Social determinants and behavioural factors influencing toothbrushing frequency among primary school children in rural Australian community of Lithgow, New South Wales

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Abstract
Objective: This study aims to determine the social determinants and behavioural factors influencing frequency of toothbrushing among primary school children residing in the rural community of Lithgow in New South Wales, Australia. All six primary schools of Lithgow were approached to participate in a cross-sectional survey prior to implementation of water fluoridation. A validated oral health survey questionnaire was completed by 703 parents of the children. Multivariable logistic regression analysis was employed to determine significant predictors associated with frequency of toothbrushing.

Results: Parents with a positive attitude towards water fluoridation had 74% higher odds (OR = 1.74, 95% CI 1.17–2.60) of their children brushing twice or more daily. Children living in a single parent household had 34% reduced odds (OR = 0.66, 95% CI 0.43–0.99) of brushing twice daily. Poor maternal oral health was significantly associated with suboptimal dental hygiene practices in children, where mothers who had any tooth extracted had 7% reduced odds of their children brushing their teeth twice or more daily (OR = 0.93, 95% CI 0.90–0.97). Subsequently, children with increased consumption of chocolates per day were less likely to brush twice or more daily. Finally, children with dental insurance had two times higher odds (OR = 2.04, 95% CI 1.40–2.96) of brushing twice daily.

Keyword: Toothbrushing, Socioeconomic status, Children, Rural, Non-fluoridated, Oral health

Introduction
Dental caries is recognised as a global public health concern [1]. Amongst 354 diseases considered in the Global Burden of Disease study (1990–2017), untreated dental caries was the most ubiquitous disease [2, 3]. In Australia, dental caries is the most common health issue in childhood [4]. The recent Australian National Child Oral Health Survey (NCOHS) 2012–2014 reported that over 25% of 5 to 10-year-old children had untreated caries in the primary dentition, while one in ten children aged 6 to 14 years had untreated caries in the permanent dentition [5].

Although dental caries has imminent negative health consequences, it is largely preventable by regular toothbrushing with a fluoridated toothpaste along with other measures such as a low sugary diet, regular dental visits, and water fluoridation [6]. Toothbrushing using a fluoridated toothpaste is one of the most effective methods to prevent dental caries [7] and the motor skills required...
for toothbrushing are developed from an early age to adolescence [8]. The fluoride in the toothpaste promotes enamel remineralisation through the formation of fluorapatite crystals [9]. A Cochrane review reported that parental supervision and children’s frequency of toothbrushing enhances the protective effect of fluoridated toothpaste [10]. However, the most recent Australian NCOHS reported that only 50% of children aged 5 to 14 years brushed their teeth twice daily with a fluoridated toothpaste [5].

There is ample evidence on health inequality as a result of geographical remoteness, limited fluoride exposure, access to dental services, and affordability [11]. The Australian national survey reported that children living in rural and remote areas had 38% higher proportion of untreated caries than those living in major cities [5] due to a multitude of factors such as lack of water fluoridation, socio-economic status, and shortage of dental workforce [12].

Lithgow Local Government Area (LGA) within the jurisdiction of former Sydney West Area Health Service (now under Nepean Blue Mountains Local Health District) is a recently fluoridated community in NSW [13–15]. Studies have been conducted to ascertain dental caries burden in Lithgow children prior to water fluoridation [13, 14]. Although there is some evidence on the oral health of rural Australian children, there is paucity of evidence on the predictors of toothbrushing frequency among rural children. Therefore, the aim of this study is to identify the factors influencing toothbrushing frequency among primary school children in the rural Lithgow community, Australia.

Main text

Study background

This study is a secondary data analysis of the cross-sectional survey on primary school children in rural non-fluoridated community of Lithgow, prior to water fluoridation in 2014 [13, 15]. All six primary school principals in Lithgow LGA gave permission to conduct the survey. The parents of children were then invited to take part in a survey via a take-home information pack. Further details of our previous work are mentioned elsewhere [13–15].

Data collection

For standardised collection of information, the dental survey questionnaire was adapted from the Australian NCOHS as used in our previous studies [13, 14]. The socio-demographic information collected in the questionnaire include child-specific characteristics including child’s age, gender, age when toothbrushing commenced, discretionary diet, and dental visit history. Additionally, family or parental characteristics include parent’s age, education, occupation, country of birth, marital status, extraction history, language spoken at home, private health insurance (PHI) status, and family income. The primary outcome of this study was a dichotomised version of toothbrushing frequency: brush at least twice per day (coded yes or no). Clinical dental examination of children’s oral health was performed by primary researchers. The guidelines of the World Health Organization (WHO) were adopted as the diagnostic criteria for dental caries [16].

Statistical analysis

A theoretical model based on previous literature with use of Fisher-Owen’s framework [17] was employed wherein all variables present in the model were fitted in the multiple logistic regression analyses to determine the factors that were independent predictors of toothbrushing frequency in Lithgow LGA community. All variables were tested against the outcome variable and were adjusted for other covariates in the multivariable regression analysis where a backward stepwise method was used to eliminate variables that had a non-significant effect in a stepwise manner. All variables in the final model were variables for which, when excluded, the change in deviance compared with the corresponding Chi-square ($\chi^2$) test statistic on the relevant degrees of freedom was significant ($p < 0.05$).

In addition, variables were tested for collinearity using Pearson’s product-moment collinearity tests against each other and against other covariates, before including them in multivariable logistic regression analysis. However, all variables tested had correlations of less than 0.5 implying that the possibility of collinearity between the variables is small.

One sample z-tests of proportions were performed to compare the data collected from this survey with Australian Bureau of Statistics census of Lithgow region for 2011 [18] for help determining the external validity of the data. All statistical analyses were undertaken using the IBM SPSS Statistics version 24.

Results

Of the 1400 parents contacted in the Lithgow LGA, 703 (52.1%) completed the survey questionnaire. The descriptive statistics shows that only 65% of children brushed twice or more daily whereas 35% of children brushed once or less daily (Table 1).

Table 2 shows unadjusted and adjusted odds ratios of the regression analyses respectively. In the multivariable analysis, positive parental attitude towards water fluoridation and private dental insurance were significantly associated with increased frequency of toothbrushing. Parents with a positive attitude towards
Table 1  Socio-behavioural factors influencing tooth-brushing frequency in primary school children of LGA (n = 703)

| Socio-behavioural factors | n\(^a\) | Tooth-brushing Frequency | | Chi square\(^b\) | p value |
|---------------------------|---------|--------------------------|---------|-----------------|----------|
|                           | < 2/ day (n = 247) | ≥ 2/ day (n = 454) |         |                 |          |
| Child-specific characteristics |         |                          |         |                 |          |
| Age of the child, mean (SD) | 703     | 8.7 (2.0) | 8.9 (2.0) | 0.004\(^c\) | 0.324    |
| Gender of the child |         |                          |         |                 |          |
| Female | 348 | 120 (48.6) | 228 (50.2) | 0.172 | 0.679 |
| Male | 353 | 127 (51.4) | 226 (49.8) | 1.742 | 0.187 |
| Age when toothbrushing commenced |         |                          |         |                 |          |
| Less than 12 months of age | 45 | 12 (5.1) | 33 (7.8) | 9.850 | 0.007 |
| 12 months or more | 612 | 223 (94.9) | 389 (92.2) | 15.600 | < 0.001 |
| Last visit to dentist |         |                          |         |                 |          |
| Less than 12 months | 536 | 178 (72.4%) | 358 (79.0%) | 3.968 | 0.046 |
| 12 months or more | 163 | 68 (27.6%) | 95 (21.0%) | 9.850 | 0.007 |
| Serves of sugar sweetened beverages per day |         |                          |         |                 |          |
| 0 | 78 | 23 (9.3) | 55 (12.1) | 25.499 | < 0.001 |
| 1 | 132 | 28 (11.3) | 104 (22.9) | 15.600 | < 0.001 |
| 2 | 171 | 54 (21.9) | 117 (25.8) | 15.600 | < 0.001 |
| 3 | 138 | 59 (23.9) | 79 (17.4) | 9.850 | 0.007 |
| 4 or more | 182 | 83 (33.6) | 99 (21.8) | 9.850 | 0.007 |
| Serves of chocolate per day |         |                          |         |                 |          |
| 0 | 235 | 64 (25.9) | 171 (37.7) | 15.600 | < 0.001 |
| 1 | 329 | 118 (47.8) | 211 (46.5) | 15.600 | < 0.001 |
| 2 or more | 137 | 65 (26.3) | 72 (15.9) | 9.850 | 0.007 |
| Family-specific characteristics |         |                          |         |                 |          |
| Marital status of parents |         |                          |         |                 |          |
| Married or having partner | 560 | 177 (71.7%) | 383 (84.4%) | 16.061 | < 0.001 |
| Single parent | 141 | 70 (28.3%) | 71 (15.6%) | 16.061 | < 0.001 |
| Age of mother |         |                          |         |                 |          |
| 20–29 years | 73 | 36 (14.8%) | 37 (8.2%) | 9.850 | 0.007 |
| 30–39 years | 400 | 143 (58.6%) | 257 (57.0%) | 9.850 | 0.007 |
| ≥ 40 years | 222 | 65 (26.6%) | 157 (34.8%) | 9.850 | 0.007 |
| Age of father |         |                          |         |                 |          |
| 20–29 years | 25 | 10 (5.7) | 15 (3.9) | 9.850 | 0.007 |
| 30–39 years | 275 | 94 (54.0) | 181 (47.5) | 9.850 | 0.007 |
| ≥ 40 years | 255 | 70 (40.2) | 185 (48.6) | 9.850 | 0.007 |
| Education status of mother |         |                          |         |                 |          |
| University | 170 | 44 (18.2%) | 126 (28.3%) | 8.643 | 0.003 |
| Vocational or High school | 517 | 198 (81.8%) | 319 (71.7%) | 8.643 | 0.003 |
| Education status of father |         |                          |         |                 |          |
| University | 98 | 22 (12.3%) | 76 (20.1%) | 5.060 | 0.024 |
| Vocational or high school | 460 | 157 (87.7%) | 303 (79.9%) | 5.060 | 0.024 |
| Job of Mother |         |                          |         |                 |          |
| Managers and professionals | 147 | 36 (14.8%) | 111 (24.9%) | 23.694 | < 0.001 |
| Skilled workers | 309 | 98 (40.2%) | 211 (47.4%) | 23.694 | < 0.001 |
| Pensioners and employed | 233 | 110 (45.1%) | 123 (27.6%) | 23.694 | < 0.001 |
| Job of father |         |                          |         |                 |          |
| Managers and professionals | 166 | 55 (31.6) | 111 (29.2) | 0.397 | 0.820 |
| Skilled workers | 348 | 106 (60.9) | 242 (63.7) | 0.397 | 0.820 |
| Pensioners and employed | 40 | 13 (7.5) | 27 (7.1) | 0.397 | 0.820 |
water fluoridation had 74% higher odds (OR = 1.74, 95% CI 1.17–2.60) of their children brushing twice or more daily. Children who were covered by a private dental insurance had two times higher odds (OR = 2.04, 95% CI 1.40–2.96) of brushing twice or more daily.

However, factors such as single parent household, one or more tooth extraction history in mothers, and increased serves of chocolates consumed per day were determined to be significantly associated with decreased frequency of toothbrushing in children. Children living in a single parent household had 34% reduced odds (OR = 0.66, 95% CI 0.43–0.99) of brushing twice daily compared to those living with married parents. Poor maternal oral health was significantly associated with suboptimal dental hygiene practices in children, where mothers who had any tooth extracted had 7% reduced odds of their children brushing their teeth twice or more daily (OR = 0.93, 95% CI 0.90–0.97). Subsequently, children with increased consumption of chocolates per day were less likely to brush twice or more daily.

Table 3 shows the comparison of the socio-demographic characteristics of the Lithgow study population with that of the 2011 Australian Census. It is seen that the expected population estimates of the Lithgow survey did not significantly differ from the Census for factors such as Indigenous status and highest education level in the household. However, it is observed that the children with two Australian born parents were 4% over-represented in the Lithgow survey compared to Census report.

**Discussion**

This study provided insights on various factors influencing toothbrushing frequency in primary school children in rural non-fluoridated Lithgow LGA. Approximately 65% of the parents who completed the survey, reported that their children brushed their teeth twice or more daily. This is less than the 75% reported by the AIHW report in 2012 which could be due to remoteness of the area compared to the overall Australian rates [12].

The multivariable analysis show that parents with a positive attitude towards water fluoridation had higher odds of having their children brush twice daily or more with fluoridated toothpaste compared to parents who are unsure or antipathic towards water fluoridation. The positive attitude of parents may be due to the result of increased awareness of the benefits of water fluoridation to oral health, thereby encouraging their children to brushing frequently with a fluoridated toothpaste, as reported in other studies [19].

Children who were covered by a private dental insurance had higher odds of brushing their teeth frequently compared to those who were not covered by a private insurance. The Australian government currently provides Medicare and Pharmaceutical Benefit Schemes to fund the general health expenditure [20]. It is worthy to note...
Table 2 Univariate and multivariate logistic regression analysis of Tooth-brushing Frequency with non-imputed and imputed models

| Socio-behavioural factors                      | Tooth-brushing frequency |  |  |  |  |
|-----------------------------------------------|--------------------------|---|---|---|---|
|                                               |                          |  | Univariable analysis |  | Adjusted odds ratio |  |
|                                               |                          |  | Unadjusted odds ratio | p value |  | 95% CI | p value |  |  |
| Age of the child, mean (SD)                   |                          |  | 1.04 | 0.323 |  |  |  |
| Gender of the child                           |                          |  | 1.00 |  |  |  |  |
| Female                                        |                          |  | 1.00 |  |  |  |  |
| Male                                          |                          |  | 0.94 (0.69, 1.28) | 0.679 |  |  |  |
| Age when tooth brushing commenced             |                          |  | 1.00 |  |  |  |  |
| Less than 12 months of age                    |                          |  | 1.00 |  |  |  |  |
| 12 months or more                             |                          |  | 0.63 (0.32, 1.25) | 0.190 |  |  |  |
| Last visit to Dentist                         |                          |  | 1.00 |  |  |  |  |
| Less than 12 months                           |                          |  | 1.00 |  |  |  |  |
| 12 months or more                             |                          |  | 0.69 (0.48, 0.99) | 0.047 |  |  |  |
| Serves of sugar sweetened beverages per day   |                          |  | 1.00 |  |  |  |  |
| 0                                            |                          |  | 1.00 |  |  |  |  |
| 1                                            |                          |  | 1.55 (0.82, 2.95) | 0.178 |  |  |  |
| 2                                            |                          |  | 0.91 (0.50, 1.62) | 0.741 |  |  |  |
| 3                                            |                          |  | 0.56 (0.31, 1.01) | 0.055 |  |  |  |
| 4 or more                                     |                          |  | 0.50 (0.28, 0.88) | 0.016 |  |  |  |
| Serves of chocolate per day                   |                          |  | 1.00 |  |  |  |  |
| 0                                            |                          |  | 1.00 |  |  |  |  |
| 1                                            |                          |  | 0.67 (0.46, 0.96) | 0.031 | 0.60 (0.40, 0.90) | 0.013 |  |
| 2 or more                                     |                          |  | 0.41 (0.27, 0.64) | < 0.001 | 0.41 (0.25, 0.65) | < 0.001 |  |
| Marital status of parents                     |                          |  | 1.00 |  |  |  |  |
| Married or having partner                     |                          |  | 1.00 |  |  |  |  |
| Single parent                                 |                          |  | 0.46 (0.32, 0.68) | < 0.001 | 0.66 (0.43, 0.99) | 0.044 |  |
| Age of Mother                                 |                          |  | 1.00 |  |  |  |  |
| 20–29 years                                   |                          |  | 1.00 |  |  |  |  |
| 30–39 years                                   |                          |  | 1.74 (1.05, 2.89) | 0.029 |  |  |  |
| ≥ 40 years                                    |                          |  | 2.35 (1.36, 4.04) | 0.002 |  |  |  |
| Age of Father                                 |                          |  | 1.00 |  |  |  |  |
| 20–29 years                                   |                          |  | 1.00 |  |  |  |  |
| 30–39 years                                   |                          |  | 1.29 (0.55, 2.98) | 0.551 |  |  |  |
| ≥ 40 years                                    |                          |  | 1.75 (0.75, 4.08) | 0.194 |  |  |  |
| Education status of mother                    |                          |  | 1.00 |  |  |  |  |
| University                                    |                          |  | 0.56 (0.38, 0.82) | 0.004 |  |  |  |
| Vocational degree or high school              |                          |  | 0.55 (0.33, 0.93) | 0.026 |  |  |  |
| Education status of father                    |                          |  | 1.00 |  |  |  |  |
| University                                    |                          |  | 1.00 |  |  |  |  |
| Vocational degree or high school              |                          |  | 0.69 (0.44, 1.09) | 0.114 |  |  |  |
| Job of mother                                 |                          |  | 1.00 |  |  |  |  |
| Managers and professionals                    |                          |  | 1.00 |  |  |  |  |
| Skilled workers                               |                          |  | 0.36 (0.23, 0.57) | < 0.001 |  |  |  |
| Pensioners and unemployed                     |                          |  | 1.13 (0.76, 1.68) | 0.541 |  |  |  |
| Job of father                                 |                          |  | 1.00 |  |  |  |  |
| Managers and professionals                    |                          |  | 1.00 |  |  |  |  |
| Skilled workers                               |                          |  | 0.51 (0.35, 0.75) | 0.001 |  |  |  |
that children covered by private health insurance readily have access to comprehensive dental treatment whereas children who are not covered by a private insurance are limited to public dental services, which often have long waiting periods [21]. The descriptive findings of this study show that only 37% of children reported having

### Table 2 (continued)

| Socio-behavioural factors | Tooth-brushing frequency |
|---------------------------|--------------------------|
|                           | Univariable analysis     | Multivariable analysis |
|                           | Unadjusted odds ratio (95% CI) | p value | Adjusted odds ratio (95% CI) | p value |
| Pensioners and employed   | 1.03 (0.49, 2.14)        | 0.939   | 1.00                          |        |
| Parental attitude towards fluoridation | | | |
| Negative or unsure        | 1.00                     |        | 1.00                          |        |
| Positive                  | 1.83 (1.27, 2.63)        | 0.001   | 1.74 (1.17, 2.60)             | 0.007  |
| Extractions due to tooth decay in Mother | | | |
| No extractions            | 1.00                     |        | 1.00                          |        |
| One or more               | 0.53 (0.39, 0.73)        | <0.001  | 0.93 (0.90, 0.97)             | <0.001 |
| Extractions due to tooth decay in Father | | | |
| No extractions            | 1.00                     |        | 2.67 (1.88, 3.80)             | <0.001 |
| One or more               | 0.64 (0.45, 0.92)        | 0.018   | 0.93 (1.17, 2.60)             |        |
| Private dental insurance  | 2.67 (1.88, 3.80)        | <0.001  | 2.04 (1.40, 2.96)             | <0.001 |
| No extractions            | 1.00                     |        | 1.00                          |        |
| One or more               | 0.53 (0.39, 0.73)        | <0.001  | 0.93 (0.90, 0.97)             | <0.001 |
| Income of the family      | 2.67 (1.88, 3.80)        | <0.001  | 2.04 (1.40, 2.96)             | <0.001 |
| More than $100 K          | 1.00                     |        | 2.04 (1.40, 2.96)             | <0.001 |
| $40–100 K                 | 0.95 (0.53, 1.71)        | 0.878   | 0.93 (1.17, 2.60)             |        |
| Up to $40 K               | 0.40 (0.22, 0.72)        | 0.002   | 0.93 (1.17, 2.60)             |        |

Independent variables adjusted in the risk model are: Marital status of parents, Age of mother, Education status of Mother, Education status of Father, Job of Mother, Extractions due to tooth decay in Mother, Extractions due to tooth decay in Father, Attitude towards Water Fluoridation, Private dental insurance, Income of the family

CI: Confidence interval, NS: Not significant

Model 1—Original (non-imputed data)
Model 2—Imputed data

### Table 3 Population benchmark comparison of demographic characteristics of Lithgow from ABS census 2011 report

| Socio-demographic characteristics | Survey estimate (observed percentages) % of children (95% CI) | Observed p-value | 2011 census report (expected percentages) % of children |
|----------------------------------|---------------------------------------------------------------|------------------|---------------------------------------------------------|
| Country of birth of household*   | 12.02 (9.60–14.42)                                            | <0.001*          | 16.45                                                   |
| Overseas                         | 87.9 (85.36–90.19)                                            |                  | 83.55                                                   |
| Australia                        |                                                               |                  |                                                         |
| Indigenous status of householdb | 4.42 (2.90–5.94)                                              | <0.001*          | 5.57                                                    |
| Indigenous                       |                                                               |                  |                                                         |
| Non-indigenous                   | 95.58 (94.06–97.10)                                           |                  | 94.43                                                   |
| Highest education level in the householdc | 71.14 (67.79–74.50)                                            | 0.268            | 73.17                                                   |
| University or college degree     |                                                               |                  |                                                         |
| High school or vocational training |                                                          |                  |                                                         |

a: Statistically significant at 5% level
b: Children were classified to the Indigenous category if they had at least one parent who was Indigenous
c: Children were classified to the University or College degree category if they had at least one parent who had a University or College degree
private insurance which is consistent with other study findings reporting that the lack of private insurance is further exacerbated by residence in rural and remote areas [22]. In addition, disparities in private insurance coverage and optimal oral health care are also evident by socioeconomic status as reported in other studies. Children who are covered by private dental insurance are more likely to come from a family with higher socioeconomic status and therefore have better access and increased visits to the dentist resulting in better dental hygiene practices and experience as opposed to children without private dental insurance [22].

Studies report that the development of oral hygiene practices in children are primarily influenced by the mother’s oral hygiene attitudes and beliefs [23–26]. The study findings show a significantly lower odds of toothbrushing in children whose mothers have poor oral health. Mothers who are less concerned about their oral hygiene and those who under-estimate the importance of oral health eventually would not take notice of their child’s dental hygiene and maintenance, which could lead to negative oral health outcomes. This may be manifested in terms of their children's discretionary diet, where children having increased serves of chocolates consumed per day also had reduced odds of toothbrushing twice or more daily. This relationship of maternal oral health and toothbrushing frequency of their children is comparable to other studies [24–26].

The study also identified that children in single parent household had reduced odds of brushing their teeth twice or more daily. It has been suggested that lack of paternal support and financial strain causes increased stress may lead to development of suboptimal oral hygiene practices [27, 28]. Emotional stress related to family structure and changing thereof can also contribute to suboptimal oral hygiene practices [28].

Although this study had a response rate of 52%, it does not necessarily lead to bias. In order to help clarify the external validity, comparison with the 2011 census was performed which confirmed that the population estimates of the survey did not differ significantly from the census estimates for indigenous status and education level of household as reported in previous study [29]. However, this survey over-represented the percentage of children born to two Australian born parents by 4% (Table 3) [29].

Limitations
This study has some limitations. The cross-sectional method used to collect data is limited in establishing temporality between the social determinants and the tooth-brushing frequency [30]. In addition, the self-reported method used in the form of questionnaire allows potential for self-reporting bias [31]. Although the study included a several social determinants and behavioural factors to test against the outcome of toothbrushing frequency, some behavioural factors such as parent’s TB behaviour which were not recorded in the study. In terms of generalisability of the research to the source population, children born to Australian parents were 4 percent over-represented in the survey in comparison to the Census. However, this study provided useful insights on the social determinants and behavioural factors that significantly predict frequent toothbrushing in Lithgow children which could prove valuable in informing oral health promotion and policy development programs. Future scope of research would prove useful to further explore the impact of other possible predictors such as perception of parents on the level of prioritisation of oral health for their children and the role of teachers on oral health promotion in children.

Abbreviations
AIHW: Australian Institute of Health and Welfare; CI: Confidence interval; LGA: Local Government Area; NSW: New South Wales; NCOHS: National Child Oral Health Survey; OR: Odds ratio; WHO: World Health Organization.

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Authors’ contributions
AA was responsible for the project co-ordination, clinical and questionnaire data collection, data analysis and write-up. JRJ conducted the data analysis under the supervision of PF and drafted sections of the manuscript with AA. SN and HJ completed the literature review under the supervision of AA.

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Availability of data and materials
The data of this study can’t be shared publicly due to the presence of sensitive (confidential) participants’ information.

Ethics approval and consent to participate
Ethical clearance for this cross-sectional survey was obtained from the Catholic Education Board, the Human Research Ethics Committee at the University of Sydney and the New South Wales Department of Education. All participants signed a written consent form to be a part of this study.

Consent for publication
All research participants consented to use their data de-identified data for publishing in scientific publications.

Competing interests
AA is an Associate Editor of BMC Public Health and BMC Oral Health but did not play any role in the peer-review and decision-making process for this manuscript.

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