BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-042908
Article Type:	Original research
Date Submitted by the Author:	18-Jul-2020
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Keywords:	Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Health economics < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Epidemiology < ONCOLOGY

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Association between socioeconomic status and dental caries among Chinese preschool children: A cross-sectional national study

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Running Title: Socioeconomic status and dental caries

Keywords: Dental caries, oral health, social class, Preschool child

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Word count: 3016 words

Abstract count: 196 words

Abstract

Objectives: To assess the association between child caries status and socioeconomic status (SES) in China.

Methods: Data from the 4th National Oral Health Survey of China, which was done in 2015. The sampling process was conducted by a multistage stratified cluster method, comprising of 40,360 children aged 3-5 years. Caries indicators including untreated caries, dental pain and dmft. SES was measured by parental education level and household income. Inequality by education and income were estimated by using the relative index of inequality and slope index of inequality (RII and SII, respectively).

Results: There were significant associations between SES and all caries indicators ($p<0.05$). And significant inequalities for all outcomes and SES indicators were identified with RII and SII with the exception of dental pain experience. Relative inequalities were larger relative inequalities in untreated caries by parental educational level. Children whose parents with the low education had higher prevalence of untreated caries (RII:1.64; 95% CI:1.46 to 1.84), and higher dmft (RII:1.55; 95% CI:1.38 to 1.74). Absolute inequalities were the same pattern as relative inequalities.

Conclusions: There were consistently wide socioeconomic inequalities in child oral health in China, posing challenges for designing public health strategies and social policies.

Strength and limitation

- The Fourth National Oral Heath Survey of China use of a relatively large and representative sample of children, which ensured study results are likely to be generalizable across the mainland of China children.
- It was the first study to measure inequalities in child oral health by using SII and RII in China.
- The study design was the cross-sectional nature precluding inference about causality which limited to examine how socioeconomic inequalities in oral health changed as children grew into adolescents.

- Reliance on parental report of children's oral health and oral health behaviors.

Introduction

Currently, dental caries is still the greatest global oral health burden with 532 million children affected worldwide[1]. Dental caries not only post a threat on health and quality of life but also impose a substantial economic burden on the society[2]. While World Health Organization (WHO) findings suggested that the prevalence of dental caries has been declined. However, the decline in caries was obvious in high-income but not in low or middle - income countries[3-5], moreover the increase in caries had been seen in some of low or middle - income countries, suggesting that socioeconomic inequalities in oral health have remained. Children from socially disadvantaged families have higher risk of dental caries[6].

Socioeconomic inequalities in child caries is a great concern in many countries[6-8], and it is supposed to be an important determinant in child oral health[9]. Various studies have identified children from poor SES had higher dental caries and greater dental pain experience, including low household income, low mother's education, poor oral hygiene, high sugar consumption and living in socially disadvantaged families[6-8 10-14]. Lower household income in childhood associated with higher dental caries was confirmed in Mongolia[8]. In India, A lagged analysis of a structural equation modeling showed that SES contribute to oral health status indirectly[15]. Poor SES can have a deleterious impact on child oral health as a result.

China is a rapidly developing country of 1.4 billion people in the world[16], whose GDP ranking 2rd in the world[17]. China has undergone rapid economic development while also experiencing a processing of increasing inequalities in health [18]. Children from rural areas or poor families are more likely to be stunted than those from urban areas or rich families[19 20]. Few previous studies have explored socioeconomic inequalities in oral health in Chinese preschool children[21 22]. Meanwhile, there has been a lack of nationally representative data on oral health inequalities for Chinese preschool children. Hence, additional research to improve current understanding of socioeconomic inequalities in oral health in preschool children of China is needed.

This study was to explore the association between SES and dental caries in 3-5 years old children, and evaluated the inequalities in dental caries among children around the mainland of China, and to discover the correlations of socioeconomic factors in dental inequalities.

Methods

Data source

We used data of 3-5 years old children from the Fourth National Oral Heath Survey of China carried out in 2015, which was based on a nationally representative sample of 40,360 children, providing information on individual dental health and socioeconomic status. The survey produced representative data enrolled all 31 provinces, autonomous regions and municipalities of the mainland of China at national and regional levels by using a multistage, stratified, equal-capacity random sampling design. Probability proportional to size (PPS) design was used to randomly select two urban areas and two rural areas from in each province. A structured parental questionnaire collected socioeconomic indicators including household income and parental education attainment were conducted by face to face. Clinical dental examination including dental caries experience was completed by trained and calibrated dentists. Full details of the survey's design can be found in the methodology[23]. Ethnics approval (Approval no. 2014-003) was obtained from the Ethnics Committee of Chinese Stomatological Association, and written consent was obtained in every guardian of each child.

Study measures

Three oral health outcomes included (1) prevalence of untreated caries, defined as dt ≥1 (2) dental pain experience ("yes" or "no"), defined as having toothache in the last 12 months. (3) dmft, defined as mean number of decayed, missing and filled teeth and used as a count variable.

The social inequalities were measured by using two different dimensions of socioeconomic status (SES), namely household income and parental education level. Education was divided into 3 groups according to the number of years of schooling:

low(≤9 years), middle (10 to 12 years), and high(> 12 years). Household income was categorized into five groups according to the quintiles: lowest (< 30,000 ¥ /year);low (≥30,000 ¥ and < 50,000 ¥ /year); middle (≥50,000 ¥ and < 80,000 ¥); high(≥80,000 ¥ and < 100,000 ¥);highest(≥100,000 ¥). Place of residence was departed into urban and rural.

Age, gender, ethnicity, place of residence, region and self-perceived general health were considered as covariates.

Statistical analysis

Data were analyzed on STATA MP 16.0 (Stata Corp., College Station, TX, USA). Descriptive statistics are used to characterize the study population. Statistical significance in sample characteristics were evaluated using Chi square tests, Mann-Whitney test and Kruskal-Wallis test.

Since the proportion of household income with missing data was 37.2%, multiple imputation of missing data was carried out. This method uses the distribution of observed individual values to determine the values to be imputed[24], and 20 imputed datasets were generated. Association between SES indicators and prevalence of untreated caries, dental pain were evaluated using Poisson regression models for the reason of count data[25], and negative binomial regression was used to examine the association between SES indicators and children's dmft score because the latter was a count variable with over-dispersion[26]. The association of parental educational level and household income between prevalence of untreated caries, dmft, and dental pain experience was explored in both of unadjusted and adjusted models. Crude model was unadjusted. Model 1 was adjusted for children's age, gender, ethnicity and place of residence and self-perceived general health to exclude the effects of all covariates. Confounding can lead to an overestimate or underestimate of the true association between the explanatory variable and outcome and can even change the direction of the observed effect [27]. Therefore, the effects of the confounding variables should be adjusted for in order to get the true relationship between explanatory variable and the

outcome variables. The incident rate ratio (IRR) and 95% CIs were calculated for the discrete dependent variables to study the effect of independent variables on oral health in the regression analysis.

The relative index of inequality (RII) and slope index of inequality (SII) were estimated to assess relative and absolute inequalities respectively[28]. We included all the above covariates in the models and took into account the survey weights and missing data. RII estimated the prevalence ORs of the outcome between the highest and lowest SES conversely. Values of RII>1 signify higher prevalence of caries, dental pain experience, or higher dmft among those with lowest SES. The SII estimated the absolute predicted difference in caries experience between the highest and lowest SES. Values of SII >0 indicate inequality. The ridit score for estimating SII and RII was calculated by the RIIGEN command in STATA[29]. Using the ridit score and continuous caries experience measurements, the ratio of the mean by Poisson regression was considered as RII and the beta coefficient by linear regression was considered as SII. The ridit score, RII, and SII were calculated for each of the 20 datasets and RII and SII were integrated.

Analyses were also conducted stratifying by place of residence (urban/rural). We stratified by place of residence due to differences between urban and rural settings in factors that could influence health inequalities. In all the analyses, the level of statistical significance was set at $P < 0.05$.

Results

Data were obtained on 40,360 children aged 3-5 years in China in 2015. About three-quarters of children' parents reported child's general health as being good and better. Nearly half of children (49.83%) resided in homes with low or lowest household income. Both SES indicators were significantly associated with caries outcomes. The highest levels of mean dmft were observed among those in the low parental education attainment (3.91±0.01), those in the lowest household income (3.69±0.02), and those parent-report self-perceived general health as fair and less

(3.85±0.01). Moreover, significant differences were found in the demographic characteristics, self-perceived general health (table 1).

The regression models demonstrated that, caries outcomes by SES showed a socioeconomic gradient, with the only exception of dental pain experience. IRR of dmft was statistically significant rising after adjusting for demographic characteristics, ethnicity, geographical location and parents-reported general health, with the decreasing parental education (IRR of dmft was 1.13 (95% CI 1.09 to 1.17) in 9 to 12 schooling years, 1.20 (95% CI 1.17 to 1.24) in less than 9 schooling years. The only exception from this observation was dental pain experience by both SES indicators. There were stronger relationships between socioeconomic disadvantage and high prevalence of untreated caries and high dmft. The prevalence of untreated caries and dmft of children from the lowest household income families were 1.10 and 1.16 times higher than those from the highest household income families respectively. Furthermore, after adjusting for demographic characteristics, ethnicity, geographical location and parents-reported general health, socioeconomic inequalities in the child caries experience were consistently found by IRRs (table 2).

RII and SII estimates showed significant relative and absolute inequalities for caries indicators and SES indicators except for dental pain experience (table 3). There were larger relative inequalities in prevalence of untreated caries and dmft by parental educational level, with the low schooling years having higher prevalence of untreated caries (RII:1.64; 95% CI:1.46 to 1.84), and having higher dmft (RII:1.55; 95% CI:1.38 to 1.74). Similarly, relative inequalities were as well as larger in prevalence of untreated caries by household income (RII:1.38;95% CI:1.19 to 1.61), and in dmft by household income (RII: 1.33; 95% CI:1.14 to 1.55) among the low SES groups. However, there were no significant inequalities in dental pain experience by both SES groups. This pattern was not in line with absolute inequalities by SII estimates. However, when stratifying by place of residence, relative inequalities were observed in all caries outcomes and SES indicators. Meanwhile, our findings revealed that inequalities tend to be larger in rural area by parental educational attainment. Inequalities related to

income were larger in urban area by household income on the contrary (table 4).

Discussion

In general, it was identified that both SES indicators was associated with the prevalence of untreated caries, dental pain experience and dmft among children around school age, and significant inequalities in dental caries were existed among Chinese young children and parental educational attainment being the main contributors to the identified inequalities. Besides, household income inequalities in child oral health were generally larger in urban areas, while inequalities were larger in urban areas by parental educational attainment. The study findings inform collective actions targeting parental socioeconomic status to address this critical oral health inequalities.

Our study showed that parental educational attainment was an obvious marker relate to dental caries in children, as inequalities by parental educational attainment tended to be high across all outcomes with the exception of dental pain experience. This not only showed socioeconomic inequalities in child caries experience, supporting the previous literature but also are in agreement with an earlier dental health inequality study. Some previous studies showed that children from low SES families suffer from more severe dental pain and higher prevalence of caries[30 31]. Moreover, a study on 3-year-old Japanese children confirmed that higher level of parental education decreased the prevalence of dental caries[32]. Meanwhile, parental educational attainment was related to childhood oral health related quality in life[22]. However, a study among Mongolian children showed that parental educational attainment was not associated with caries experience[8]. Similarly, a study on four provinces of China reported that parental education was not related to children's dental caries[33]. Moreover, an extended path analysis in Hong Kong children showed that parental educational attainment did not have impact on the caries experience[34].

Results of this study also revealed household income as a traditional SES indicator of children, affected the distribution of caries experience. Evidence from a current study confirmed that household income was one of the most strongly factors related to oral health-related quality of life[35]. A cross-sectional study on Australian children proved

that inequalities in dental caries were concentrated among children from lower income families[36]. A cohort study investigated trends in oral health from a life course data in Hong Kong suggested that household income had an effect on children's oral health status[34]. However, the evidence on the relationship between income and oral health is various and unclear[37].

It is surprising to find that there was no inequality in dental pain experience among children. Previous study from Brazil showed that dental pain in children was not related to the socioeconomic characteristics[38], while a study on Mexican schoolchildren found that the association of socioeconomic status with dental pain. Nevertheless, our findings also revealed that inequality in dental pain was existed in high SES groups in rural areas. This contradiction can be explained by the fact that the neglect of discomfort and pain in children from low SES groups in rural areas. Children in rural areas also had higher dmft and untreated caries than those in urban areas, which was keeping with the trend of four provinces in China[33]. The dmft in Chinese preschool children decreased from 3.5 to 3.35 slightly. Health services utilization is a proximal factor accounting for the large inequalities in health between urban and rural residents in China[39 40]. Existing literature has found inequalities in health care not only existing in both rural and urban areas of China[41], but also existing in ethnic minorities and migrant children[42 43]. People living in the eastern developed areas are more likely to use outpatient care, while the people living in western underdeveloped areas are more likely to use inpatient care[44], which indicated that children living in low SES areas are less likely to go to a dental clinic. Meanwhile, utilization of dental services did a positive impact on the caries experience in children and adolescents[34].

This study used only two measures of socioeconomic status. Nonetheless, these variables represent considerable diversity in terms of their relationship to the broad concept of SES. For example, education is a primary determinant of a person's labor market position on the other hand, which in turn influences income, housing, and other material resources. In addition, the strongest predictor of oral health in adulthood is oral health in childhood[45]. The appearance of inequalities in oral health in these very young

children is important given the evidence that childhood oral health inequalities can persist into adulthood irrespective of later changes in social position[45]. However, parental education, household income, and other socioeconomic factors are difficult to modify in the short term. Therefore, strategies must be developed to increase child oral health and parental knowledge and tools for prevention. Confirmation of this would advance the argument for oral health promotion initiatives that engage parents of children very early. For example, the positive effect of increased household income and high parental educational attainment on child health implies that government provide health service targeting the poor and the illiteracy may be an effective way to improve the oral health of children from low SES families, and public welfare programs should focus on rural areas, or considering the importance of child oral health in future life quality, which implies a potential increasing oral health education in such an inequality in child oral health.

Strength and limitation

A major strength of our study was the Fourth National Oral Heath Survey of China use of a relatively large and representative sample of children, which ensured study results are likely to be generalizable across the mainland of China children. And it was the first study to measure inequalities in child oral health by using SII and RII in China. The study findings should be considered with a number of limitations. The study design was the cross-sectional nature precluding inference about causality. We were not able to examine how socioeconomic inequalities in oral health changed as children grew into adolescents. Longitudinal studies of the oral health of representative samples of Chinese children are rare, and that will provide stronger evidence of the potential causal pathways underlying oral health inequalities as further longitudinal data become available. A notable limitation of this study was the reliance on parental report of children's oral health and oral health behaviors. A study suggested that parent-reported single-item indicators of their children's oral health have satisfactory construct validity[46] and are robust across socioeconomic circumstances[47]. However, it has also been suggested that the accuracy of such reports towards under-reporting children's

oral health problems when children are very young[48]. In addition, parental education and household income were the only two measures of socioeconomic status collected for this age group. Some other indicators should also be considered, such as occupation and health insurance. It is conceivable that socioeconomic indicators may be more sensitive and persuasive to measure socioeconomic inequalities in oral health in China. For both these reasons, it is likely that the current study represents an under-estimation of caries impact on children's life.

Conclusions

This study provides recent details of oral health examined nationally for some time. It shows that children form the low SES families were less likely to engage in oral health promoting behaviors and were more likely to have caries. Furthermore, the data suggest that significant inequalities do exist at a very early age. Such findings further strengthen calls for early life oral health prevention and promotion efforts. Our findings of this research have policy implications for China. Policy makers need to be aware of this challenge when they try to achieve and maintain equality in distribution of oral health.

What is already known on this subject

- Most previous studies on child oral health suggested that children from low SES family suffer more dental caries experience. These can include parental educational attainment, household income and parental occupation. There has been concern that socioeconomic inequalities in child oral health could persist into adulthood and exacerbate social inequality. Yet, there have been no national analysis measuring socioeconomic inequalities in oral health among Chinese preschool children.

What this study adds

- This study confirms that there were clear inequalities by parental socioeconomic status in Chinese preschool children. This was most clearly seen for parental educational attainment but less for household income. The findings from this paper suggest that child from lower SES family are experiencing more caries and supports calls for early life oral health prevention and promotion efforts to improve child oral

health those at low SES.

Funding

This study was supported by "Scientific Research Fund of National Health Commission of the People's Republic of China (201502002)".

Author Contributions

All authors meet the ICMJE authorship criteria. Tingting Zhang, Xiaojuan Zeng, Jialan Hong and Xueting Yu conceived the study and developed the analysis strategy. Tingting Zhang, Jialan Hong and Xueting Yu carried out the analysis. Tingting Zhang drafted the manuscript. Xueting Yu, Qiulin Liu, Andi Li, Zhijing Wu and Xiaojuan Zeng critically reviewed the drafts and gave text suggestions. All authors approved the final manuscript.

Acknowledgements

This paper uses confidentialized data from children in China. This study is conducted in partnership between 35 colleges and university, Center of Disease Control (CDC) of Chinese Health Commission of the People's Republic of China, Chinese Stomatological Association.

Conflicts of Interest: The authors declare that there is no conflict of interest.

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Table 1 Summary of the characteristics of the study participants. (n=40360)

Independent Variable: Category	n	Weighted %†	Untreated caries (%)†	Dental pain (%)†	dmft($\bar{x}$±s)†
Sex			***	***	***
Male	20245	49.93	50.73	28.36	3.52±0.01
Female	20115	50.07	63.29	29.42	3.43±0.01
Age (years)			***	***	***
3	12390	29.89	50.73	17.90	2.33±0.01
4	13978	35.20	63.29	27.45	3.47±0.01
5	13992	34.91	72.26	39.63	4.47±0.01
Ethnicity			***	***	***
Han	36087	89.47	62.15	28.46	3.45±0.01
Non-Han	4273	10.53	67.07	32.51	3.73±0.02
Place of residence			***	***	***
Urban	20490	54.61	59.65	27.20	3.22±0.01
Rural	19870	45.39	66.30	30.95	3.79±0.01
Region			***	***	***

East	14127	46.28	65.21	29.90	3.90±0.01	
Middle	10403	26.15	59.92	27.78	3.11±0.01	
West	15830	27.22	60.99	28.24	3.12±0.01	
Self-perceived general health			***	***		***
Good and better	28885	72.78	61.30	26.56	3.34±0.01	
Fair and less	11475	27.22	66.33	35.26	3.85±0.01	
Parental educational level			***	***		***
> 12 years	12615	35.85	56.56	27.16	2.95±0.01	
9-12 years	9457	23.17	63.48	28.95	3.52±0.02	
≤9 years	18278	40.99	67.54	30.41	3.91±0.01	
Household income			***	***		***
Highest	4431	23.65	58.65	27.14	3.21±0.01	
High	4319	18.04	61.65	28.31	3.41±0.02	
Middle	5509	18.17	63.27	29.31	3.48±0.02	
Low	4972	17.91	63.57	29.33	3.62±0.02	
Lowest	6619	22.65	65.66	30.17	3.69±0.02	

†Frequencies are weighted but counts are not after multiple imputation for household income.

P-values were obtained using Mann-Whitney test and Kruskal-Wallis test for dmft, Pearson's chi-square test for categorical variables.

†Frequencies and dmft are weighted after multiple imputation for household income.

dmft, decayed, missing and filled primary teeth.

$^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

Table 2. Incidence Rate Ratio (IRR) and 95% confidence intervals (CIs) of untreated caries, dental pain and dmft for 3-5-year-olds by socioeconomic status in China.

Variables	Untreated caries		Dental pain		dmft	
	IRR[a] (95%CI)	IRR[b] (95%CI)	IRR[a] (95%CI)	IRR[b] (95%CI)	IRR[a] (95%CI)	IRR[b] (95%CI)
Parental educational level						
12 year or above	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
9-12 years	1.09(1.07, 1.12)***	1.08(1.06, 1.11)***	1.01(0.96, 1.06)	0.98(0.93, 1.03)	1.15(1.11, 1.19)***	1.13(1.09, 1.17)***
Up to 9 years	1.14(1.12, 1.16)***	1.12(1.10, 1.14)***	1.03(0.99, 1.08)	0.97(0.93, 1.01)	1.24(1.20, 1.28)***	1.20(1.17, 1.24)***
Household income						
Highest	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
High	1.07(1.03, 1.10)***	1.06(1.03, 1.10)***	1.05 (0.98, 1.12)	1.04(0.97, 1.11)	1.11(1.05, 1.17)***	1.10(1.05, 1.16)***
Middle	1.05(1.02, 1.09)	1.05(1.02, 1.09)**	1.05 (0.99,	1.04(0.98, 1.11)	1.07(1.02,	1.09(1.03,

	**		1.12)		1.13)*	1.15)**
Low	1.09(1.06, 1.13)***	1.09(1.05, 1.12)***	1.04(0.97, 1.11)	1.02(0.96, 1.09)	1.15(1.09, 1.21)***	1.15(1.09, 1.21)***
Lowest	1.11(1.07, 1.14)***	1.10(1.06, 1.14)***	1.09(1.03, 1.16)**	1.06(1.00, 1.12)	1.15(1.09, 1.21)***	1.16(1.09, 1.22)***

Survey weighted models include age, sex, ethnicity, place of residence, region, and socioeconomic measures.

Multiple imputation for household income.

[a]Crude model: each SEE measure (parental education level and household income) and outcomes (untreated caries, dental pain and dmft).

[b]Model Ⅱ: adjusted for age, sex, ethnicity, place of residence, region and self-perceived general health.

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

Table3 Relative and absolute inequalities in oral health outcomes by different SES measures.

	Untreated caries	Dental pain experience	dmft
SES	Relative inequalities——RII (95%CI)		
Parental educational level	1.64(1.46, 1.84) ***	1.06(0.93, 1.21)	1.55(1.38, 1.74) ***
Household income	1.38(1.19, 1.61) ***	0.90(0.78, 1.04)	1.33(1.14, 1.55) ***
	Absolute inequalities——SII (95%CI)		
Parental educational level	1.53(1.26, 1.85) ***	1.00(0.98, 1.01)	1.83(-0.09, 3.75)
Household income	1.11(0.98, 1.04)	0.96(0.76, 1.23)	1.13(0.84, 1.52)

Models adjusted by age, gender, ethnicity, place of residence, region and self-perceived general health.

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

SES, socioeconomic status; RII, Relative Index of Inequality; SII, Slope Index of Inequality.

Table 4 Relative inequalities in oral health outcomes by different SES measures, place of residence.

	Untreated caries	Dental pain experience	dmft
	RII (95%CI)		
Urban areas			
Parental educational level	1.47(1.25, 1.73) ***	1.31(1.09, 1.58) **	1.37(1.17, 1.61) ***
Household income	1.50(1.23, 1.83) ***	1.03(0.82, 1.29)	1.42(1.17, 1.73) ***
Rural areas			
Parental educational level	1.85(1.56, 2.19) ***	0.69(0.57, 0.83) ***	1.82(1.54, 2.15) ***
Household income	1.26(1.02, 1.56) *	0.81(0.65, 1.00) **	1.24(1.00, 1.53) *

Models adjusted by age, gender, ethnicity, region and self-perceived general health.

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

SES, socioeconomic status; RII, Relative Index of Inequality.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-5
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	5-6
		(*e*) Describe any sensitivity analyses	5-6
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	No
		(c) Consider use of a flow diagram	No
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-7
		(b) Indicate number of participants with missing data for each variable of interest	No
Outcome data	15*	Report numbers of outcome events or summary measures	6-7
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7

		(*b*) Report category boundaries when continuous variables were categorized	7
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	7
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	No
Discussion			
Key results	18	Summarise key results with reference to study objectives	8-9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10-11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9-10
Generalisability	21	Discuss the generalisability (external validity) of the study results	9-10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	12

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-042908.R1
Article Type:	Original research
Date Submitted by the Author:	17-Jan-2021
Complete List of Authors:	Zhang, Tingting; Guangxi Medical University, College & Hospital of Stomatology, Dental Public Health Hong, Jialan; University College London, Department of Epidemiology & Public Health Yu, Xueting; Guangxi Medical University, College & Hospital of Stomatology, Dental Public Health Liu, Qiulin; Guangxi Medical University, College & Hospital of Stomatology, Dental Public Health Li, Andi; Guangxi Medical University, College & Hospital of Stomatology, Dental Public Health Wu, Zhijing; Guangxi Medical University, College & Hospital of Stomatology, Dental Public Health Zeng, Xiaojuan ; Guangxi Medical University, College & Hospital of Stomatology, Dental Public Health
Primary Subject Heading:	Dentistry and oral medicine
Secondary Subject Heading:	Epidemiology, Health policy
Keywords:	Community child health < PAEDIATRICS, Epidemiology < INFECTIOUS DISEASES, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

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Association between socioeconomic status and dental caries among Chinese preschool children: A cross-sectional national study

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Running Title: Socioeconomic status and dental caries

Keywords: Socioeconomic inequalities, dental caries, oral health, preschool children

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Word count: 2603 words

Abstract count: 230 words

Abstract

Objectives: Socioeconomic inequalities in oral health are often neglected in oral health promotion. This cross-sectional study assessed the association between dental caries and socioeconomic status (SES) among preschool children in China.

Design Cross-sectional study.

Setting Data from the Fourth National Oral Health Survey of China (2015), comprising of 40,360 children aged 3-5 years was used.

Methods: Dental caries indicators including prevalence of dental caries, dental pain experience and number of decayed, missing and filling teeth (dmft). SES indicators included parental education and household income. The associations between SES and dental caries were analyzed by using negative binomial regression or Poisson regression models according to data distribution. Relative and absolute inequalities in dental caries were quantified by using the relative index of inequality (RII) and slope index of inequality (SII), respectively.

Results: There were significant associations between SES and prevalence of dental caries and dmft (P<0.001). Children from lower-educated (RII: 1.36, 95%CI 1.3 to 1.43; SII: 0.97, 95%CI 0.81 to 1.13) and lower household income (RII: 1.17, 95%CI 1.11 to 1.24; SII: 0.55, 95%CI 0.35 to 0.75) families had higher dmft than those from well-educated and most affluent families. Relative and absolute inequalities in dental caries were larger in urban areas by household income, and in rural areas by parental education.

Conclusions: Association between dental caries and SES was demonstrated and socioeconomic inequalities in dental caries existed among Chinese preschool children.

Strength and limitation

- The first study to quantify socioeconomic inequalities in dental caries among Chinese preschool children using relative and absolute inequality regression.
- The data was from a relatively large cross-sectional national study.
- Cross-sectional nature of the study design precluding inference about causality.

Introduction

Currently, dental caries is still the greatest global oral health burden with 532 million children affected worldwide[1]. Dental caries not only post a threat on health and quality of life but also impose a substantial economic burden on the society[2]. Although World Health Organization (WHO) found that the prevalence of dental caries has been declined over the past decade, the declining trend in dental caries was evident in high-income countries but was nonsignificant in low and middle - income countries[3 4], even the prevalence of dental caries have increased in some low and middle income countries, suggesting that oral health inequalities remain across countries.

An individual's socioeconomic status (SES) is one of the most important determinants in children's oral health[5], and Evidence has been found that children with low SES, including low household income, low mother's education and living in socially disadvantaged families, were more likely to have higher prevalence of dental caries and greater dental pain experience[6-8]. In India, a lagged analysis of a structural equation modeling showed that SES contribute to oral health status indirectly[9]. Poor SES can have a deleterious impact on child oral health as a result. Socioeconomic inequality in child dental caries is a great concern in many countries[7 8 10]. Considering children's critical role in ensuring the well-being of oral health inequality, it is important to explore the oral health in children.

China is the world's most populous country, having 1.4 billion people[11]. China has been undergoing rapid economic developments while also experiencing a processing of increasing inequalities in health[12]. For example, Chinese children from rural areas or poorer families are more likely to be stunted than those from urban areas or wealthier families[13 14]. The inequalities in oral health were also observed in China, suggesting that childhood oral health inequalities can persist into adulthood, irrespective of later changes in social position[15]. However, few studies have explored the association between SES and oral health in Chinese preschool children[16 17]. Hence, additional researches to improve current understanding of socioeconomic inequalities in oral health in preschool children of China is needed.

This study was to explore the association between SES and dental caries, and evaluated the socioeconomic inequalities in dental caries among children aged 3 to 5 years around the mainland of China.

Methods

Data source

We used data from the Fourth National Oral Heath Survey of China conducted in 2015, which was based on a nationally representative sample of 40,360 children aged 3-5 years old, providing information on individual oral health status, sociodemographic data and general health status. As previously described[18], a multistage cluster sampling method was used. Ethics approval (Approval no. 2014-003) was obtained from the Ethics Committee of Chinese Stomatological Association, and written consent was obtained by parents of each child to participate in the study.

Dental examination was completed by trained and calibrated dentists during the national survey. Those with kappa values higher than 0.8 for the dmft index were qualified. Dental caries diagnostic criteria were adopted according to the WHO recommendation[19]. Socioeconomic information from the children's families was obtained by structured questionnaire finished by their parents.

Dependent variables

The three main dependent variables of dental caries status were (1) prevalence of dental caries. (2) dental pain experience ("yes" or "no"), defined as having toothache in the last 12 months, reported by the parents. (3) dmft (count variable), the number of decayed, missing and filled teeth.

Independent variables

Parental education and household income were considered as SES indicators. Parental education was grouped into three categories: low level (secondary school degree or below), middle level (high school degree), and high level (college degree or above) according to the Chinese education system. Household income in the study year (2015) was categorized into five groups according to National Income Quintiles of

China: lowest (≤4,000$/year), low (4,000-9,000$/year), middle (9,000-15,000$/year), high(15,000-20,000$/year), highest(>20,000$/year).

Covariates

Age, gender, ethnic (Han/other ethnics), place of residence (urban/rural) and region (east/central/west) as well as parent-reported child general health (good or better, fair or less) were considered as covariates.

Statistical analysis

Data were analyzed using STATA MP 16.0 (Stata Corp., College Station, TX, USA). Descriptive results were conducted in order to identify the main patterns of data. Proportional differences between different groups were compared by using Chi square tests. Continuous data lack of normal distribution was analyzed using Mann-Whitney test (two groups) or Kruskal-Wallis test (more than two groups).

Multiple imputation (MI) was carried out for incomplete data in parental education and household income, which were 10 and 15010 respectively. Overall distribution of available values were used to determine the values to be imputed[20], and 40 imputed datasets were generated according to the proportion of missing data, which was at least equal to the percentage of incomplete data[21]. The collinearity between income and education was assessed. Their variance inflation factors (VIF) were both less than 10, indicating these two SES indicators cannot be considered as a linear combination of other independent variables.

Poisson regression was used to assessed the associations between SES indicators and prevalence of dental caries or dental pain[22]. Since the proportion of "zero" caries counts was only 37.5%[23], a negative binomial regression model was used to assess the association between SES indicators and the log dmft . Odds ratios (ORs) for Poisson regression and incidence rate ratio (IRR) for negative binomial regression with 95% confidence intervals (CIs) were reported. Estimates were significantly different from the reference if its 95%CIs do not include 1. Crude model and adjusted model were built. Adjusted model further take consideration of the covariates.

Considering the social structure of the population, the relative index of inequality (RII) and slope index of inequality (SII) were used to assess relative and absolute inequalities respectively[24]. By disposing the SES indicators as a continuous variable, RII and SII use all available data and are not limited to comparisons of extreme groups, and finally result into two different types of measures of socioeconomic inequalities in health, which are relative and absolute. The SII estimated the absolute predicted difference in caries experience between the highest and lowest SES, interpreted as the difference in predicted health rates at the two extremes of the socioeconomic spectrum, and RII is their ratio. Values of RII>1 or SII >0 signify existence of a SES gradient in oral health, and higher the score the greater the magnitude of the inequity. Considering the survey weights and missing data, all the above covariates were included in the models. The ridit score for estimating SII and RII was calculated[25]. Using the ridit score and continuous caries experience measurements, the ratio of the mean by Poisson regression was considered as RII and the beta coefficient by linear regression was considered as SII. The ridit score, RII, and SII were calculated for each of the 40 datasets and RII and SII were integrated.

Taking into account sampling method and the post stratification, all estimates were weighted. Analyses were also conducted stratifying by urban areas and rural areas.

Patient and public involvement

Patients and the public were not involved in developing the research question, study design or outcome measures. While direct dissemination of study results has not been planned, they will be communicated through our institutional media services.

Results

Of the 40,360 children in the study, 50.2% were boys and 49.8% were girls. Sociodemographic information was summarized in table 1. In addition, the prevalence of dental caries and dental pain, and mean dmft in rural areas were higher than those in urban areas, and there was an increasing trend with age, parental education, and household income (Table 1).

The prevalence of dental caries and dental pain was 62.5% and 26.9%, respectively,

and the mean dmft was 3.35±0.02 (Table 2).

There were significant associations between oral health and both SES indicators (P<0.001). After adjusting for gender, age, ethnic, region, place of residence and parent-reported child general health, the existence of social gradients in dental caries indicators was confirmed, with the exceptions of dental pain. Figure 1 showed that children from middle and low parental education group had higher dmft (IRR=1.13, 95% CI: 1.09-1.17; and IRR=1.20, 95% CI: 1.17-1.24, respectively). This pattern was also observed for prevalence of dental caries by parental education. Additionally, there was a gradient in the association between household income and prevalence of dental caries and dmft (Figure 1).

RII and SII estimates showed significant relative and absolute inequalities for oral health and SES indicators except for dental pain experience. We observed higher dmft among children in the lowest household income families (IRR=1.16, 95% CI:1.10-1.23) than those from the highest household income families (Figure 1), with this being reflected significantly in the relative and absolute index of inequality (RII=1.17, 95%CI:1.11-1.24 and SII=0.55, 95%CI: 0.35-0.75) (Figure 2), representing an excess of 1.17 decayed, missing or filling teeth and 55 more children with decayed, missing or filling teeth per 100 children in the lowest household income group compared with the highest one respectively. Similarly, relative inequalities were as well as larger in prevalence of dental caries and dmft by parental education (RII=1.17, 95% CI:1.13-1.21 and RII=1.36, 95% CI:1.30-1.43, respectively). Significant absolute and relative inequalities in dental pain were also observed when stratified by place of residence. In rural areas, inequalities in dental caries in favor of those with lower household income and lower parental education. However, parental education was only significantly associated with prevalence of dental pain in rural areas (RII= 0.87, 95%CI: 0.79-0.95 and SII=-0.05, 95%CI: -0.08--0.03). Meanwhile, our findings revealed that inequalities were larger in rural areas by parental education, while inequalities related to household income were larger in urban areas (Figure 2).

Discussion

In general, we identified a social gradient in oral health of children, with lower SES being associated with a higher risk of dental caries and dental pain experience. In urban areas, a positive gradient was observed with higher parental education being associated with higher dental pain experience. Different from children in urban areas whose inequalities in dental caries were larger by household income, inequalities in dental caries of children in rural areas were more affected by parental education. This characteristic should be considered in future oral health promotion programs.

Parental education and household income were obvious markers relating to oral health in children, with lower parental education and household income being significantly associated with higher prevalence of dental caries and higher dmft in this study. This finding was in agreement with an earlier dental health inequality studies[6 26]. There was some evidence showed that children from lower SES families suffer from more severe dental pain and higher prevalence of dental caries[27 28]. Among 3-year-old Japanese children, higher prevalence of dental caries was associated with lower level of parental education[26]. A cross-sectional study in Australia showed that parental education with higher level were significantly inversely associated with dmft of children aged 4 to 13 years old[29]. On the other hand, no association was observed between parental education and caries experience in Chinese[30] and Mongolian childrene[8], which may be due to small sample size and the time of data collection.

This study also revealed household income as a traditional SES indicator of children, affected the distribution of caries experience. Evidence from a recent study confirmed that household income was one of the strongest factors related to oral health[31]. A cohort study on trends in oral health from a life course data in Hong Kong suggested that household income had an effect on children's oral health status[32]. Significant inverse associations between household income and dental caries were also observed in Chinese[16], American[33], Japanese[26], Australian[6 29], and Mongolian[8] children.

Our findings also revealed that inequality by parental education was existed in lower parental education in rural areas. And children in rural areas also had higher dmft and prevalence of dental caries than those in urban areas, which keeping with the trend

of a former study in China[30]. Our finding is also consistent with a Thailand study which examined the time trends in dental caries among children and indicated the prevalence of dental caries was higher for the children who lived in rural areas[34]. However, from the perspective of household income, relative and absolute inequalities were larger in urban areas in the results. We found that parental education was positively associated with dental pain experience in urban areas. This might be explained by the fact that the neglect of discomfort and pain in children from low parent educated groups, with proportion of high educated parents being larger in urban areas, and larger inequalities by household income in urban areas. Health services utilization is as well as a potential factor accounting for the large inequalities in health between urban and rural residents in China[35 36]. Utilization of dental services had a positive impact on the caries experience in children and adolescents[32].

Parental SES might influence child oral health through oral health practice, knowledge and attitude[37]. Parents of higher education visited a dentist more frequently not only when their children had dental pain, but also to bring their children in for preventive checkups and learn oral health knowledge[38 39]. Meanwhile, education is a primary determinant of a person's labor market position on the other hand, which in turn influences income, housing, and other material resources. And higher income promotes improved living conditions, such as safe housing, ability to preferentially attend public dental services and receive oral health advices compared with those from lower income[5].

However, parental education and household income are difficult to modify in the short term. Therefore, strategies must be developed to improve oral health of children, facilitate parental knowledge and promote preventive tools. Our findings would advance the argument for oral health promotion initiatives that engage parents of children very early. For example, the positive effect of increased household income and high parental education on child health implies that government provide health service targeting the poor and the illiteracy may be an effective way to improve the oral health of children from low SES families, and public welfare programs should focus on rural

areas, or considering the importance of child oral health in future life quality, which implies a potential increasing oral health education in such an inequality in oral health of children. Oral health inequalities are not unconquerable but need government support. For example, socioeconomic inequalities in oral health of children were less conspicuous in areas with water fluoridation compared to non-fluoridated places in Australia[40]. Policies targeting poverty to reduce socioeconomic inequalities may be successful as well as the interventions in health utilization[41]. Interprofessional collaboration between professional dentists, non-dentistry professionals and fellow-health professionals should be established to jointly provide services aiming at low SES groups at the same time[42].

Strength and limitation

A major strength of our study was the Fourth National Oral Heath Survey of China use of a relatively large and representative sample of children, which ensured study results are likely to be generalizable across the mainland of China children. And it was the first study to measure inequalities in child oral health by using slope index of inequality and relative index of inequality in China. The study findings should be considered with number of limitations. The study design was the cross-sectional nature precluding inference about causality. We were not able to examine how socioeconomic inequalities in oral health changed as children grew into adolescents. Longitudinal studies of the oral health of representative samples of Chinese children are rare, and that will provide stronger evidence of the potential causal pathways underlying oral health inequalities as further longitudinal data become available.

Conclusions

Children from the lower SES families were more likely to have dental caries. Furthermore, significant inequalities can be found at a very early age.

Acknowledgements The authors are grateful to the study participants whose data has made this study possible. This study is conducted in partnership between 35 colleges and universities, Center of Disease Control (CDC) of Chinese Health Commission of the People's Republic of China, Chinese Stomatological Association.

Contributors All authors meet the ICMJE authorship criteria. Tingting Zhang, Xiaojuan Zeng, Jialan Hong and Xueting Yu conceived the study and developed the analysis strategy. Tingting Zhang, Jialan Hong and Xueting Yu carried out the analysis. Tingting Zhang drafted the manuscript. All authors critically reviewed the drafts, gave text suggestions, and approved the final manuscript.

Funding This study was supported by "Scientific Research Fund of National Health Commission of the People's Republic of China (201502002)".

Conflicts of Interest: None declared.

Patient consent for publication Not required.

Ethics approval Ethical approval was obtained from the Ethics Committee of Chinese Stomatological Association (Approval no. 2014-003), and parents of each participant were required to sign an informed consent form.

Provenance and peer review Not commissioned; externally per reviewed.

Data sharing statement Consent has not been obtained to share the data publicly. However, data may be accessed on contacting the corresponding author. The same principle applies for statistical analysis scripts.

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Figure Legends

Figure 1. Odds ratio (OR), Incidence rate ratio (IRR) stratified by parental education and household income.

Footnote: Odds ratio (OR), Incidence rate ratio (IRR) and 95% confidence intervals (CIs) by parental education and household income are presented as well as the level of significance. Crude model: each SES measure (parental education and household income) and outcomes (dental caries, dental pain and dmft). Adjusted model: adjusted for age, gender, ethnic, place of residence, region, and parent-reported child general health. All estimates models are weighted. $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

Figure 2. Relative index of inequality (RII) and slope index of inequality (SII) for urban and rural area by parental education and household income.

Footnote: Estimates and 95% confidence intervals (CIs) are presented as well as the level of significance, adjusted by age, gender, ethnic, region and parent-reported child general health. All estimates models are weighted. $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

Supplementary fig 1 Odds ratio (OR), Incidence rate ratio (IRR) stratified by parental education and household income.

Footnote: Odds ratio (OR), Incidence rate ratio (IRR) and 95% confidence intervals (CIs) by parental education and household income are presented as well as the level of significance. Crude model: each SES measure (parental education and household income) and outcomes (dental caries, dental pain and dmft). Adjusted model: adjusted for age, gender, ethnic, place of residence, region and parent-reported child general health. All estimates models are weighted. $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

Supplementary fig 2 Relative index of inequality (RII) and slope index of inequality (SII) for urban and rural area by parental education and household income. Footnote:

Estimates and 95% confidence intervals (CIs) are presented as well as the level of significance, adjusted by age, gender, ethnic, region and parent-reported child general health. All estimates models are weighted. *P < 0.05, **P < 0.01, ***P < 0.001.

Table 1 Summary of the characteristics of the study participants.

Category	n	%	caries		P value*	pain		P value*	dmft	P value*
			n	%		n	%		(mean±SD)	
Gender					<0.001			<0.001		<0.001
Male	20245	50.2	12598	62.7		5078	26.2		3.39±0.03	
Female	20115	49.8	12545	62.4		5340	27.7		3.31±0.03	
Age (years)					<0.001			<0.001		<0.001
3	12390	30.7	6292	50.8		2024	17.1		2.28±0.03	
4	13978	34.6	8895	63.6		3420	25.5		3.40±0.04	
5	13992	34.7	10056	71.9		4974	37.0		4.24±0.04	
Ethnic					<0.001			<0.001		<0.001
Han	36087	89.4	22401	62.1		9231	26.7		3.32±0.02	
Other ethnics	4273	10.6	2842	66.5		1187	28.9		3.63±0.06	

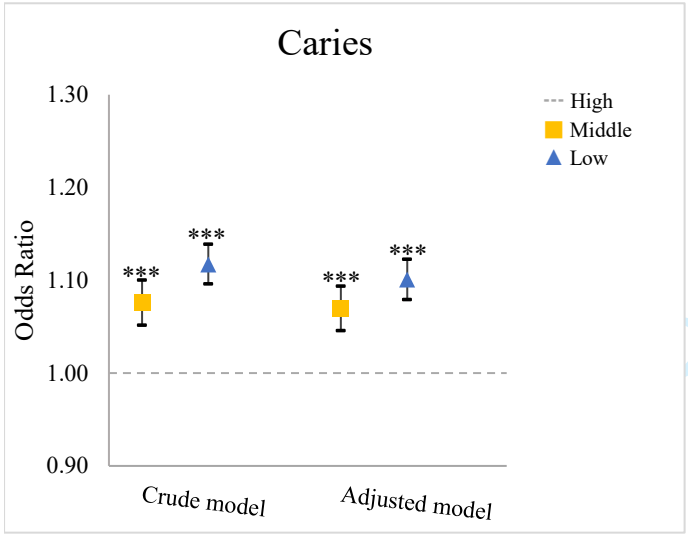
Place of residence					<0.001			<0.001	<0.001
Urban	20490	50.8	12449	60.8		5166	26.2	3.14±0.03	
Rural	19870	49.2	12794	64.4		5252	27.7	3.57±0.03	
Region					<0.001			<0.001	<0.001
East	14127	35.0	9385	66.4		3872	28.5	3.83±0.04	
Middle	10403	25.8	6216	59.8		2654	27.0	3.09±0.04	
West	15830	39.2	9642	60.9		3892	25.5	3.09±0.03	
Parents-reported child general health					<0.001			<0.001	<0.001
Good or better	28885	71.6	17860	61.8		6954	25.0	3.25±0.02	
Fair or less	11475	28.4	7383	64.3		3464	32.0	3.60±0.04	
Parental education					<0.001			0.137	<0.001
High	12615	36.1*	7326	58.1*		3208	26.3*	2.90±0.04*	

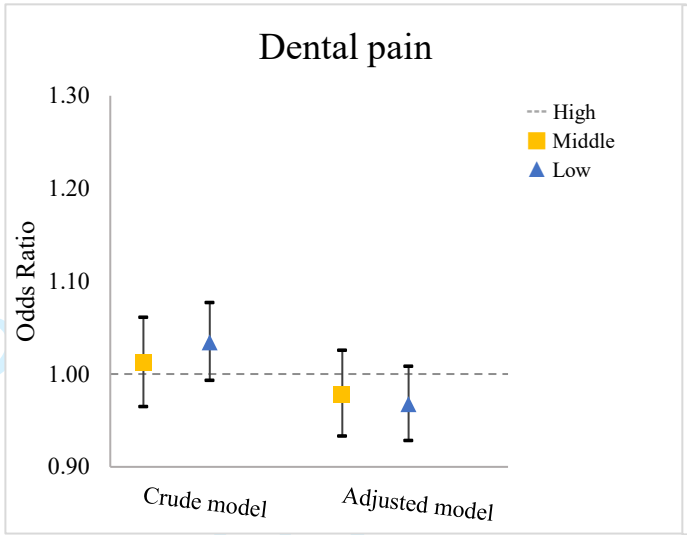
Middle	9457	23.2*	5914	62.5*		2445	26.9*	3.34±0.04*
Low	18278	40.7*	11998	65.6*		4762	27.4*	3.66±0.03*
Household income					<0.001			
Highest	4431	17.7*	1942	59.2*	0.011	753	25.2*	3.01±0.06*
High	4319	21.7*	3037	62.1*		1233	27.1*	3.37±0.05*
Middle	5509	20.9*	3256	61.6*		1326	27.0*	3.27±0.05*
Low	4972	26.2*	4638	63.9*		1812	27.1*	3.48±0.04*
Lowest	6619	13.6*	2825	65.1*		1131	28.2*	3.53±0.06*

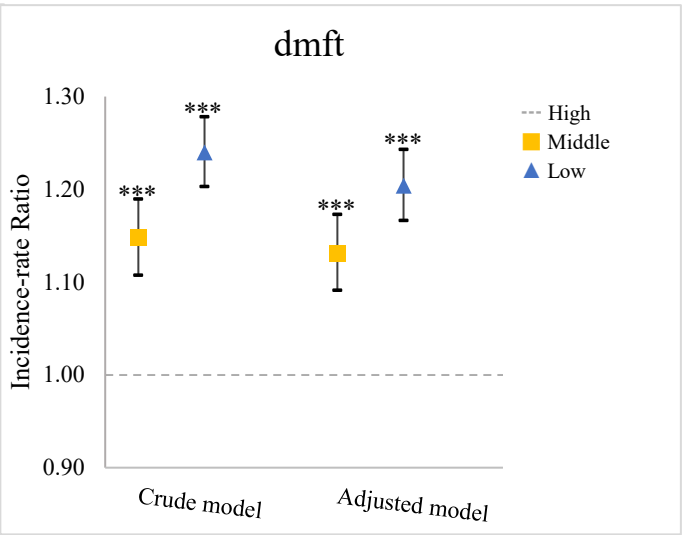
*Proportions and *P*-values are presented after multiple imputation for parental education and household income.

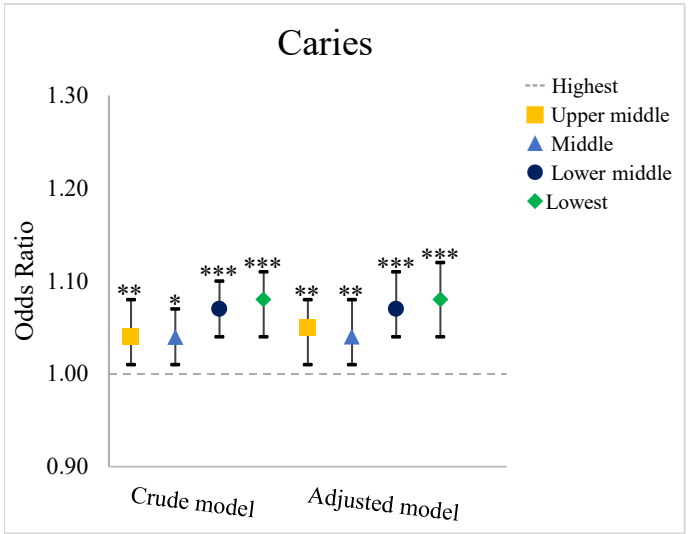
Table 2. Basic characteristics of dental caries indicators in the study participants.

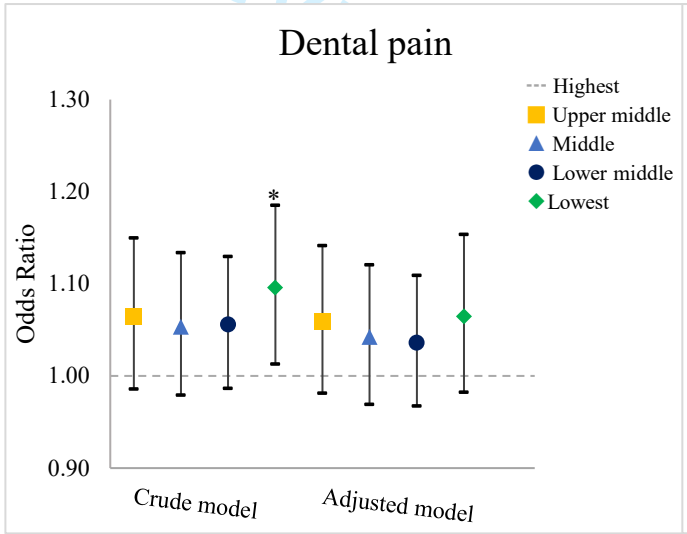
Category	**Overall**	
	n	**%**
Caries	25243	62.5
Dental pain	10418	26.9
dmft(Mean±SD)	3.35±0.02	











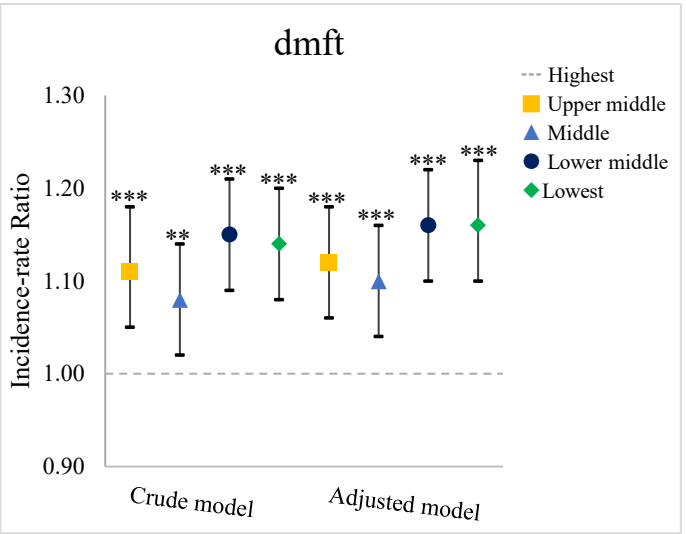


Figure 1. Odds ratio (OR), Incidence rate ratio (IRR) stratified by parental education and household income. Odds ratio (OR), Incidence rate ratio (IRR) and 95% confidence intervals (CIs) by parental education and household income are presented as well as the level of significance. Crude model: each SES measure (parental education and household income) and outcomes (dental caries, dental pain and dmft). Adjusted model: adjusted for age, gender, ethnic, place of residence, region and parent-reported child general health. All estimates models are weighted. $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

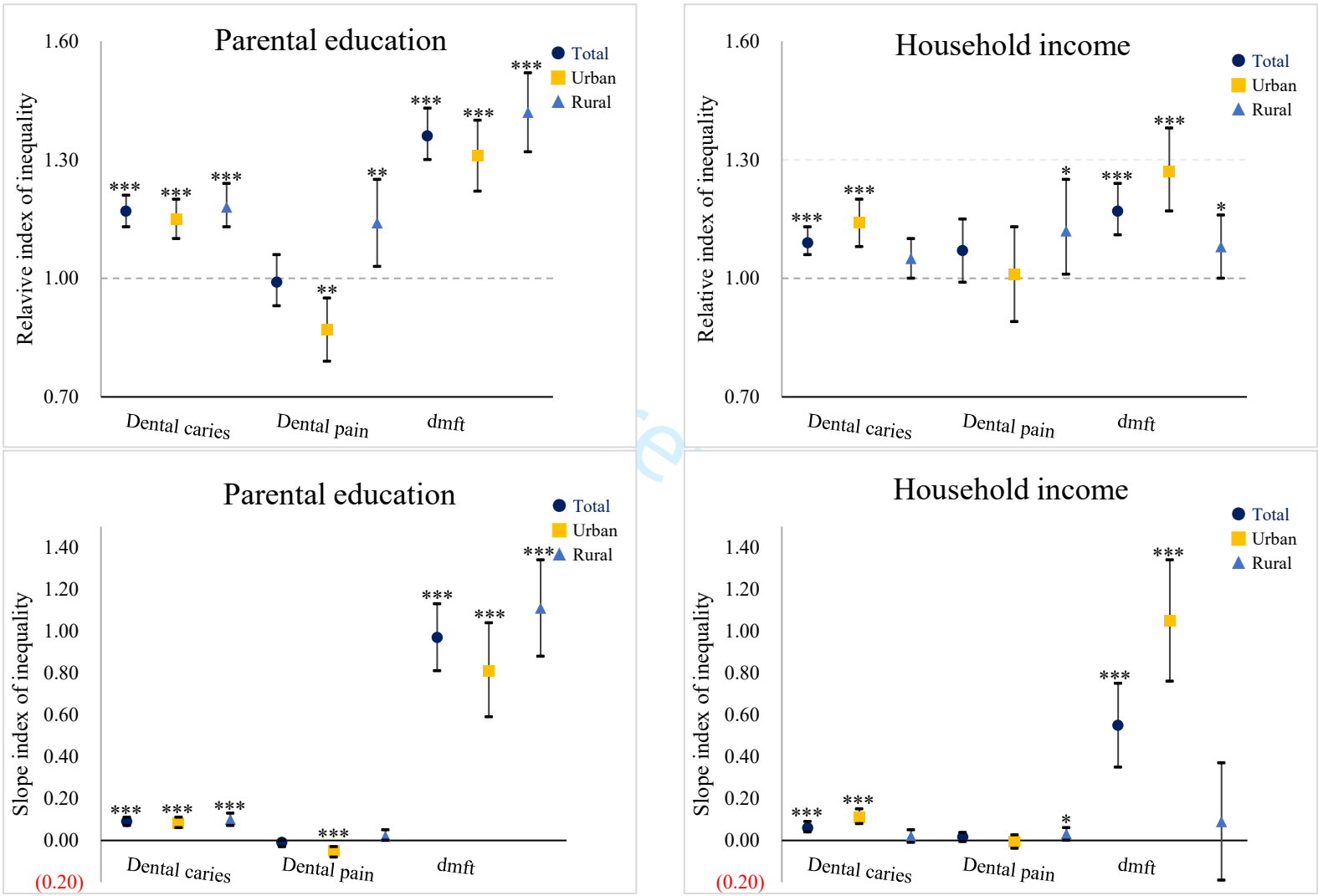
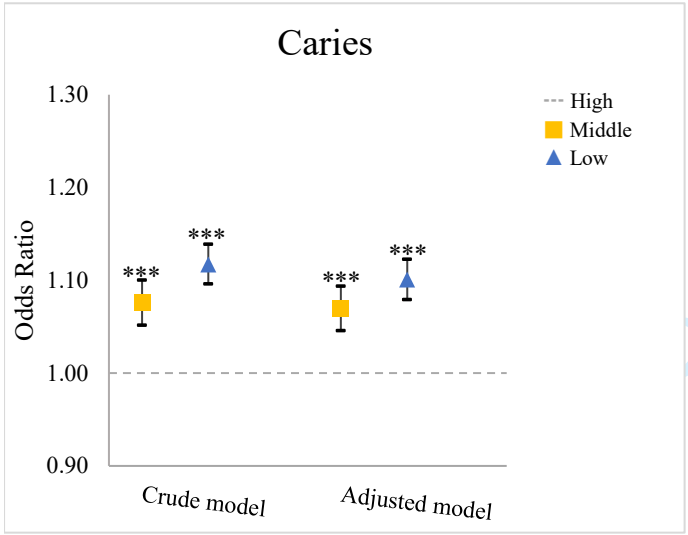
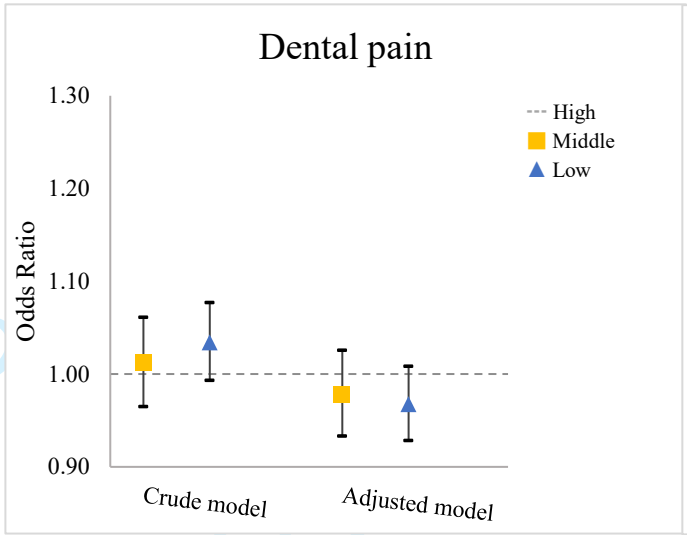
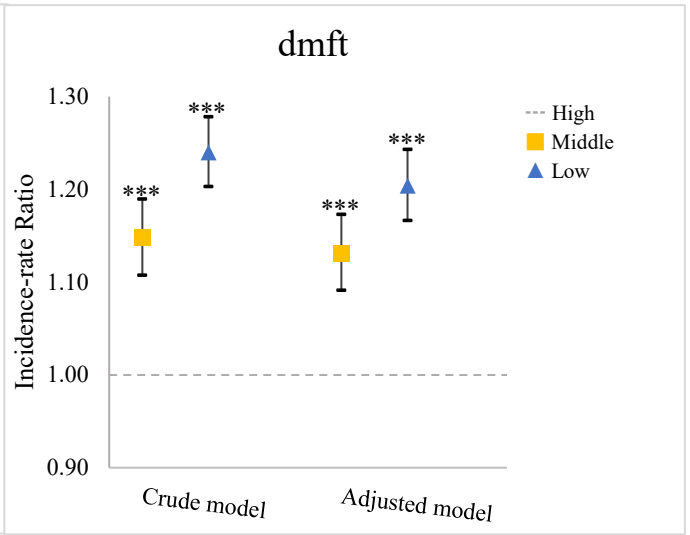
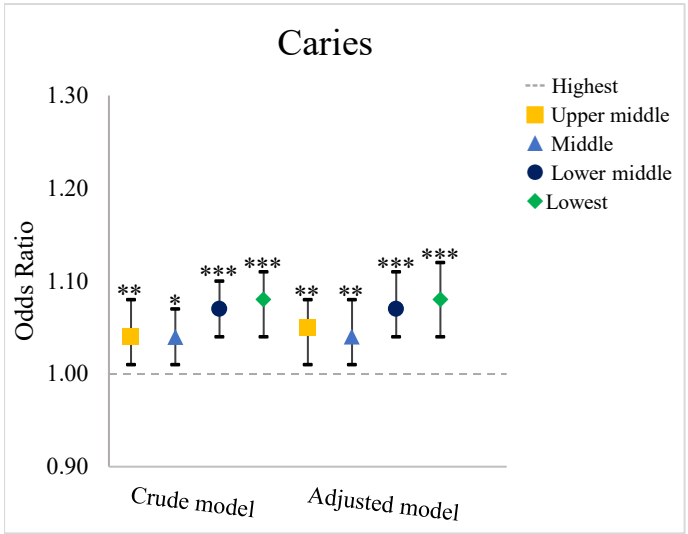


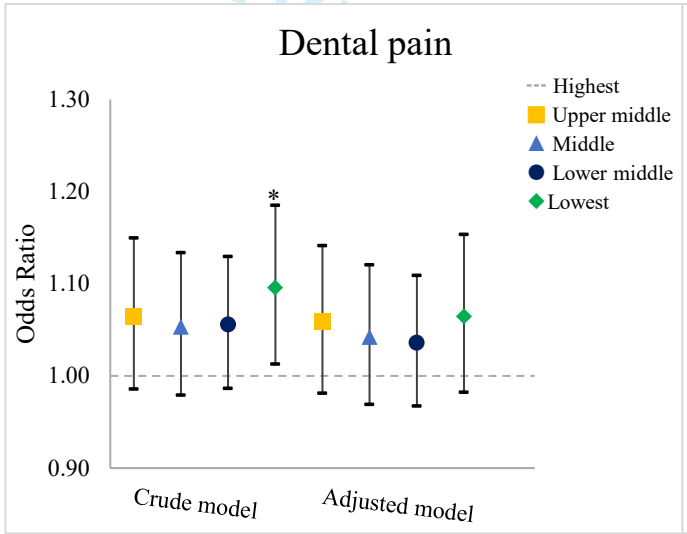
Figure 2. Relative index of inequality (RII) and slope index of inequality (SII) for urban and rural area by parental education and household income. Estimates and 95% confidence intervals (CIs) are presented as well as the level of significance, adjusted by age, gender, ethnic, region and parent-reported child general health. All estimates models are weighted. $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

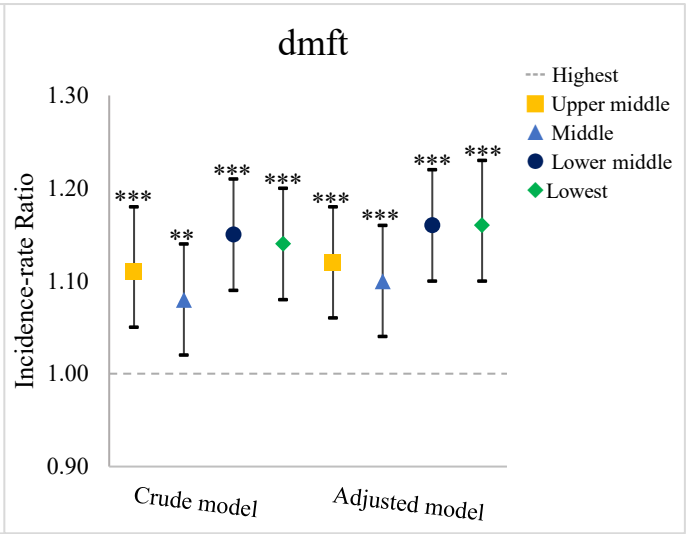












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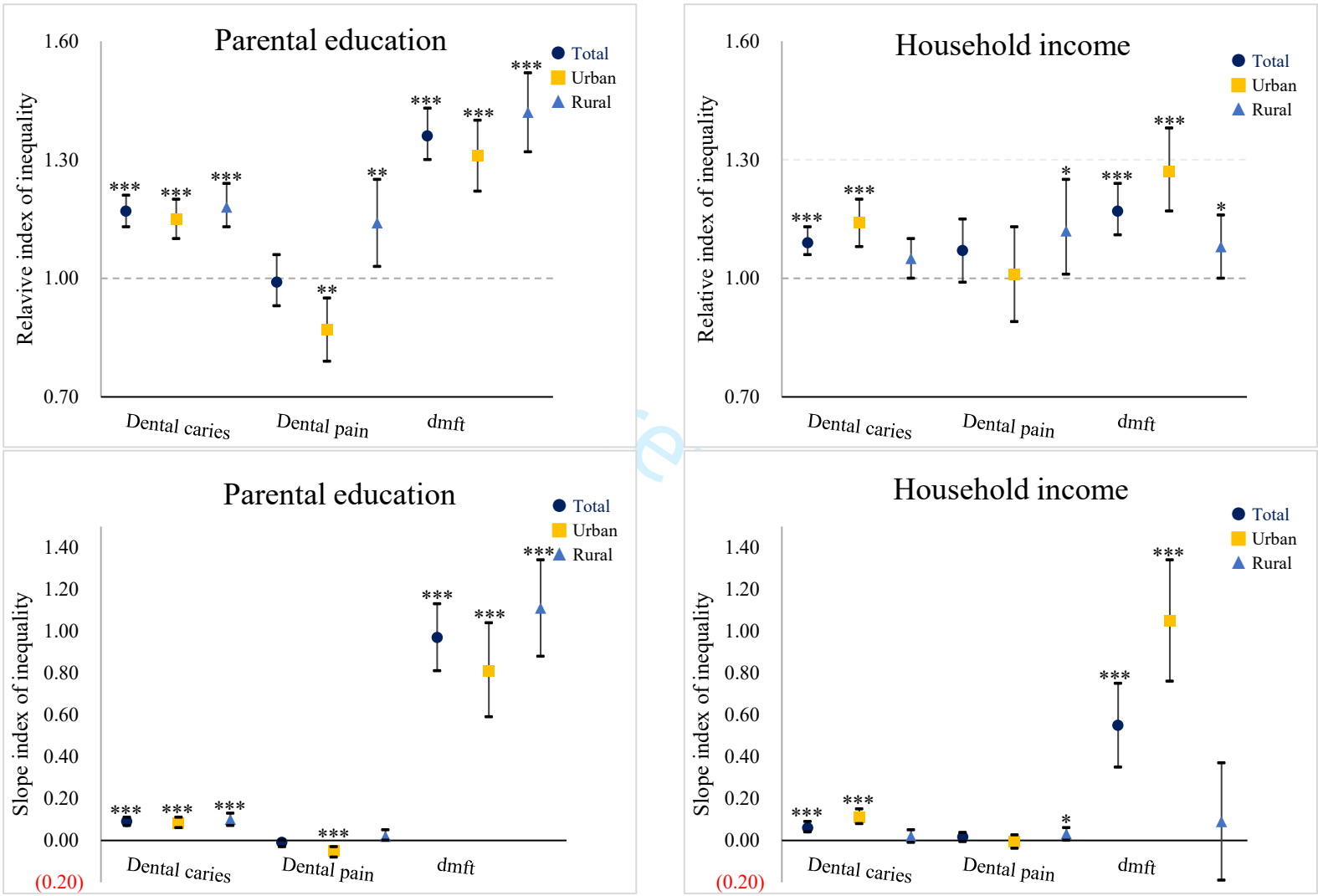

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-5
Bias	9	Describe any efforts to address potential sources of bias	4-5
Study size	10	Explain how the study size was arrived at	4-5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	5-6
		(*e*) Describe any sensitivity analyses	5
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	No
		(c) Consider use of a flow diagram	No
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-7
		(b) Indicate number of participants with missing data for each variable of interest	No
Outcome data	15*	Report numbers of outcome events or summary measures	6-7
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7

		(*b*) Report category boundaries when continuous variables were categorized	7
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	7
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	No
Discussion			
Key results	18	Summarise key results with reference to study objectives	8-9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9-10
Generalisability	21	Discuss the generalisability (external validity) of the study results	9-10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	10

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-042908.R2
Article Type:	Original research
Date Submitted by the Author:	27-Apr-2021
Complete List of Authors:	Zhang, Tingting; Guangxi Medical University, College & Hospital of Stomatology, Dental Public Health Hong, Jialan; University College London, Department of Epidemiology & Public Health Yu, Xueting; Guangxi Medical University, College & Hospital of Stomatology, Dental Public Health Liu, Qiulin; Guangxi Medical University, College & Hospital of Stomatology, Dental Public Health Li, Andi; Guangxi Medical University, College & Hospital of Stomatology, Dental Public Health Wu, Zhijing; Guangxi Medical University, College & Hospital of Stomatology, Dental Public Health Zeng, Xiaojuan ; Guangxi Medical University, College & Hospital of Stomatology, Dental Public Health
Primary Subject Heading:	Dentistry and oral medicine
Secondary Subject Heading:	Epidemiology, Health policy
Keywords:	Community child health < PAEDIATRICS, Epidemiology < INFECTIOUS DISEASES, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

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Association between socioeconomic status and dental caries among Chinese preschool children: A cross-sectional national study

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Running Title: Socioeconomic status and dental caries

Keywords: Socioeconomic inequalities, dental caries, oral health, preschool children

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Word count: 2602 words

Abstract count: 230 words

Abstract

Objectives: Socioeconomic inequalities in oral health are often neglected in oral health promotion. This cross-sectional study assessed the association between dental caries and socioeconomic status (SES) among preschool children in China.

Design Cross-sectional study.

Setting Data from the Fourth National Oral Health Survey of China (2015), comprising of 40,360 children aged 3-5 years was used.

Methods: Dental caries indicators including prevalence of dental caries, dental pain experience and number of decayed, missing and filling teeth (dmft). SES indicators included parental education and household income. The associations between SES and dental caries were analyzed by using negative binomial regression or Poisson regression models according to data distribution. Relative and absolute inequalities in dental caries were quantified by using the relative index of inequality (RII) and slope index of inequality (SII), respectively.

Results: There were significant associations between SES and prevalence of dental caries and dmft (P<0.001). Children from lower-educated (RII: 1.36, 95%CI 1.3 to 1.43; SII: 0.97, 95%CI 0.81 to 1.13) and lower household income (RII: 1.17, 95%CI 1.11 to 1.24; SII: 0.55, 95%CI 0.35 to 0.75) families had higher dmft than those from well-educated and most affluent families. Relative and absolute inequalities in dental caries were larger in urban areas by household income, and in rural areas by parental education.

Conclusions: Association between dental caries and SES was demonstrated and socioeconomic inequalities in dental caries existed among Chinese preschool children.

Strength and limitation

- The first study to quantify socioeconomic inequalities in dental caries among Chinese preschool children using relative and absolute inequality regression.
- The data was from a relatively large cross-sectional national study.
- Cross-sectional nature of the study design precluding inference about causality.

Introduction

Currently, dental caries is still the greatest global oral health burden with 532 million children affected worldwide[1]. Dental caries not only post a threat on health and quality of life but also impose a substantial economic burden on the society[2]. Although World Health Organization (WHO) found that the prevalence of dental caries has been declined over the past decade, the declining trend in dental caries was evident in high-income countries but was nonsignificant in low and middle - income countries[3 4], even the prevalence of dental caries has increased in some low and middle income countries, suggesting that oral health inequalities remain across countries.

An individual's socioeconomic status (SES) is one of the most important determinants in children's oral health[5], and Evidence has been found that children with low SES, including low household income, low mother's education and living in socially disadvantaged families, were more likely to have higher prevalence of dental caries and greater dental pain experience[6-8]. In India, a lagged analysis of a structural equation modeling showed that SES contribute to oral health status indirectly[9]. Poor SES can have a deleterious impact on child oral health as a result. Socioeconomic inequality in child dental caries is a great concern in many countries[7 8 10]. Considering children's critical role in ensuring the well-being of oral health inequality, it is important to explore the oral health in children.

China is the world's most populous country, having 1.4 billion people[11]. China has been undergoing rapid economic developments while also experiencing a processing of increasing inequalities in health[12]. For example, Chinese children from rural areas or poorer families are more likely to be stunted than those from urban areas or wealthier families[13 14]. The inequalities in oral health were also observed in China, suggesting that childhood oral health inequalities can persist into adulthood, irrespective of later changes in social position[15]. However, few studies have explored the association between SES and oral health in Chinese preschool children[16 17]. Hence, additional research to improve current understanding of socioeconomic inequalities in oral health in preschool children of China is needed.

This study was to explore the association between SES and dental caries, and evaluated the socioeconomic inequalities in dental caries among children aged 3 to 5 years around the mainland of China.

Methods

Data source

We used data from the Fourth National Oral Health Survey of China conducted in 2015, which was based on a nationally representative sample of 40,360 children aged 3-5 years old, providing information on individual oral health status, sociodemographic data and general health status. As previously described[18], a multistage cluster sampling method was used. Ethics approval (Approval no. 2014-003) was obtained from the Ethics Committee of Chinese Stomatological Association, and written consent was obtained by parents of each child to participate in the study.

Dental examination was completed by trained and calibrated dentists during the national survey. Those with kappa values higher than 0.8 for the dmft index were qualified. Dental caries diagnostic criteria were adopted according to the WHO recommendation[19]. Socioeconomic information from the children's families was obtained by structured questionnaire finished by their parents.

Dependent variables

The three main dependent variables of dental caries status were (1) prevalence of dental caries. (2) dental pain experience ("yes" or "no"), defined as having toothache in the last 12 months, reported by the parents. (3) dmft (count variable), the number of decayed, missing and filled teeth.

Independent variables

Parental education and household income were considered as SES indicators. Parental education was grouped into three categories: low level (secondary school degree or below), middle level (high school degree), and high level (college degree or above) according to the Chinese education system. Household income in the study year (2015) was categorized into five groups according to National Income Quintiles of

China: lowest (≤4,000$/year), low (4,000-9,000$/year), middle (9,000-15,000$/year), high(15,000-20,000$/year), highest(>20,000$/year).

Covariates

Age, gender, ethnic (Han/other ethnics), place of residence (urban/rural) and region (east/central/west) as well as parent-reported child general health (good or better, fair or less) were considered as covariates.

Statistical analysis

Data were analyzed using STATA MP 16.0 (Stata Corp., College Station, TX, USA). Descriptive results were conducted in order to identify the main patterns of data. Proportional differences between different groups were compared by using Chi square tests. Continuous data lack of normal distribution was analyzed using Mann-Whitney test (two groups) or Kruskal-Wallis test (more than two groups).

Multiple imputation (MI) was carried out for incomplete data in parental education and household income, which were 10 and 15010 respectively. Overall distribution of available values was used to determine the values to be imputed[20], and 40 imputed datasets were generated according to the proportion of missing data, which was at least equal to the percentage of incomplete data[21]. The collinearity between income and education was assessed. Their variance inflation factors (VIF) were both less than 10, indicating these two SES indicators cannot be considered as a linear combination of other independent variables.

Poisson regression was used to assess the associations between SES indicators and prevalence of dental caries or dental pain[22]. Since the proportion of "zero" caries counts was only 37.5%[23], a negative binomial regression model was used to assess the association between SES indicators and the log dmft. Odds ratios (ORs) for Poisson regression and incidence rate ratio (IRR) for negative binomial regression with 95% confidence intervals (CIs) were reported. Estimates were significantly different from the reference if its 95%CIs do not include 1. Crude model and adjusted model were built. Adjusted model further take consideration of the covariates.

Considering the social structure of the population, the relative index of inequality (RII) and slope index of inequality (SII) were used to assess relative and absolute inequalities respectively[24]. By disposing the SES indicators as a continuous variable, RII and SII use all available data and are not limited to comparisons of extreme groups, and finally result into two different types of measures of socioeconomic inequalities in health, which are relative and absolute. The SII estimated the absolute predicted difference in caries experience between the highest and lowest SES, interpreted as the difference in predicted health rates at the two extremes of the socioeconomic spectrum, and RII is their ratio. Values of RII>1 or SII >0 signify existence of a SES gradient in oral health, and higher the score the greater the magnitude of the inequity. Considering the survey weights and missing data, all the above covariates were included in the models. The ridit score for estimating SII and RII was calculated[25]. Using the ridit score and continuous caries experience measurements, the ratio of the mean by Poisson regression was considered as RII and the beta coefficient by linear regression was considered as SII. The ridit score, RII, and SII were calculated for each of the 40 datasets and RII and SII were integrated.

Taking into account sampling method and the post stratification, all models were survey-weighted. Analyses were also conducted stratifying by urban areas and rural areas.

Patient and public involvement

Patients and the public were not involved in developing the research question, study design or outcome measures. While direct dissemination of study results has not been planned, they will be communicated through our institutional media services.

Results

Of the 40,360 children in the study, 50.2% were boys and 49.8% were girls. Sociodemographic information was summarized in table 1. In addition, the prevalence of dental caries and dental pain, and mean dmft in rural areas were higher than those in urban areas, and there was an increasing trend with age, parental education, and household income (Table 1).

The prevalence of dental caries and dental pain was 62.5% and 26.9%, respectively, and the mean dmft was 3.35±0.02 (Table 2).

There were significant associations between oral health and both SES indicators (P<0.001). After adjusting for gender, age, ethnic, region, place of residence and parent-reported child general health, the existence of social gradients in dental caries indicators was confirmed, with the exceptions of dental pain. Figure 1 showed that children from middle and low parental education group had higher dmft (IRR=1.13, 95% CI: 1.09-1.17; and IRR=1.20, 95% CI: 1.17-1.24, respectively). This pattern was also observed for prevalence of dental caries by parental education. Additionally, there was a gradient in the association between household income and prevalence of dental caries and dmft (Figure 1).

RII and SII estimates showed significant relative and absolute inequalities for oral health and SES indicators except for dental pain experience. We observed higher dmft among children in the lowest household income families (IRR=1.16, 95% CI:1.10-1.23) than those from the highest household income families (Figure 1), with this being reflected significantly in the relative and absolute index of inequality (RII=1.17, 95%CI:1.11-1.24 and SII=0.55, 95%CI: 0.35-0.75) (Figure 2), representing an excess of 1.17 decayed, missing or filling teeth and 55 more children with decayed, missing or filling teeth per 100 children in the lowest household income group compared with the highest one respectively. Similarly, relative inequalities were as well as larger in prevalence of dental caries and dmft by parental education (RII=1.17, 95% CI:1.13-1.21 and RII=1.36, 95% CI:1.30-1.43, respectively). Significant absolute and relative inequalities in dental pain were also observed when stratified by place of residence. In rural areas, inequalities in dental caries in favor of those with lower household income and lower parental education. However, parental education was only significantly associated with prevalence of dental pain in rural areas (RII= 0.87, 95%CI: 0.79-0.95 and SII=-0.05, 95%CI: -0.08--0.03). Meanwhile, our findings revealed that inequalities were larger in rural areas by parental education, while inequalities related to household income were larger in urban areas (Figure 2).

Discussion

In general, we identified a social gradient in oral health of children, with lower SES being associated with a higher risk of dental caries and dental pain experience. In urban areas, a positive gradient was observed with higher parental education being associated with higher dental pain experience. Different from children in urban areas whose inequalities in dental caries were larger by household income, inequalities in dental caries of children in rural areas were more affected by parental education. This characteristic should be considered in future oral health promotion programs.

Parental education and household income were obvious markers relating to oral health in children, with lower parental education and household income being significantly associated with higher prevalence of dental caries and higher dmft in this study. This finding was in agreement with an earlier dental health inequality studies[6 26]. There was some evidence showed that children from lower SES families suffer from more severe dental pain and higher prevalence of dental caries[27 28]. Among 3-year-old Japanese children, higher prevalence of dental caries was associated with lower level of parental education[26]. A cross-sectional study in Australia showed that parental education with higher level were significantly inversely associated with dmft of children aged 4 to 13 years old[29]. On the other hand, no association was observed between parental education and caries experience in Chinese[30] and Mongolian childrene[8], which may be due to small sample size and the time of data collection.

This study also revealed household income as a traditional SES indicator of children, affected the distribution of caries experience. Evidence from a recent study confirmed that household income was one of the strongest factors related to oral health[31]. A cohort study on trends in oral health from a life course data in Hong Kong suggested that household income had an effect on children's oral health status[32]. Significant inverse associations between household income and dental caries were also observed in Chinese[16], American[33], Japanese[26], Australian[6 29], and Mongolian[8] children.

Our findings also revealed that inequality by parental education was existed in lower parental education in rural areas. And children in rural areas also had higher dmft

and prevalence of dental caries than those in urban areas, which keeping with the trend of a former study in China[30]. Our finding is also consistent with a Thailand study which examined the time trends in dental caries among children and indicated the prevalence of dental caries was higher for the children who lived in rural areas[34]. However, from the perspective of household income, relative and absolute inequalities were larger in urban areas in the results. We found that parental education was positively associated with dental pain experience in urban areas. This might be explained by the fact that the neglect of discomfort and pain in children from low parent educated groups, with proportion of high educated parents being larger in urban areas, and larger inequalities by household income in urban areas. Health services utilization is as well as a potential factor accounting for the large inequalities in health between urban and rural residents in China[35 36]. Utilization of dental services had a positive impact on the caries experience in children and adolescents[32].

Parental SES might influence child oral health through oral health practice, knowledge and attitude[37]. Parents of higher education visited a dentist more frequently not only when their children had dental pain, but also to bring their children in for preventive checkups and learn oral health knowledge[38 39]. Meanwhile, education is a primary determinant of a person's labor market position on the other hand, which in turn influences income, housing, and other material resources. And higher income promotes improved living conditions, such as safe housing, ability to preferentially attend public dental services and receive oral health advice compared with those from lower income[5].

However, parental education and household income are difficult to modify in the short term. Therefore, strategies must be developed to improve oral health of children, facilitate parental knowledge and promote preventive tools. Our findings would advance the argument for oral health promotion initiatives that engage parents of children very early. For example, the positive effect of increased household income and high parental education on child health implies that government provide health service targeting the poor and the illiteracy may be an effective way to improve the oral health

of children from low SES families, and public welfare programs should focus on rural areas, or considering the importance of child oral health in future life quality, which implies a potential increasing oral health education in such an inequality in oral health of children. Oral health inequalities are not unconquerable but need government support. For example, socioeconomic inequalities in oral health of children were less conspicuous in areas with water fluoridation compared to non-fluoridated places in Australia[40]. Policies targeting poverty to reduce socioeconomic inequalities may be successful as well as the interventions in health utilization[41]. Interprofessional collaboration between professional dentists, non-dentistry professionals and fellow-health professionals should be established to jointly provide services aiming at low SES groups at the same time[42].

Strength and limitation

A major strength of our study was the Fourth National Oral Health Survey of China use of a relatively large and representative sample of children, which ensured study results are likely to be generalizable across the mainland of China children. And it was the first study to measure inequalities in child oral health by using slope index of inequality and relative index of inequality in China. The study findings should be considered with number of limitations. The study design was the cross-sectional nature precluding inference about causality. We were not able to examine how socioeconomic inequalities in oral health changed as children grew into adolescents. Longitudinal studies of the oral health of representative samples of Chinese children are rare, and that will provide stronger evidence of the potential causal pathways underlying oral health inequalities as further longitudinal data become available.

Conclusions

Children from the lower SES families were more likely to have dental caries. Furthermore, significant inequalities can be found at a very early age.

Acknowledgements The authors are grateful to the study participants whose data has made this study possible. This study is conducted in partnership between 35 colleges and universities, Center of Disease Control (CDC) of Chinese Health Commission of

the People's Republic of China, Chinese Stomatological Association.

Contributors All authors meet the ICMJE authorship criteria. Tingting Zhang, Xiaojuan Zeng, Jialan Hong and Xueting Yu conceived the study and developed the analysis strategy. Tingting Zhang, Jialan Hong and Xueting Yu carried out the analysis. Tingting Zhang drafted the manuscript. Qiulin Liu, Andi Li and Zhijing Wu critically reviewed the drafts, gave text suggestions, and approved the final manuscript.

Funding This study was supported by "Scientific Research Fund of National Health Commission of the People's Republic of China (201502002)".

Conflicts of Interest: None declared.

Patient consent for publication Not required.

Ethics approval Ethical approval was obtained from the Ethics Committee of Chinese Stomatological Association (Approval no. 2014-003), and parents of each participant were required to sign an informed consent form.

Provenance and peer review Not commissioned; externally per reviewed.

Data sharing statement Consent has not been obtained to share the data publicly. However, data may be accessed on contacting the corresponding author. The same principle applies for statistical analysis scripts.

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Figure Legends

Figure 1. Odds ratio (OR), Incidence rate ratio (IRR) stratified by parental education and household income.

Footnote: Odds ratio (OR), Incidence rate ratio (IRR) and 95% confidence intervals (CIs) by parental education and household income are presented as well as the level of significance. Crude model: each SES measure (parental education and household income) and outcomes (dental caries, dental pain and dmft). Adjusted model: adjusted for age, gender, ethnic, place of residence, region, and parent-reported child general health. All models are weighted. $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

Figure 2. Relative index of inequality (RII) and slope index of inequality (SII) for urban and rural area by parental education and household income.

Footnote: Estimates and 95% confidence intervals (CIs) are presented as well as the level of significance, adjusted by age, gender, ethnic, region and parent-reported child general health. All models are weighted. $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

Table 1 Summary of the characteristics of the study participants.

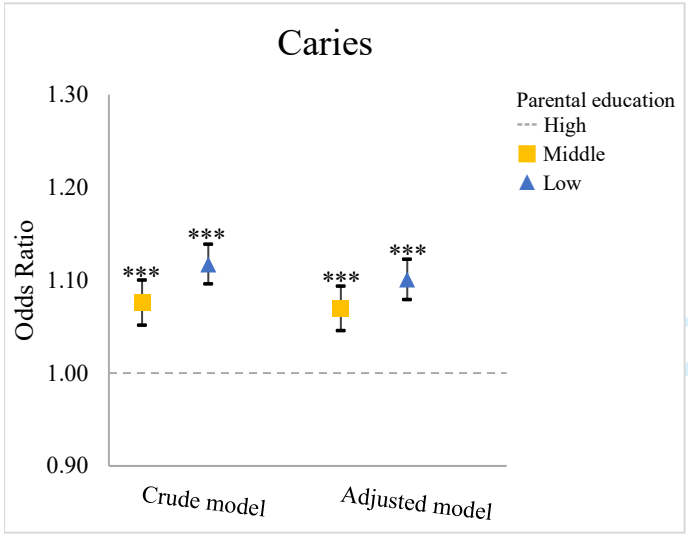
Category	n (%)	caries	*P* value*	pain	*P* value*	dmft	*P* value*
		n (%)		n (%)		(mean±SD)	
Gender			<0.001		<0.001		<0.001
Male	20245(50.2)	12598(62.7)		5078(26.2)		3.39±0.03	
Female	20115(49.8)	12545(62.4)		5340(27.7)		3.31±0.03	
Age (years)			<0.001		<0.001		<0.001
3	12390(30.7)	6292(50.8)		2024(17.1)		2.28±0.03	
4	13978(34.6)	8895(63.6)		3420(25.5)		3.40±0.04	
5	13992(34.7)	10056(71.9)		4974(37.0)		4.24±0.04	
Ethnic			<0.001		<0.001		<0.001
Han	36087(89.4)	22401(62.1)		9231(26.7)		3.32±0.02	
Other ethnics	4273(10.6)	2842(66.5)		1187(28.9)		3.63±0.06	
Place of residence			<0.001		<0.001		<0.001
Urban	20490(50.8)	12449(60.8)		5166(26.2)		3.14±0.03	
Rural	19870(49.2)	12794(64.4)		5252(27.7)		3.57±0.03	
Region			<0.001		<0.001		<0.001
East	14127(35.0)	9385(66.4)		3872(28.5)		3.83±0.04	
Middle	10403(25.8)	6216(59.8)		2654(27.0)		3.09±0.04	
West	15830(39.2)	9642(60.90		3892(25.5)		3.09±0.03	
Parents-reported child general health			<0.001		<0.001		<0.001
Good or better	28885(71.6)	17860(61.8)		6954(25.0)		3.25±0.02	
Fair or less	11475(28.4)	7383(64.3)		3464(32.0)		3.60±0.04	
Parental education			<0.001		0.137		<0.001
High	12615(36.1*)	7326(58.1*)		3208(26.3*)		2.90±0.04*	

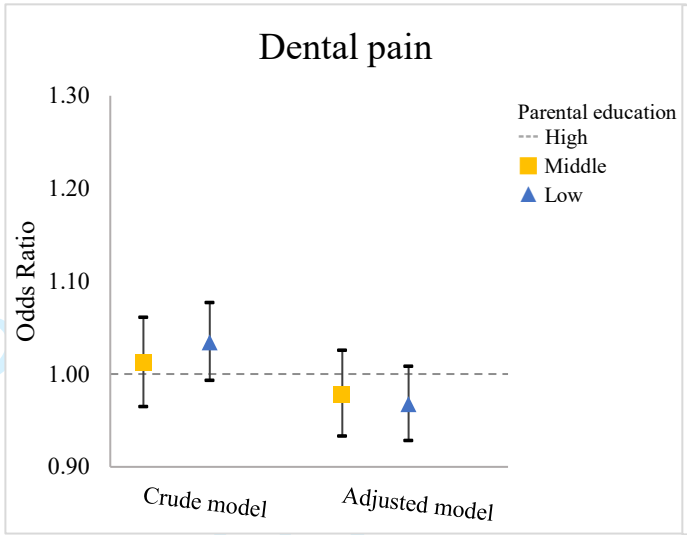
Middle	9457(23.2*)	5914(62.5*)	2445(26.9*)	3.34±0.04*	
Low	18278(40.7*)	11998(65.6*)	4762(27.4*)	3.66±0.03*	
Household income		<0.001	0.011		<0.001
Highest	4431(17.7*)	1942(59.2*)	753(25.2*)	3.01±0.06*	
High	4319(21.7*)	3037(62.1*)	1233(27.1*)	3.37±0.05*	
Middle	5509(20.9*)	3256(61.6*)	1326(27.0*)	3.27±0.05*	
Low	4972(26.2*)	4638(63.9*)	1812(27.1*)	3.48±0.04*	
Lowest	6619(13.6*)	2825(65.1*)	1131(28.2*)	3.53±0.06*	

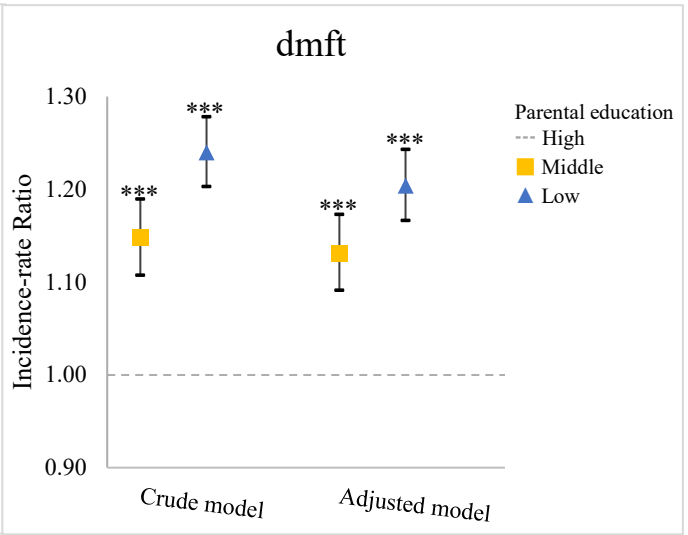
*Proportions and *P*-values are presented after multiple imputation for parental education and household income.

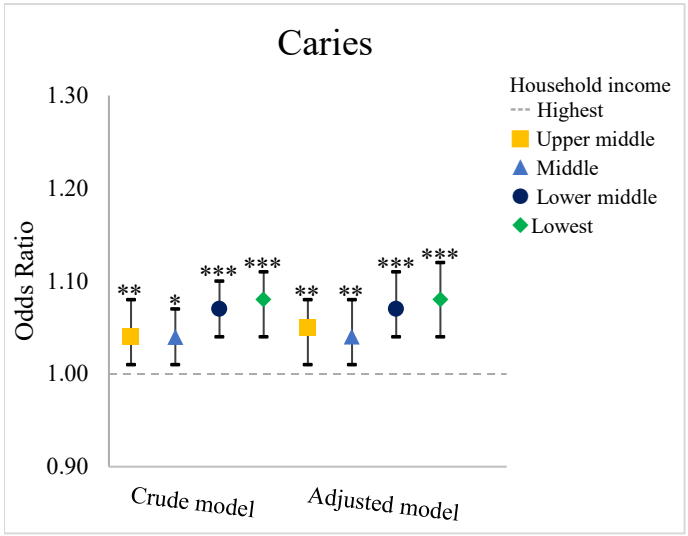
Table 2. Basic characteristics of dental caries indicators in the study participants.

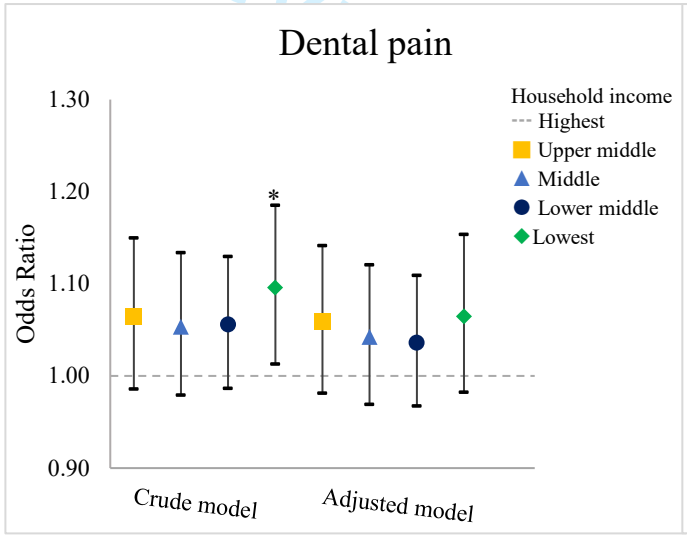
Category	**Overall**	
	n	**%**
Caries	25243	62.5
Dental pain	10418	26.9
dmft(Mean±SD)	3.35±0.02	











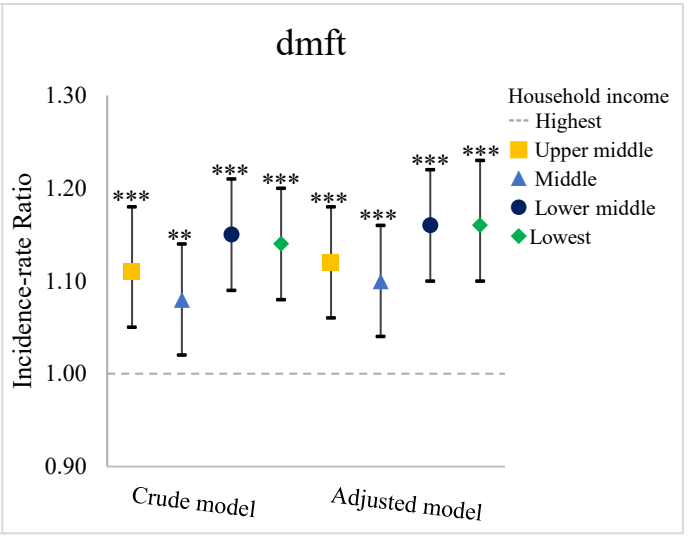


Figure 1. Odds ratio (OR), Incidence rate ratio (IRR) stratified by parental education and household income. Odds ratio (OR), Incidence rate ratio (IRR) and 95% confidence intervals (CIs) by parental education and household income are presented as well as the level of significance. Crude model: each SES measure (parental education and household income) and outcomes (dental caries, dental pain and dmft). Adjusted model: adjusted for age, gender, ethnic, place of residence, region and parent-reported child general health. All models are weighted. $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

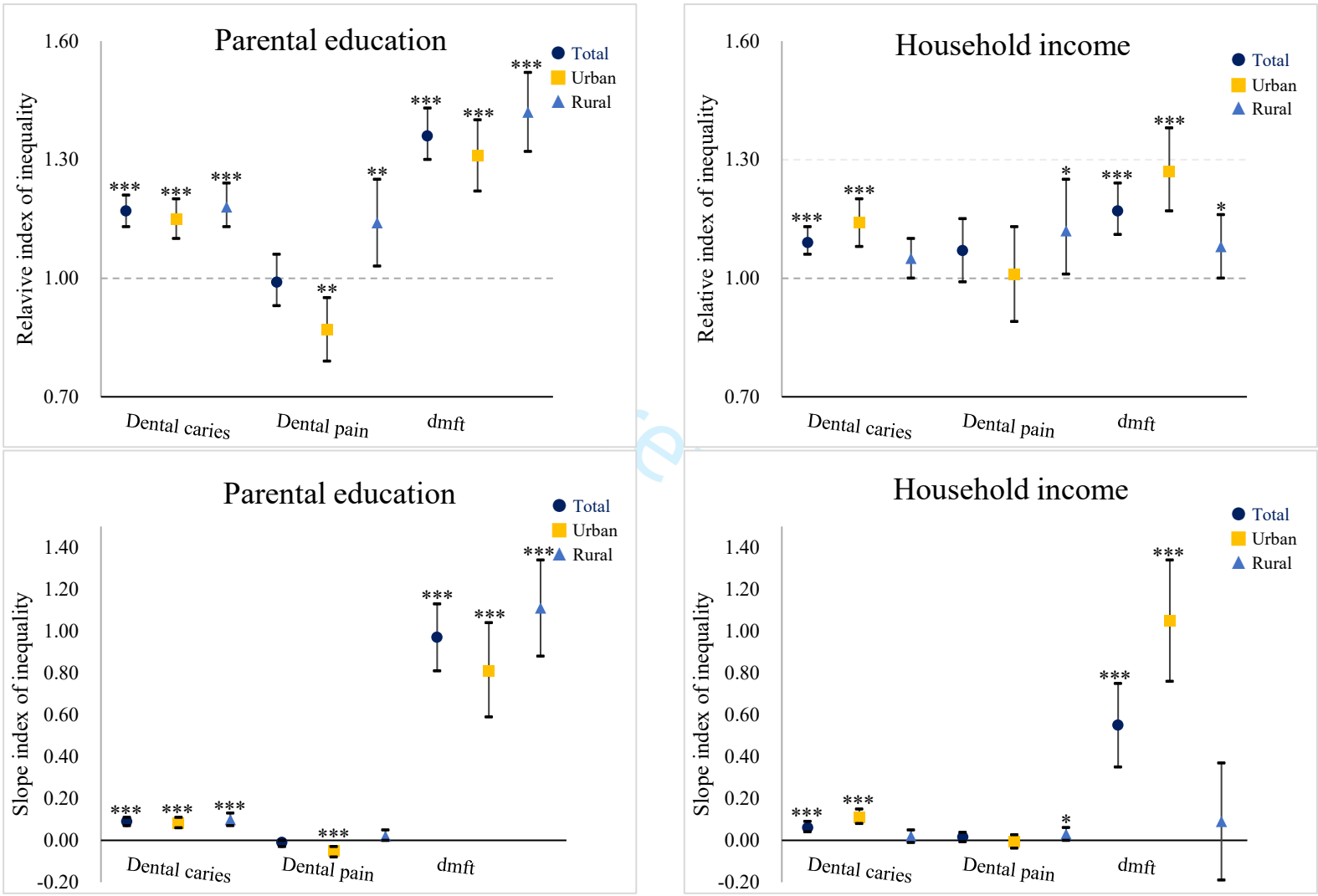


Figure 2. Relative index of inequality (RII) and slope index of inequality (SII) for urban and rural area by parental education and household income. Estimates and 95% confidence intervals (CIs) are presented as well as the level of significance, adjusted by age, gender, ethnic, region and parent-reported child general health. All models are weighted. $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-5
Bias	9	Describe any efforts to address potential sources of bias	4-5
Study size	10	Explain how the study size was arrived at	4-5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	5-6
		(*e*) Describe any sensitivity analyses	5
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	No
		(c) Consider use of a flow diagram	No
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-7
		(b) Indicate number of participants with missing data for each variable of interest	No
Outcome data	15*	Report numbers of outcome events or summary measures	6-7
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7

		(*b*) Report category boundaries when continuous variables were categorized	7
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	7
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	No
Discussion			
Key results	18	Summarise key results with reference to study objectives	8-9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9-10
Generalisability	21	Discuss the generalisability (external validity) of the study results	9-10
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	10

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.