Received: 13 November 2020 | Revised: 20 May 2021 | Accepted: 8 July 2021
DOI: 10.1111/cdoe.12682

ORIGINAL ARTICLE

Community Dentistry and Oral Epidemiology WILEY

Ten-year changes in children's oral health disparities: Findings from the 3rd and 4th oral health surveys in Beijing, China

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Abstract

Objectives: Little is known about children's oral health disparities and their changes in developing countries. This study aimed to measure rural-urban and maternal education-related disparities in dental visits and untreated caries among Chinese children, and to describe their changes between 2005 and 2015.

Methods: The 12-year-old children's oral health data were from the 3rd (2005) and 4th (2015) oral health surveys in Beijing, China. Rural-urban disparities and maternal education-related disparities in dental visits and untreated caries were measured. The slope index of inequality (SII) and a relative index of inequality (RII) were applied to reflect the absolute and relative disparities respectively. These were estimated using a generalized linear regression model.

Results: Data were analysed from 388 children in 2005 and 1926 children in 2015. The proportion of 12-year-old schoolchildren who visited the dentist was 24.0% in 2005 and 36.0% in 2015. Untreated caries prevalence in 2005 and 2015 was 20.9% and 16.2% respectively. Rural-urban disparities in dental visits narrowed between 2005 and 2015 (SII: −10.75 to −3.30, RII: 0.55 to 0.87), and maternal education-related disparities in dental visits also decreased during this decade (SII: −18.52 to −8.49, RII: 0.38 to 0.65). These changes were statistically significant. For disparities in untreated caries, only maternal education-related disparities in untreated caries in 2015 were found. The SII and RII were 6.39% (95% CI: 1.65, 11.13) and 1.57 (95% CI: 1.13, 2.20) respectively. The change in disparities in untreated caries was not statistically significant for rural-urban disparities ($P = .319$) or maternal education-related disparities ($P = .501$).

Conclusions: These findings indicate that in Beijing, China, disparities in children's dental visits narrowed between 2005 and 2015. However, maternal education-related disparities in dental visits and in untreated caries were still apparent, suggesting that policies to improve children's oral healthcare utilization equality should target the children with less-educated mothers.

KEYWORDS
dental visit, oral health inequalities, social determinants of health, untreated caries

1 | INTRODUCTION

Dental caries is the most common oral disease among children; untreated caries affects more than 560 million children (60%-90% of schoolchildren) worldwide.[1] The burden of dental caries on a child can be significant,[2] leading to pain and negative effects on eating, weight gain, growth, sleeping and quality of life. Children with dental pain might experience more time off school, decreased ability to learn and, consequently, a negative impact on school performance. Good oral health is not only a part of children's general health but also a key indicator of school readiness.

Oral health disparities have been reported among children, and untreated caries has been reported to be more widespread among disadvantaged socioeconomic backgrounds.[3] Children from low-income families or less-educated mothers have high rates of untreated caries.[4,5] Rural children reportedly have more untreated decay than their urban counterparts.[6,7] However, these findings are mainly from developed countries, and little is known about the situation in developing countries.

Socioeconomic disparities in dental visits also have been noted, with children of higher socioeconomic status being more likely to have a dental visit.[8,9] Greater use of dental visits is associated with lower disparities in untreated caries.[10] Recent studies showed that the gap in dental visits among American children has narrowed in the past 3 decades,[11] and disparities among young children also have declined.[12] It remains unknown whether such trends have occurred in developing countries.

Evidence from developed countries may not have policy relevance for developing countries. With the ongoing progress of globalization and urbanization, children in developing countries are exposed to a high-sugar-intake environment than before[13,14] and suffer a greater risk of dental caries.[15] Furthermore, dental care coverage in developing counties is lower than that in developed countries.[16] Oral health disparities are more likely when the publicly provided services coverage is low.[17] In an environment with high caries susceptibility and inadequate oral health service coverage, a greater understanding of children's oral health disparities and their changes in developing countries is needed.

China is the world's largest developing country and has experienced rapid economic development in recent years. Chinese children have been exposed to a cariogenic environment, and their sweetened beverage consumption has increased.[18] Describing Chinese children's oral health disparities and their changes in Beijing is of interest both to other cities in China and other developing nations. Using data from the 3rd and 4th oral health surveys from Beijing, this study aimed to measure disparities in children's dental visits and untreated caries, and to assess changes between 2005 and 2015.

2 | METHODS

2.1 | Data source

This study was a secondary analysis of data derived from the 3rd and 4th oral health surveys in Beijing, China, conducted in the years 2005 and 2015 respectively. As the World Health Organization (WHO) has suggested monitoring the oral health of 12-year-olds,[19] only the data of this age group were extracted from the 2005 and 2015 surveys. Both surveys used the multistage cluster sampling method,[20] and sampling size and methods are provided in Table A1. The unweighted data were used for analysis. The data were collected using clinical dental examinations and questionnaire surveys per the oral health survey methods recommended by the WHO. The children answered the questionnaire.

Children with both questionnaire and oral examination data were included, while those who failed to report their parents' education level were excluded from this study. As 59.5% of parents have the same level of education in our dataset, the father's education level was used to complete the mother's education level when the maternal education data were missing. In total, data of 388 children from the 2005 survey and 1926 children from the 2015 survey were analysed. The inclusion/exclusion eligibility criteria for participants and missing data treatment process are provided in Figure A1.

2.2 | Ethics approval and consent to participate

The study protocol was approved by the Ethics Committee of the Chinese Stomatological Association (Approval no. 2014-003). All children consented to participate, and their parents or guardians signed a term of consent.

2.3 | Outcomes

The proportion of children having dental visits in the past 12 months and that of children with untreated caries were dependent variables in this study.[4] Untreated caries was defined as having at least one primary or permanent tooth with untreated decay.

2.4 | Exposures

Rural-urban and maternal education-related disparities were examined. Rural-urban status was distinguished by the child's household registration type. As maternal education is a key factor in family socioeconomic status and highly related to children's oral health,[21] maternal education-related disparities were analysed in this study. Maternal education was categorized into 3 levels of junior middle school and below, high school and college and above. The relative measure was used to address the significant change in the distribution of maternal education during the 10-year period. The maternal education variable used in the analyses was a ridit score, reflecting the average cumulative frequency of the educational category.[22] Gender, nationality (Han or minority) and family size (single or nonsingle children) were the potential confounders considered in this study.

2.5 | Measures of oral health disparities

The absolute and relative viewpoints were used to describe the oral health disparities in dental visits and untreated caries. The slope index of inequality (SII) and the relative index of inequality (RII) were used to reflect the absolute and relative health disparities respectively.[23] The SII can be interpreted as the prevalence difference and the RII as the prevalence ratio between those at the hypothetical bottom (or rural group) vs the top of the education hierarchy (or urban group). SII < 0 or RII < 1 indicates a higher prevalence in the urban or higher education groups; conversely, SII > 0 or RII > 1 indicates a higher prevalence in the rural or lower education groups. SII = 0 or RII = 1 indicates no disparity.

2.6 | Statistical analysis

A generalized linear model (GLM) was used to describe the prevalence of overall dental visits and untreated caries, adjusting for demographic characteristics, including gender, rural-urban status, nationality and maternal education. Both the unadjusted and adjusted results were reported. To assess the absolute and relative disparities, the SII and RII were estimated via GLM with a binomial distribution, with an identity link for the SII and a log-link function for RII.[22] Interaction items were included in the model to test whether changes in disparities in different survey years were statistically significant, namely rural-urban status × survey year and maternal education × survey year. To calculate absolute (percentage points) changes in dental visits and untreated caries for rural/urban and each maternal education group, a GLM with an identity link function was applied. Absolute changes were estimated as the coefficient on the relevant survey-year level by varying the reference level (eg the changes from 2005 to 2015 were provided by comparing the coefficients for 2005 and 2015). Data analyses were performed using SPSS 24.0.

3 | RESULTS

3.1 | Demographic characteristics of participants

As parental education was not reported by 6 children in the 2005 survey and 232 children in the 2015 survey, the data of these children were excluded from this study. There were no statistical differences between included and excluded participants in demographic characteristics and oral-related variables, except for the rural-urban status (Table A2). There were 2 cases of missing maternal education data (0.5%) in 2005 and 58 (3.0%) in 2015, all of which were imputed as the father's education level. Sensitivity analysis showed that the results of the current study were unchanged before and after data imputation (Table A3). Overall, data of 388 schoolchildren from the 2005 survey and 1926 schoolchildren from the 2015 survey were included in the analysis.

TABLE 1 Demographic characteristics of the participants in 2005 and 2015 survey

	2005 (N = 388)		2015 (N = 1926)	
Variables	**n**	**%**	**n**	**%**
Gender				
Male	193	49.7%	963	50.0%
Female	195	50.3%	963	50.0%
Rural-urban status				
Rural	171	44.1%	468	24.3%
Urban	217	55.9%	1458	75.7%
Single children				
Yes	262	67.5%	1404	72.9%
No	126	32.5%	522	27.1%
Nationality				
Han	361	93.0%	1788	92.8%
Minority	27	7.0%	138	7.2%
Maternal education				
Junior middle school and below	194	50.0%	499	25.9%
High school	100	25.8%	561	29.1%
College and above	94	24.2%	866	45.0%

Table 1 reports the demographic characteristics of schoolchildren by survey year. The ratio of male to female was close to 1:1 in both surveys. The proportions of rural children in the 2005 and 2015 surveys were 44.1% and 24.3% respectively. In 2005, half of the mothers have obtained a high school degree or above, and this rate rose to three-quarters by 2015.

3.2 | Disparities in dental visits

Table 2 presents the prevalence of dental visits and untreated caries by region and maternal education by survey year. After adjusting for demographic variables, overall dental visit prevalence increased from almost one-fifth in 2005 to just over one-third in 2015; this change was statistically significant. The absolute and relative rural-urban disparities in dental visits in 2005 were −10.75 (−20.91, −0.59) for SII and 0.55 (0.31, 0.98) for RII, while values of SII and RII were not statistically significantly different from 0 or 1 in 2015, indicating

TABLE 2 Dental visit, untreated caries and absolute and relative inequalities in 12-y-old children by household registration types and by maternal educations, 2005 and 2015, Beijing, China

	Dentist visit		Untreated caries	
	2005	2015	2005	2015
Total[a]				
Unadjusted	23.97 (19.98, 28.47)	36.03 (33.92, 38.20)	20.88 (17.12, 25.21)	16.15 (14.57, 17.86)
Adjusted	23.76 (19.08, 29.17)	34.87 (30.74, 39.26)	20.48 (15.78, 26.12)	16.69 (13.59, 20.35)
Overall change	$P < .001$		$P = .096$	
Rural-urban status[b]				
Rural	18.59 (11.29, 29.07)	33.27 (27.67, 39.40)	27.85 (17.95, 40.55)	17.84 (13.43, 23.31)
Urban	29.34 (20.08, 40.68)	36.57 (32.06, 41.33)	19.20 (12.01, 29.27)	14.19 (11.15, 17.89)
SII[d]	−10.75 (−20.91, −0.59)*	−3.30 (−8.89, 2.29)	8.65 (−1.67, 18.97)	3.65 (−0.49, 7.85)
RII[d]	0.55 (0.31, 0.98)*	0.87 (0.68, 1.11)	1.62 (0.93, 2.85)	1.31 (0.98, 1.77)
P-value for disparities' change	$P = .017$		$P = .319$	
Maternal educations[c]				
Junior middle school and below	17.48 (10.83, 26.99)	28.83 (23.95, 34.26)	26.03 (16.85, 37.94)	20.25 (15.69, 25.72)
High school	26.69 (16.64, 39.89)	35.87 (30.40, 41.74)	23.50 (13.87, 36.94)	15.55 (11.67, 20.42)
College and above	36.00 (22.99, 51.46)	38.32 (32.79, 44.17)	17.44 (8.87, 31.42)	13.85 (10.36, 18.29)
SII[d]	−18.52 (−32.16, −4.87)**	−8.49 (−15.46, −3.53)**	8.59 (−3.78, 20.97)	6.39 (1.65, 11.13) **
RII[d]	0.38 (0.20, 0.73)**	0.65 (0.50, 0.85)**	1.66 (0.77, 3.62)	1.57 (1.13, 2.20) **
P-value for disparities' change	$P = .012$		$P = .501$	

*$P < .05$; **$P < .01$; ***$P < .0001$.

[a]Total population data were adjusted for gender, nationality, household registration types and maternal educations.

[b]Data were adjusted for gender, nationality and maternal educations.

[c]Date were adjusted for gender, nationality and household registration types.

[d]SII = Slope index of inequality; RII = Relative index of inequality.

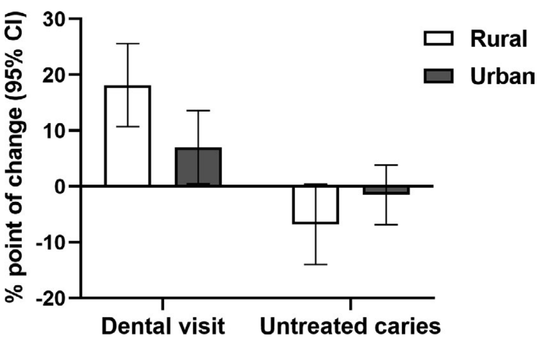


FIGURE 1 Absolute change in dental visit prevalence and in untreated caries prevalence by rural-urban status between 2005 and 2015, Beijing, China

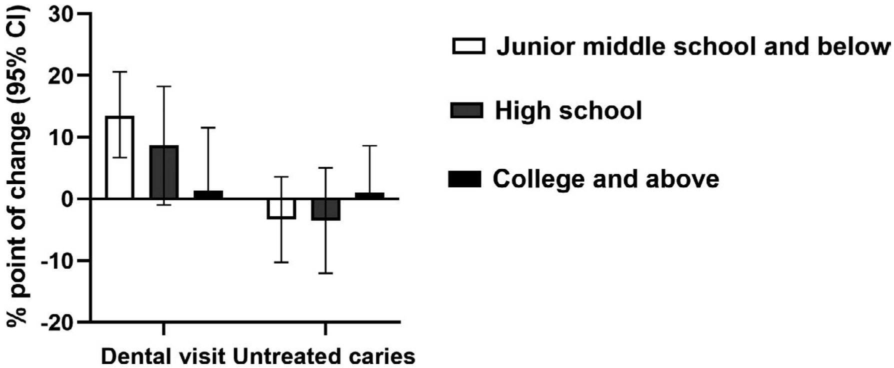
that there were rural-urban disparities in dental visits in 2005 but not in 2015. The disparity changes between 2005 and 2015 were statistically significant ($P = .017$), indicating that rural-urban disparities in dental visits narrowed during this period (Table 2). Figure 1 shows that the greater absolute change in dental visits was found in rural children. This supports the observation that rural-urban disparities in dental visits narrowed in this decade.

Absolute and relative maternal education-related disparities in dental visits were apparent in 2005 and 2015 (Table 2); however, these values have decreased significantly during this period (SII: −18.52 to −8.49, RII: 0.38 to 0.65; $P = .012$). Compared to children with high-educated mothers (high school and above), children with less-educated mothers (junior middle school and below) experienced a greater change in dental visits (Figure 2), supporting the disparities in dental visits decreased.

3.3 | Disparities in untreated caries

After adjusting for demographical variables, overall untreated caries experience decreased from just over one-fifth in 2005 to approximately 1 in 6 in 2015. However, this change was not statistically significant ($P = .096$). The absolute and relative rural-urban disparities in untreated caries were not statistically significant, regardless of the survey year. The changes in rural-urban disparities ($P = .319$) and maternal education-related disparities ($P = .501$) in untreated caries were not statistically significant. However, 95% CI of SII and RII for untreated caries in 2015 did not include 0 or 1, indicating

FIGURE 2 Absolute change in dental visit prevalence and in untreated caries prevalence by maternal educations between 2005 and 2015, Beijing, China



that the maternal education-related disparities in untreated caries existed in 2015.

4 | DISCUSSION

This study highlights children's oral health disparities and their changes in recent years in Beijing, China. Evidence from this study has implications for other metropolises in China and other developing countries. The findings showed that disparities in dental visits narrowed between 2005 and 2015, but the disparities in untreated caries did not change. Both the maternal education-related disparities in dental visits and untreated caries persisted in 2015.

Children's dental visits are related to both the accessibility of oral healthcare service and the family socioeconomic status.[24] In this study, we captured these 2 factors and measured the disparities in children's dental visits from rural-urban and maternal education perspectives. The findings showed that both these disparities decreased between 2005 and 2015. This is consistent with the findings from developed countries.[10,11] The narrowing disparities in dental visits might have been related to the changes in policy, the health system and individual factors. First, this reduction may be partly due to an implemented oral health programme in Beijing, China. The Beijing government commenced an ongoing comprehensive oral health intervention programme for school children in 2005, including offering oral health education, oral health examinations and pit and fissure sealing.[25] All these oral healthcare services are free, and each school-age child has access to the services. A previous study showed that net benefits of free health services are significantly higher for the rural residents and the lower-income population,[26] particularly when the health services have high coverage.[17] Thus, the rural children and those with less-educated mothers likely benefited from the free oral health programmes, leading to reductions in disparities in dental visits. Second, steady growth in the number of dentists in China has made dental services more accessible,[27] partially contributing to the reduced rural-urban disparities. Third, improved maternal education and maternal health literacy also likely played important roles in this reduction. Previous findings showed that a mother's poor oral health literacy is associated with low utilization of children's oral healthcare services.[28,29] A lack of oral health literacy is a major reason for parents' noncooperation with the dental sealant service for Chinese children.[30] Improved health literacy regarding basic medical care may encourage Chinese mothers to take more initiative in terms of oral healthcare.[31]

However, the narrowing disparities in dental visits were not associated with a reduction in disparities in untreated caries, which is inconsistent with the findings from a developed country.[10] The difference in caries trends between developed and developing countries can partially explain this inconsistent finding. Caries has been prevalent among disadvantaged children in the past several decades, but the prevalence pattern has changed in developing countries. A previous study showed that caries in developing countries was more prevalent in urban settings.[32] However, due to globalization and urbanization, caries has become more prevalent among rural children in recent years. Globalization has a considerably strong influence on the increase in the rate of sugar consumption in low- and middle-income countries,[14] changing the pattern of sugar consumption and caries between rural and urban children. Evidence from Chinese children also supports the existence of a change in sugar-sweetened beverage consumption and a change in the pattern of caries among rural and urban children. A survey conducted in 2012 among Chinese children showed that rural children consumed triple the amount of sugar-sweetened beverages as those from urban areas.[33] Based on data from 4 National Oral Health Surveys, the proportion of Chinese rural and urban children with caries were as follows: 31.3% vs 45.9% (1983 survey), 40.8% vs 48.8% (1995 survey), 28.6% vs 29.3% (2005 survey) and 44.8% vs 37.0% (2015 survey),[34,35] indicating an inversion in rural-urban disparities in caries. The narrowing of rural-urban disparities in dental visits might be offset by the increasing rural-urban disparities in caries, resulting in no change in the rural-urban disparities in untreated caries. Furthermore, the estimation results in 2005 might not be significantly robust due to its limited sample size. Thus, there is a possibility that extant disparities in untreated caries were not detected due to sample size limitations.

Moreover, both maternal education-related disparities in dental visits and untreated caries were apparent in the 2015 survey, indicating that maternal education is a key social determinant of children's health. Educated mothers often have greater decision-making powers in the household, and their children have better health outcomes than less-educated mothers.[36] Regarding children's oral health, less-educated mothers tend to have low oral health literacy, which interferes with children's oral hygiene behaviours and oral healthcare utilization, affecting children's oral health.[37] The existing maternal education-related disparities in dental visits and untreated caries suggest that attempts to improve children's oral healthcare utilization equality should target children with less-educated mothers.

This study has several limitations. First, the findings represent the overall impact of all measures on children's oral health and social development between 2005 and 2015. We could not isolate and analyse independent effects of each factor, but we controlled for the effects of other factors when measuring rural-urban disparities or maternal education-related disparities. Second, although caries is commonly used when evaluating children's oral health status, untreated caries was selected as the main variable in this study. Untreated caries is a major component of caries related to dental visits and helps interpret children's oral health inequalities from the perspective of dental healthcare utilization and oral health outcomes. Third, the assessment of dental visits was through self-reported data, which have been subject to recall bias. Fourth, the sample size of the 2005 survey was sufficient for dental visit estimation with a deviation of 5% and a level of significance at 0.05 but insufficient for estimating untreated caries. Thus, future studies are encouraged to replicate the results regarding disparities in untreated caries using larger population data.

To the best of our knowledge, this is the first study to reveal the disparities in children's oral health and disparity changes between 2005 and 2015 in a metropolis of a developing country. Our findings have important policy implications for first-tier cities in China and other developing countries undergoing rapid economic development. When applying the current findings to other regions, local oral health policies and socioeconomic status should be considered. Moreover, maternal education-related disparities in dental visits, as well as untreated caries, suggest that further action to achieve oral health equality should focus on children with less-educated mothers.

ACKNOWLEDGEMENTS

Authors thank Dr Ying ji for contributing to the data analysis.

CONFLICT OF INTEREST

The authors declare no conflict of interests.

AUTHOR CONTRIBUTIONS

Qingping Yun was a major contributor in conception, analysis of the data and drafting the manuscript. Min Liu did contributions to the design of this study and revised the article. Mei Zhao, Wei Chen, Hui Zhang and Hou Wei were responsible for acquisition of data and review of the article. Chun Chang contributed to the conception and revision of the manuscript. All authors gave their final approval and agreed to be accountable for all aspects of the work.

DATA AVAILABILITY STATEMENT

The datasets are available from the corresponding author upon reasonable request.

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How to cite this article: Yun Q, Liu M, Zhao M, et al. Ten-year changes in children's oral health disparities: Findings from the 3rd and 4th oral health surveys in Beijing, China. *Community Dent Oral Epidemiol*. 2021;49:513–521. https://doi.org/10.1111/cdoe.12682

APPENDIX 1

TABLE A1 Sampling size and sampling methods for 12-year-old children in the year of 2005 and 2015 survey in Beijing

	2005	2015
Sampling size calculation index (sampling size)		
	Caries prevalence of whole population (792)	Caries prevalence of 12-year-old group (1869)
Sampling methods		
Stage I	Six districts were sampled from 18 districts using digital random table.	
Stage II	In the selected district, 6 committees were sampled by using random digital table. The school belonging to the selected committee was sampled.	In each selected district, the information including school list and school scale were collected. Using the probability proportional to size sampling method according to the school data, 3 schools were sampled.
Stage III	In the selected school, the student information including gender and age were collected. Using gender-stratified random sampling, 11 male and 11 female school children aged 12 were sampled.	In each selected school, the student information including gender and age were collected. Recruitment started from the first class in 7th grade, and 60 male and 60 female school children aged 12 were enrolled.
Stage IV	Totally, 792 children were enrolled and have clinical dental examination. But 50% of them (394 children) were randomly selected to finish questionnaire survey.	Totally, 2160 children were enrolled. All of them have both clinical dental examination and questionnaire survey. Two students failed to finish the questionnaire and were excluded from data analysis.

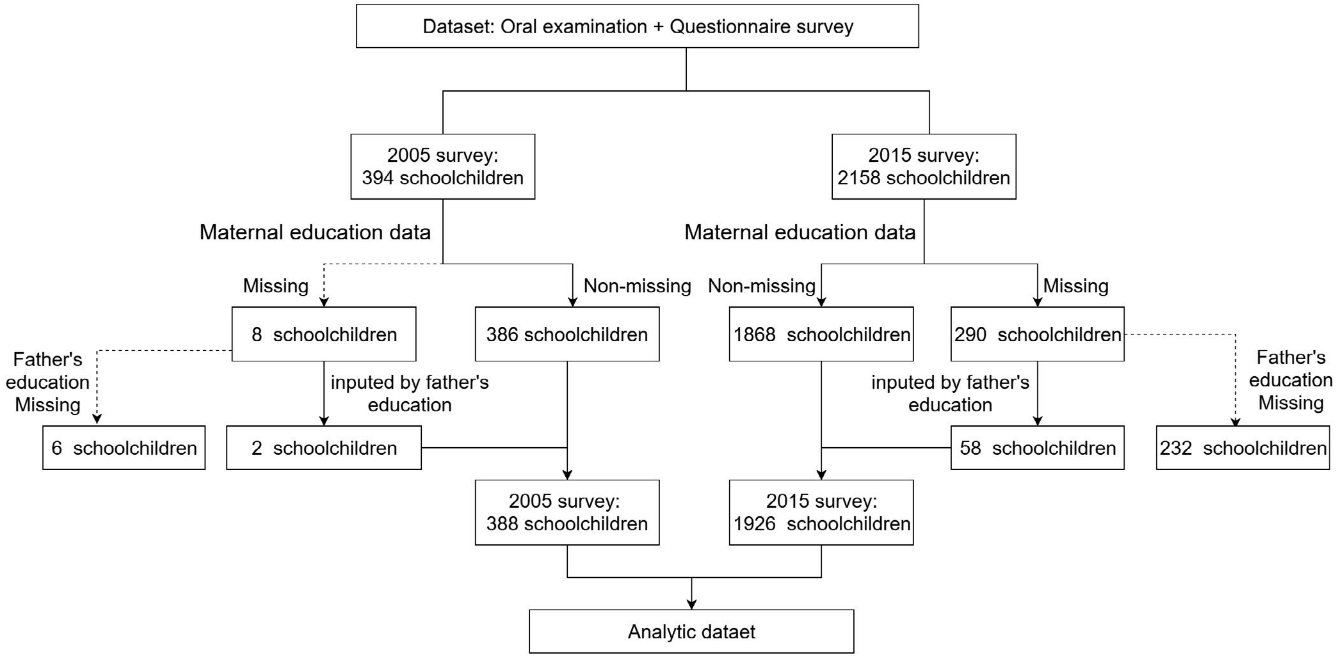

FIGURE A1 Inclusion and exclusion criteria for participants

TABLE A2 Demographic characteristic, dental visit and untreated caries of the included and excluded data

	Included data (n = 2314)	Excluded data (n = 238)	*P* value
Gender			
Male	1156 (50.0%)	120 (50.4%)	.892
Female	1158 (50.0%)	118 (49.6%)	
Single children			
Yes	1666 (72.0%)	176 (73.9%)	.522
No	648 (28.0%)	62 (26.1%)	
Urban-rural status			
Urban	1675 (72.4%)	189 (79.4%)	.020
Rural	639 (27.6%)	49 (20.6%)	
Nationality			
Han	2149 (92.9%)	222 (93.3%)	.815
Minority	165 (7.1%)	16 (6.7%)	
Dental visit			
No	1527 (66.0%)	169 (71.0%)	.118
Yes	787 (34.0%)	69 (29.0%)	
Untreated caries			
Absent	1922 (83.1%)	198 (83.2%)	.958
Present	392 (16.9%)	40 (16.8%)	

TABLE A3 Dental visit, untreated caries and absolute and relative inequalities in 12-year-old children by rural-urban status and by maternal educations, 2005 and 2015, Beijing, China

	Dentist visit		Untreated caries	
	2005	2015	2005	2015
Total[a]				
Unadjusted	24.09 (20.09, 28.61)	36.19 (34.04, 38.39)	20.98 (17.21, 25.33)	16.27 (14.67, 18.02)
Adjusted	23.76 (19.06, 29.19)	34.68 (30.51, 39.09)	20.68 (15.95, 26.38)	16.94 (13.79, 20.65)
	$P < .001$		$P = .103$	
Rural-urban status[b]				
Rural	18.76 (11.39, 29.31)	32.42 (26.82, 38.56)	28.16 (18.14, 40.93)	18.20 (13.70, 23.77)
Urban	29.44 (20.17, 40.78)	36.88 (32.31, 41.70)	19.23 (12.03, 29.30)	14.34 (11.26, 18.09)
SII[d]	−10.68 (−20.87, −0.49)*	−4.46 (−10.10, 1.18)	8.92 (−1.45, 19.30)	3.86 (−0.45, 8.17)
RII[d]	0.55 (0.31, 0.98) *	0.82 (0.64, 1.06)	1.65 (0.94, 2.89)	1.33 (0.98, 1.80)
P-value for disparities' change	$P = .031$		$P = .292$	
Maternal educations[c]				
Junior middle school and below	17.60 (10.90, 27.14)	28.92 (23.97, 34.42)	26.28 (17.02, 38.25)	20.30 (15.70, 25.83)
High school	26.76 (16.70, 39.97)	35.85 (30.29, 41.80)	23.58 (13.92, 37.04)	15.61 (11.67, 20.56)
College and above	36.12 (23.08, 51.58)	37.61 (32.07, 43.51)	17.56 (8.94, 31.61)	14.27 (10.68, 18.83)
SII[d]	−18.52 (−32.18, −4.86)**	−8.69 (−14.74, −2.65)**	8.72 (−3.72, 21.51)	6.02 (1.17, 10.88)*
RII[d]	0.38 (0.20, 0.73)**	0.68 (0.51, 0.89)**	1.67 (0.77, 3.63)	1.53 (1.09, 2.15)*
P-value for disparities' change	$P = .014$		$P = .423$	

*$P < .05$; ** $P < .01$.

[a]Total population data were adjusted for gender, nationality, household registration types and maternal educations.

[b]Data were adjusted for gender, nationality and maternal educations.

[c]Date were adjusted for gender, nationality and household registration types.

[d]SII = Slope index of inequality; RII = Relative index of inequality.