite education having a direct effect on dental services utilization, there was no indirect effect of education on dental utilization through oral health status and behaviours. These findings support the policy idea that universal health coverage (UHC) and extension of public services may lead to an increase in dental service utilization for low education individuals who suffers from low utilization regardless of their oral health attitudes.

One of the strengths of this research was the use of robust counterfactual multiple mediation analysis. Due to the lack of software support, the statistical aspects of this study were performed independently by writing new codes. The large population and the use of weighted South Australian representative data were other strengths of this study.

These findings may not be completely free of bias, and there could be some biases due to cumulative unmeasured confounders and measurement errors, yet no method has been introduced for handling these. Most of the variables were self-reported, and as it is mentioned in the method section, by dichotomising the exposure, there is a chance of information loss. In addition, dichotomization may lead to measurement error by coarsening the value into a broader category which could lead to an underestimation of the mediated effect and an overestimation of the direct effect.[18] However, to keep the analysis simple and to have a clear interpretation, we agreed to use dichotomized variables. Therefore, the results must be interpreted with caution as they can be sensitive to the cut point used in exposure dichotomization. The DAG in this study illustrated the hypothesized ordering of the variables in a cross-sectional context. However, the real ordering between confounding factors, exposure, mediators and outcomes is still unclear. Thus, longitudinal studies with clear temporal ordering are needed to validate the findings of this study.

5 | CONCLUSION

In conclusion, low education reduces the odds of optimal dental service utilization. The direct effect of low education regardless of mediation paths through smoking, tooth brushing and oral health status reduces the odds of dental service utilization, in terms of frequency of seeking dental care and times visiting a dentist annually. However, in terms of the reason for seeking dental care, lower education increases the odds of receiving emergency and treatment services. So, the key message is that if all persons with low education have their education like that of the high education level in the observed data, then the gaps in dental service utilization may reduce.

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CONFLICT OF INTEREST

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

DATA AVAILABILITY STATEMENT

Research data are not shared.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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