Does Socioeconomic Status Affect Oral Health? Results from the PERSIAN Cohort Study

Farid Najafi

Mohammad Hajizadeh

Moslem Soofi

Yahya Salimi

Ali KAzemi Karyani

Shahin Soltani

Sina Ahmadi

Enayatollah Homaie Rad

Behzad Karami MAthin

Yahya Pasdar

Behrooz Hamzeh

Mehdi Moradi Nazar

Ali Mohammadi
Reza Malekzadeh

Hossein Poustchi

Nazgol Motamed-Gorji

Alireza Moslem

Ali Asghar Khaleghi

Mohammad Reza Fatthi

Javad Aghazadeh-Attari

Ali Ahmadi

Farhad Pourfarzi

Mohammad Hossein Somi

Mehrnoush Sohrab

Alireza Ansari-Moghadam

Farhad Edjtehadi

Ali Esmaeili

Farhad Joukar

Mohammad Hasan Lotfi
Teamur Aghamolaei

Saied Eslami

Seyed Hamid Reza Tabatabaee

Nader Saki

Ali Akbar Haghdost

Satar Rezaei  satarrezaei@gmail.com
Kermanshah University of Medical Sciences
Corresponding Author

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Abstract

Background: The current study aimed to measure and decomposes socioeconomic-related inequalities in DMFT (decayed, missing, and filled teeth) index among adults in Iran. Methods: The study data was drawn from the adult component of Perspective Epidemiological research studies in Iran (PERSIAN) from 17 centers in 14 different provinces of Iran. DMFT score was used as a measure of oral health among adults in Iran. The relative and generalized (absolute) concentration index (RC and GC, respectively) was used to quantify and decompose socioeconomic-related inequalities in DMFT among Iranian adults (35 years and older). Results: A total of 128,813 adults aged 35 and older, who are enrolled in the Prospective Epidemiological Research Studies in Iran (PERSIAN), were included in the study. The mean score of DMFT of the adults was 6.01 (SD=3.17). The findings suggested that DMFT was mainly concentrated among the poor in the 14 provinces included in the study (RC = -0.064; 95% confidence interval (CI), -0.066 to -0.063 and GC = -0.387; 95% CI, 0.397 to -0.377). In addition, SES, being male, older age and being widow or divorced were identified as the main factors contributing to the concentration of DMFT among the worse-off in Iran. Conclusions: It is recommended to focus in the oral health status of socioeconomically disadvantaged groups in order to reduce socioeconomic-related inequality in oral health among adults in Iran. Moreover, it should be noted that reducing socioeconomic-related inequalities in oral health should be accompanied by appropriate health promotion policies that focus actions on the fundamental socio-economical causes of dental disease.

Introduction
Oral health is considered an important component of overall health and poor oral health condition adversely affects quality of life of peoples. Poor oral health condition can potentially lead to social and psychological problems. Beside the negative health consequences, poor oral health condition, high prevalence of oral disorders imposes substantial financial burden to individuals, their families, as well as to the society as a whole[1–3]. The financial burden of dental care is especially high for disadvantage and deprived households in developing countries such as Iran, where the cost of these services is not covered by public health insurance health system[4].

Several indicators have been used in the literature to examine the oral health condition. One of the widely used indices in oral epidemiology literature is DMFT (decayed, missing, and filled teeth) index. As a general indicator of dental health status, the DMFT index is defined as the total number of teeth that are decayed, missed and filled in an individual (5, 6). The DMFT index can be used to assess and monitor the oral health status of a given community[7].

Socioeconomic-related inequalities in various health outcomes constitute a main challenge for public health[6, 8, 9]. According to the World Health Organization’s Commission on Social Determinants of Health (CSDH), health inequalities are the result of the exposure to health risks among those living in socioeconomically disadvantaged circumstances[10, 11]. Previous studies highlighted the significant positive association between socioeconomic status (SES) and oral health status[12, 13]. The existing literature[12–16] indicated widespread inequalities in oral health outcomes across socioeconomic groups both in developed and developing countries. Higher SES also positively associated with cleaning the teeth more effectively and frequently and with using more oral hygiene aids[17].
Although the prevalence of oral disorders in developed countries has declined significantly in recent years\cite{14, 18, 19}, it remains a major public health concern in developing countries such as Iran. A recent study by Moradi and colleagues\cite{6} investigated oral health of people aged 15–40 years in Kurdistan city, western Iran, in 2015 and found significant differences in DMFT index across SES groups. The authors indicated poor DMFT index was more prevalent among disadvantaged people in Kurdistan city\cite{6}. Although the latter study shed some light on the role of SES on oral health status among younger Iranian adults, further research is required to understand socioeconomic-related inequalities in oral health status among adults in different regions in different provinces in Iran. Using information available in the Prospective Epidemiologic Research Study in IRaN (PERSIAN), we aimed to measure socioeconomic inequalities in DMFT index among adults (35 years and older) in 14 provinces in Iran. Further, we decomposed socioeconomic inequality in DMFT index in order to identify factors explaining socioeconomic inequality in oral health status in Iran. The results of our study provide useful information for health care policy makers in Iran in order to design effectiveness interventions to decline inequality in oral disorders among Iranian adults.

Methods and materials

Study setting

The study setting was 14 provinces from total 31 provinces of Iran. As a lower-middle-income country, Iran is located in the Eastern Mediterranean Region with an area of 1,648,000 km sq. Based on the 2016 census data, total population of Iran was about 80 million people, with 52 percent living in the 14 provinces included in the study.
Data source and variables

We used data from the adult component of the Prospective Epidemiological Research Studies in IrAN (PERSIAN), which has been launched by the Ministry of Health and Medical Education (MoHME) to collect epidemiological data from 18 centers in 15 different provinces of Iran: Kermanshah (KSH), Guilan (GU), Fars (FA), East Azerbaijan (EA), Mazandaran (MA), Sistan and Balouchestan (SB), Yazd (YA), Kerman (KE), Khouzestan (KH), Chaharmahal and Bakhtiari (CB), Hormozgan (HO), West Azerbaijan (WA), Ardabil (AR), Razavi Khorasan (RK), and Kohgiluyeh and Boyer-Ahmad (KBA). While there is only one PERSIAN cohort center in each 13 provinces, FA and RK have three and (Fasa, Kavar and Kharameh) two centers (Sabzevar and Mashhad), respectively. We obtained data from all the centers. The characteristics of cohort centers used in the study showed in Appendix 1.

We merged data from the provinces with more than on study centres when we analyzed the data. In addition, data from KBA province excluded from the analysis due to incomplete data collection. Figure 1 presents the flow chart of total samples included in the study.

The participants of the PERSIAN cohorts were invited to the study sites for data collection. The cohort questionnaire consists of three parts of general, medical and nutrition with 482 questions. The first part included general questions on demographic, SES, lifestyle, occupational history, physical activity, sleep and circadian rhythm and mobile use. The second part consists of questions related to medical issues (past and present medical history, type of treatment, blood pressure and pulse measurements and oral health). The third part asks questions regarding personal habits questions such as smoking, drinking alcohol and drug use. The cohort questionnaire is administrated by trained interviewers. Quality assurance
(QA) and quality control (QC) measures were re-checked by the central and local QA/QC teams to ensure all procedures are performed in accordance with the PERSIAN Cohort protocol. More details about PERSIAN study can be found elsewhere[20, 21].

DMFT score was used as a measure of oral health among adults in Iran. Based on previous studies (5, 6), the DMFT score was measured as total number of teeth that are decayed (D), missed (M) and filled (F) in an individual. As per current literature (6, 22), we used a wide variety of demographic (e.g., age groups, sex and marital status), unhealthy behaviors (e.g., alcohol drinking and smoking status), SES (e.g., level of education, durable assets, and housing characteristics) and place of residence (cohort site) as determinants of DMFT in the decomposition analysis.

Statistical analysis

Principal component analysis (PCA) technique (23, 24) was used to construct SES of samples. We entered those assets and housing characteristics that is expected to be highly associated with households’ SES in Iran (e.g., having car, motorcycle, bicycle, refrigerator, freezer, radio, stove, vacuum machine, personal computer, CD/DVD player, sewing machine, cooler, washing mashing, microwave, central heating, having kitchen, bathroom, use of natural gas for cooking, per capita house area per capita rooms and access to piped drinking water, electricity, telephone, internet and sewage network) and education level in the PCA. Based on the socioeconomic scores, samples were divided into five SES groups (quintiles), from poorest to richest.

There is general agreement on the use of both relative (invariance to multiplicative transformations) and absolute (invariance to additive transformations) measures of health inequality in health in literature[25, 26]. Thus, we used both relative and
generalized (absolute) concentration index (RC and GC, respectively) to quantify and decompose socioeconomic-related inequalities in DMFT among Iranian adults (35 years and older) in the 14 provinces combined as well as in each province, separately. The RC is calculated based on the concentration curve, which graphs the cumulative percentage of participants ranked by SES on the x-axis and the cumulative percentage of a health variable of interest (DMFT score) on the y-axis. The RC is equivalent to twice the area between line of perfect equality (45-degree line) and concentration curve. The values of the RC ranges from -1 to +1. If the concentration curve lies under (above) the line of perfect equality, the sign of the RC is positive (negative). The negative value of the RC indicated that DMFT score is more concentrated among rich vice versa. The value of zero suggested perfect equality[27].

The following formula was used to calculate the RC:

\[ \text{RC} = \frac{1}{2} \left( \frac{1}{n} \sum_{i=1}^{n} \left( \frac{y_i - \mu}{\sigma_r^2} \right) \right) \]

Where \( \mu \) shows the mean of the outcome variable of interest (i.e., DMFT scores) for whole sample; \( y_i \) represents the outcome variable (DMFT score) for individual \( i \); and \( r_i \) is the fractional rank in the SES distribution for individual \( i \); \( (r_i = i/n, \text{where } i = 1, 2, \ldots, n) \); and \( \sigma_r^2 \) denotes the variance of fractional rank. The ordinary least squares (OLS) estimate of \( \varphi \) is the RC[28].

The absolute socioeconomic inequality in DMFT score can be measured using a generalized concentration curve, which is simply the relative concentration curve multiplied by \( \mu \). The generalized concentration curve plots the cumulative share of individuals, ranked based on SES variable, against cumulative contribution of each
individual to the $\mu$. Twice the area between the line of perfect equality and the generalized concentration curve is defined as the GC and can be estimated by the RC multiplied by the $\mu$[26]. The value of this index varies between $-\mu$ and $+\mu$, with zero indicating “perfect equality”.

The RC and GC was decomposed to identify the main factors contributed to the observed socioeconomic inequality in DMFT in the 14 Iranian provinces included in the study. Consider the following linear regression model that link DMFT score, $y$, to a set of k explanatory factors, $x_k$:

[Due to technical limitations, this equation is only available as a download in the supplemental files section.]

Wagstaff et al.[29] showed that the RC can be decomposed to the its determinant using the following formula:

[Due to technical limitations, this equation is only available as a download in the supplemental files section.]

Where $\bar{x}_k$ is the mean of explanatory variables, $RC_k$ is the RC for explanatory variables. The $\beta_k\mu$ can be defined as the elasticity of the health outcome variable with respect to the explanatory variables. Based on the Equation 2, each of explanatory variable contributes to socioeconomic-related inequality in DMFT if the elasticity of the variable is statistically significant and the variable is unequally distributed by SES. The $GC_\varepsilon$ indicates the generalized concentration index for the error term and it reflects socioeconomic-related inequality in DMFT that is not explained by explanatory variables included in the study.

The GC can be decomposed to identify the main determinants of absolute socioeconomic-related inequality in DMFT using the following formula[26]:

[Due to technical limitations, this equation is only available as a download in the
supplemental files section.]

Based on the Equation (3), the extent of to which each variable \( x_k \) contributes to
the GC depends on \( \beta_k \) and \( \bar{x}_k \times R_{Ck} \) (i.e., GC of variable \( x_k \)). A variable that
significantly associated with DMFT and is unequally distributed by SES contributes
to absolute socioeconomic-related inequality in DMFT. All data analysis performed
by Stata version 14.2 and p-value less than 0.05 was considered statistically
significant.

Results

Descriptive statistics

The descriptive statistics of all the variables used in the study are presented in
Table 1. Of the total of 128813 adults aged 35 and older included in the study,
45.5% males and 55.5% females. The average age of participants was 49.3 years
(standard deviation SD = 9.18). A majority of the study population (90.9%) was
married. In addition, about 21.7% of the samples were smokers and 9.1% used
alcohol in the past year.

The mean score of DMFT of the adults was 6.01 (SD = 3.17). There is, however,
variation among the provinces in the average score of DMFT score. As illustrated in
Fig. 2, the average DMFT score was greater in cohort of Yazd, Fars, East Azerbaijan
and Ardabil compared to the rest of cohorts included in the study.

Socioeconomic inequality in DMF

Figure 3 shows the estimated values of the RC and GC for DMF for the total sample
and for each province separately. The findings suggested that DMFT was mainly
concentrated among disadvantaged population in the 14 provinces included in the
study (RC = -0.064; 95% confidence interval (CI), -0.066 to -0.063 and GC = -
The estimated RC and GC suggested statistically significant inequality in the DMF in favour of the rich in all cohort centers. The extent of socioeconomic-related inequality in DMFT was found to be especially large in cohort of Kermanshah (RC = -0.077 and GC = -0.414), Guilan (RC = -0.060 and GC = -0.291), Fars (RC = -0.059 and GC = -0.411).

Determinants of socioeconomic inequalities in DMFT

Table 2 contains the results of the decomposition analysis of socioeconomic-related inequalities in DMFT (RC and GC) measured for all included cohorts. The table reports 1) the coefficients estimating the effect of each explanatory factor on DMFT, 2) the elasticities of DMFT with respect to explanatory variables, 3) the RC for each explanatory variable, and 4) the contribution of each factor to the overall RC and GC for DMFT.

The results of multivariable regression (the coefficients results) indicated that older age was associated with higher DMFT score. Compared to females, males had statistically significantly greater DMFT score. Also, the DMFT score among single was found to be lower than compared to other marital status groups. The mean of DMFT score was lower among people with better-off compared to socioeconomically disadvantaged individuals. Positive associations were found between unhealthily behaviors of smoking status and drinking alcohol and DMFT score. The results also suggested higher DMFT score among individuals residing in the provinces of WA, AR, RK, CB, YA, KE, FA, EA and MA than those living in KSH province. The DMFT score was found to be lower in the provinces of GU, HO and KH as compared to KSH. The RC for each of explanatory variables, RCK, were presented in third column of Table 2. A positive value of this index suggested that the explanatory variable is
more concentrated among the wealthier people and vice versa. The RCk results indicated those who were male, married, smokers and drinker were relatively wealthier in study population, whereas individuals who were divorced or widowed and older were relatively poor.

The term “contribution” shows that how much the variation of each explanatory variable across SES groups can explain the observed association between SES and DMFT score. If the sign of contribution for a given explanatory factor is positive (negative), it suggests that the socioeconomic distribution of the factor and the association between this variable and DMFT score leads to a higher DMFT score among the better-off (worse-off). Based on the results reported in Table 2, it is evident that that SES is the main factor contributed to the concentration of DMFT score among the poor (70.06%, calculated as its contribution divided by the total the RC/GC). Besides socioeconomic status, demographic factors (age, gender and divorced or widowed) were the main factors contributed to the concentration of DMFT among lower SES groups in DMFT in the study population.

Discussion

Poor oral health status is a major public health concern in developed and developing countries. The current studies[12–16] also highlighted socioeconomic inequalities in oral health status (defined as differences in incidence or prevalence of oral disorders) across socioeconomic groups. Although inequality in oral health status continues to be a main public health issue in Iran, there exists scant studies that aim to examine socioeconomic inequalities in oral health in Iran[6]. Using data collected from 17 PERSIAN cohort centers in 14 provinces, we measured and decomposed socioeconomic-related inequalities in DMFT among adults in Iran and
across different regions in Iran.

The average DMFT index was found to be 6.01 in 14 provinces in Iran with significant variation across provinces. We found statistically significant pro-rich inequality in DMFT score in all the provinces included in the study. Socioeconomic-related inequality in DMFT score was found to be large in provinces such as Kermanshah, Guilan and Fars. A study by Moradi and colleagues[6] also indicated that the higher concentration of poor DMFT score among the poor in Kurdistan city, Iran[6].

In addition to SES, our study also showed that being female, older adults, married, smoking and drinking alcohol were associated with higher DMFT score among Iranian adults. Our study indicated that higher DMFT score among individuals residing in the cohorts of WA, AR, RK, CB, YA, KE, FA, EA and MA compared to other provinces included in the study. A study by Piovesan et al.[30] also found higher DMFT scores among women compared to men. A study conducted by Ditmyer et al. [14] also indicated that a higher DMFT scores among women and older individuals. Since older adults will account for 21.1% of population by 2050 in Iran[1,2], this finding calls for further attention to deliver oral health care in this population.

Previous work also highlighted unhealthy behavior (e.g., drinking alcohol and smoking) as main determinants of oral health[31, 32]. One possible explanation of the effect of drinking on DMFT score is that alcohol users consume high amount of refined carbohydrates and neglect both personal and professional health care, which, in turn, may lead to high DMFT score among these population. In line with previous studies[33, 34], we found that higher DMFT score among smokers than non-smokers.

The decomposition results indicated that SES itself is the main determinant of
socioeconomic-related inequality in DMFT score in Iran. The negative effect of SES on DMFT score can be due to, for example, lower access of lower SES individuals to dental health care services compared to their higher SES counterparts. Beside SES, being male and older age and widow or divorced were the main factors contributing to the concentration of DMFT among the worse-off in Iran. The negative contribution of being male to socioeconomic inequality in DMFT is explained by the fact that men compared to women have lower DMFT score (see the negative elasticity reported for this variable in Table 2) and they are relatively better-off compared to women in Iran (see the positive RCk for this variable Table 2). Older age and being window or divorced increase the concentration of DMFT score among the poor because older adults and those who are window or divorced in Iran have higher score of DMTF score (see the positive elasticity reported for these variables in Table 2) and they are relatively poor in Iran (see the negative RCk for these two variables in Table 2). The findings of the present study should be interpreted in light of some limitations. Firstly, since this study is a cross-sectional design, we were unable to establish causal relationships between explanatory variables and DMFT score in the decomposition analysis. Secondly, data for this study extracted from 14 provinces in Iran; thus, the generalizability of our results to other provinces is limited.

Conclusion

This study revealed that poor oral health status, as measured by DMTF score, was concentrated among socioeconomically disadvantaged adults in Iran. We also observed significant variations in socioeconomic inequality in DMTF score among different provinces in Iran. As our study demonstrated SES, being male, older age and being widow or divorced as the main factors contributing to the concentration
of DMFT among the worse-off in Iran, it is recommended to focus in the oral health status of these groups in order to reduce socioeconomic inequality in oral health among adults in Iran. For example, as the existing studies (e.g.,(35–38)) showed pro-rich inequalities in health care utilization in Iran, it is recommended to expand oral health care services for these groups through publicly funded primary health care in Iran. Moreover, it should be noted that reducing socioeconomic inequalities in oral health should be accompanied by appropriate health promotion policies that focus actions on the fundamental SES causes of dental disease.

Declaration

Ethics approval and consent to participate

While each cohort center received the ethical approval from local universities, for the purpose of this study and pooling all PERSIAN data, the ethics committee of Kermanshah University of Medical Sciences approved the study (IR.KUMS.REC.1397.187).

Consent for publication

Not applicable.

Availability of data and material

All necessary data are presented within the manuscript. All other materials and data are available upon request.

Competing Interests

The authors declare no conflict of interest

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Authors’ contributions
SR, YS, AKK, ShS, MS, SA, BKM, MMN, FN, MH and HER: contributed with the research idea, study design, performing the study, analyses of data and writing the manuscript. AM: designed the chart and graph; YP, BH, RM, HP, NMG, AAK, MRF, JAA, AA, FP, MHS, MS, AAM, FE, AE, FJ, MHL, TA, SE, SHRT, NS and AAH helped to data collection. All authors approved the final manuscript as submitted and agreed to be accountable for all aspects of the work.

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Abbreviation
DMFT: decayed, missing, and filled teeth
SES: socioeconomic status
PERSIAN: Prospective Epidemiologic Research Study in IRaN
MoHME: Ministry of Health and Medical Education
PCA: Principal component analysis
RC: relative concentration index
GC: generalized (absolute) concentration index
OLS: ordinary least squares

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Tables

Table 1. Descriptive statistics of variables used in the study
| Variables               | Proportion (%) | Standard deviation |
|-------------------------|---------------|--------------------|
| **Age groups**          |               |                    |
| 35-44                   | 35.7          | 47.93              |
| 45-54                   | 33.6          | 47.24              |
| 55-64                   | 24.2          | 42.83              |
| 65 and older            | 6.4           | 24.46              |
| **Sex**                 |               |                    |
| Male                    | 44.51         | 49.69              |
| Females                 | 55.49         | 49.69              |
| **Marital status**      |               |                    |
| Single                  | 2.27          | 14.90              |
| Married                 | 90.91         | 28.73              |
| Divorced or widowed     | 6.82          | 25.19              |
| **Smoking status**      |               |                    |
| Smoker                  | 21.68         | 41.21              |
| Non-smoker              | 78.32         | 41.21              |
| **Drinking alcohol**    |               |                    |
| Yes                     | 9.10          | 28.71              |
| No                      | 90.90         | 28.71              |
| **Socioeconomic status**|               |                    |
| 1 (Poorest)             | 19.87         | 39.90              |
| 2                       | 19.94         | 39.97              |
| 3                       | 20.04         | 40.03              |
| 4                       | 20.09         | 40.04              |
| 5 (Wealthiest)          | 20.10         | 40.07              |
| **Region of cohort**    |               |                    |
| Kermanshah (KSH)        | 7.79          | 26.80              |
| Guilan (GU)             | 8.15          | 27.35              |
| Fars (FA)               | 17.28         | 37.75              |
| East Azerbaijan (EA)    | 11.59         | 31.96              |
| Mazandaran (MA)         | 7.96          | 27.02              |
| Sistan and Balouchestan (SB) | 6.37   | 24.38 |
| Yazd (YA)               | 7.20          | 25.84              |
| Kerman (KE)             | 7.66          | 26.60              |
| Khuzestan (KH)          | 6.97          | 25.46              |
| Chaharmahal and Bakhtiari (CB) | 5.16   | 22.11 |
| Hormozgan (HO)          | 2.58          | 15.86              |
| West Azerbaijan (WA)    | 2.67          | 16.13              |
| Ardabil (AR)            | 6.35          | 24.38              |
| Razavi Khorasan (RK)    | 2.27          | 14.86              |

**Table 2.** Decomposition of socioeconomic inequalities (the RC and GC) in DMTF in Iran

| Demographic variables | Coefficient | Elasticity | RC | Contribution to RC | Contribution to GC | % Contribution to RC/GC |
|-----------------------|-------------|------------|----|--------------------|--------------------|-------------------------|
| **Age groups**        |             |            |    |                    |                    |                         |
| 35-44                 | ref         |            |    |                    |                    |                         |
| 45-54                 | 1.357*      | 0.076      | 0.028 | 2                | 0.00              | 0.01                    |
| Age Group          | Estimate | Std. Error | Lower | Upper | Value | df | Sig.  |
|--------------------|----------|------------|-------|-------|-------|----|-------|
| 55-64              | 2.857    | 0.115      | -0.07 | 8     | -0.00 | 1  |       |
| 65 and older       | 3.771    | 0.040      | -0.21 | 6     | -0.00 | 2  |       |

**Sex**

| Group      | Estimate | Std. Error | Lower | Upper | Value | df | Sig.  |
|------------|----------|------------|-------|-------|-------|----|-------|
| Male       | -0.371   | 0.02       | 0.1   | 3     | -0.00 | 8  |       |
| Females    | ref      |            |       |       |       |    |       |

**Marital status**

| Status                  | Estimate | Std. Error | Lower | Upper | Value | df | Sig.  |
|-------------------------|----------|------------|-------|-------|-------|----|-------|
| Single                  | ref      |            |       |       |       |    |       |
| Married                 | 0.548    | 0.083      | 0.0   | 0.00  | 0.01  | 3  |       |
| Divorced or widowed     | 0.590    | 0.007      | -0.01 | -0.00 | 0.01  | 5  |       |

**Socioeconomic status variable**

| Variable | Estimate | Std. Error | Lower | Upper | Value | df | Sig.  |
|----------|----------|------------|-------|-------|-------|----|-------|
| 1 (Poorest) | ref      |            |       |       |       |    |       |
| 2         | -0.338   | 0.01       | -0.4  | -0.00 | 0.02  | 7  |       |
| 3         | -0.612   | 0.02       | -0.5  | -0.00 | 0.02  | 7  |       |
| 4         | -0.900   | 0.03       | -0.7  | -0.01 | -0.07 | 2  |       |
| 5 (Wealthiest) | -1.311  | 0.04       | -0.7  | -0.03 | -0.21 | 2  |       |

**Behavioral variables**

**Smoking status**

| Status      | Estimate | Std. Error | Lower | Upper | Value | df | Sig.  |
|-------------|----------|------------|-------|-------|-------|----|-------|
| Smoker      | 1.360    | 0.049      | 0.0   | 0.00  | 0.01  | 4  |       |
| Non-smoker  | ref      |            |       |       |       |    |       |

**Drinking alcohol**

| Status      | Estimate | Std. Error | Lower | Upper | Value | df | Sig.  |
|-------------|----------|------------|-------|-------|-------|----|-------|
| Yes         | 0.134    | 0.002      | 0.2   | 0.00  | 0.00  | 6  | -4.52 |
| No          | ref      |            |       |       |       |    |       |

**Region (province)**

| Province             | Estimate | Std. Error | Lower | Upper | Value | df | Sig.  |
|----------------------|----------|------------|-------|-------|-------|----|-------|
| Kermanshah (KSH)     | ref      |            |       |       |       |    |       |
| Guilan (GU)          | -0.980   | 0.01       | -0.3  | -0.00 | 0.01  | 7  |       |
| Fars (FA)            | 0.936    | 0.027      | -0.3  | -0.00 | -0.05 | 4  |       |
| East Azerbaijan (EA) | 1.398    | 0.027      | 0.0   | 0.00  | 0.00  | 3  |       |
| Mazandaran (MA)      | 0.200    | 0.003      | -0.1  | 0.00  | 0.00  | 2  |       |
| Sistan and Balouchestan (SB) | 0.070 **| 0.001      | 0.0   | 0.00  | 0.00  | 0  |       |
| Yaz (YA)             | 1.267    | 0.015      | 0.2   | 0.00  | 0.02  | 1  |       |
| Kerman (KE)          | 0.920    | 0.012      | 0.3   | 0.00  | 0.02  | 2  |       |
| Khouzestan (KH)      | -0.02    | 0.00       | 0.0   | 0.00  | 0.03  | 1  |       |
| Region                          | Value         | P-value | Note                                      |
|--------------------------------|---------------|---------|-------------------------------------------|
| Chaharmahal and Bakhtiyari (CB) | -1.786*       | <0.001  | **P-value less than 0.1. **                |
| Hormozgan (HO)                 | 0.724*        | <0.001  |                                           |
| West Azerbaijan (WA)           | -1.855*       | <0.001  |                                           |
| Ardabil (AR)                   | 0.578*        | <0.001  |                                           |
| Razavi Khorasan (RK)           | 1.195+        | <0.013  |                                           |
| **Sum**                        | -0.04         | 0.25    | 69.8                                      |
| **Residual**                   | -0.01         | 0.10    | 29.20                                     |
| **Total RC/GC**                | -0.06         | 0.36    | 100                                       |

** Note: ref=reference category in the analysis **

Appendix 1

Appendix 1

The characteristics of cohort centers in Iran
| Row | Province                  | Population*     | Cohort site       | Population* | Cohort population |
|-----|---------------------------|-----------------|-------------------|-------------|-------------------|
| 1   | Ardabil                   | 1,270,420       | Ardabil           | 529,374     | 8,192             |
| 2   | Chaharmahal and Bakhtiari | 947,763         | Sharekord         | 93,104      | 6,664             |
| 3   | East Azerbaijan           | 3,909,652       | Khameneh          | 3,056       | 14,978            |
| 4   | Fars                      | 4,851,274       | Kavar             | 31,711      | 2,244             |
|     |                           |                 | Kharameh          | 18,477      | 10,662            |
|     |                           |                 | Fasa              | 110,825     | 10,113            |
| 5   | Gilan                     | 2,530,696       | Some‘e Sara       | 58,658      | 10,511            |
| 6   | Hormozgan                 | 1,776,415       | Bandare Kong      | 19,213      | 3,570             |
| 7   | Kerman                    | 3,164,718       | Rafsanjan         | 161,909     | 9,982             |
| 8   | Kermanshah                | 1,952,434       | Ravansar          | 47,657      | 10,077            |
| 9   | Khouzestan                | 4,710,506       | Hoveizeh          | 19,481      | 9,156             |
| 10  | Mazandaran                | 3,283,582       | Sari              | 309,820     | 10,253            |
| 11  | Razavi Khorasan           | 6,434,501       | Mashhad           | 3,001,184   | 2,189             |
|     |                           |                 | Sabzevar          | 243,700     | 784               |
| 12  | Sistan and Balouchestan   | 2,775,014       | Zahedan           | 587,730     | 8,318             |
| 13  | West Azerbaijan           | 3,265,219       | Ghoushchi         | 2,787       | 3,662             |
| 14  | Yaz                       | 1,138,533       | Shahedieh, Yazd   | 18,309      | 9,901             |

References: 1- Persian cohort sites, available from: http://persiancohort.com/cohortsites/, access: April 21, 2019. 2- Iran statistics center, available from: https://www.amar.org.ir, access: April 21, 2019.

Figures
Flow chart of samples included in the analysis
Mean of DMFT score as an indicator for oral health across 14 provinces in Iran
Figure 3

Socioeconomic-related inequalities in DMFT across 14 provinces in Iran. Note: wit
Supplementary Files

This is a list of supplementary files associated with the primary manuscript. Click to download.

eq1.jpg
eq2.jpg
eq3.jpg
eq4.jpg