Community Dental Health (2015) **32,** 185–189
Received 12 October 2014; Accepted 8 February 2015

doi:10.1922/CDH_3524Guan05

Socioeconomic inequalities in dental caries among 5-year-olds in four Chinese provinces

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Objective: To explore socioeconomic inequalities in dental caries among 5-year-olds in four Chinese provinces. ***Methods:*** This study used data from 1,732 children living in Guangxi, Hubei, Jilin and Shanxi who participated in the Third National Oral Health Survey in 2005. Questionnaires were completed by parents to collect information on family socioeconomic position (parental education and household income) and children's dental behaviours (toothbrushing frequency, sugar intake frequency and last dental visit). Children were clinically examined for dental caries, which was reported using the dmft index. Socioeconomic inequalities in children's caries experience were assessed in negative binomial regression models. ***Results:*** There were significant gradients in children's dmft by household income. Children's dmft increased from 2.63 in the highest income group to 4.70 in the lowest income group. However, parental education was not significantly related to childhood dental caries. ***Conclusion:*** Clear social gradients in caries experience of deciduous teeth were found by household income but not parental education.

Key words: *socioeconomic, inequality, dental caries, children, China*

Introduction

Oral diseases are socially patterned as indicated by how their prevalence and severity increase with every step down the social ladder (Marmot and Bell, 2011). Social inequalities are found regardless of the measure of socioeconomic position (SEP) used (Solar and Irwin, 2010); with parental education and income identified as important social determinants of childhood oral health inequalities (Fisher-Owens *et al*., 2007; Harris *et al.*, 2004; Kim Seow, 2012; Reisine and Psoter, 2001). However, most research on social inequalities in children's oral health comes from Western countries. The demonstration of the pervasive social inequalities in oral health within and between countries invites acceptance of the need for universal actions to address them (Petersen, 2009; Sheiham *et al.*, 2011).

Enormous changes are underway in China with both a growing economy and rapid urbanisation (Hu *et al.*, 2011). These social changes have brought a considerable number of impacts on people's lifestyles and as a result non-communicable diseases have become major health problems (Yang *et al.*, 2013). The rapid increase of health care needs challenges China's health care system, and a reform was introduced in 2009 (Hu *et al.*, 2011; Yang *et al.*, 2013). Clarifying social inequalities in health could provide evidence for policy making. Moreover, China adheres to a national ideology and political structure, which may play an important role in shaping the social determinants of health. All these factors make China a unique case study in terms of exploring socioeconomic inequalities in oral health.

The dmft in Chinese 5-year-olds decreased from 4.48 to 3.5 between 1995 and 2005, while the prevalence of dental caries decreased from 76.5% to 66.0% over the same period (Hu *et al.*, 2011). Furthermore, decayed teeth was the main contributor to caries experience in these children, representing 96.7% of the dmft score (Qi, 2008; Wang *et al.*, 2002). Few previous studies have explored social inequalities in oral health in Chinese preschool children, and those with conflicting results (Chu *et al.*, 1999; Gao *et al.*, 2011; Li *et al.*, 2011). Chu *et al.* (1999) showed that household income, but not parental education was negatively related to children's dental caries experience in 658 Hong Kong 4-6-year-olds. On the other hand, Li *et al.* (2011) and Gao *et al.* (2011) in separate studies among 1,650 3-6-year-olds in Xiamen City (Eastern China) and 138 5-year-olds in Guangzhou City (Southern China), respectively, showed that neither parental education nor household income were significantly related to children's caries prevalence. More evidence is therefore required to improve current understanding of the social determinants of oral health in pre-school children of China. The aim of this study was to explore socioeconomic inequalities in dental caries among 5-year-old children in four Chinese provinces.

Methods

This study used data from the Third National Oral Health Survey of China carried out in 2005 (Qi, 2008). Data from 5-year-olds living in Guangxi, Hubei, Jilin and Shanxi provinces and attending kindergartens were analysed. These provinces were chosen based on data availability making the

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study sample representative of kindergarten children in the four provinces only. Slightly over half of 5-year-olds were in kindergartens by the time of the survey. Participants were selected using multistage stratified cluster sampling. For selection, every province was divided into urban and rural areas; urban areas were classified into 3 strata by population size whereas rural areas were classified by Gross Domestic Product. One city or county was randomly selected from each stratum. Hence, 3 cities from urban areas and 3 counties from rural areas were selected from each province. For the next level, three streets or townships were randomly chosen from every city or county. Then, two kindergartens were selected as research sites. From each site, 20 children and their parents were randomly selected as participants (Qi, 2008). Overall, the target sample in the four provinces was 2880 children, of which 2,286 (79%) participated in the survey.

Data for 5-year-olds were collected through questionnaires and clinical examinations in kindergartens. Questionnaires were given to parents, and the survey personnel helped them to complete the questions and checked for missing data. The questionnaire for this particular age group included 35 questions on family characteristics, parental oral health knowledge and attitudes, as well as children's demographic factors, nursing habits and health behaviours.

Family SEP was measured through parental education and reported household income. Respondents (either father or mother) were asked to provide their highest education achievement using a 9-point scale and responses regrouped as elementary, middle school, high school, and college or above. Participants were also asked to provide an estimate of their annual household income with no pre-set categories. Income data was equivalised using the Luxembourg Income Study (LIS) scale to account for family size (Buhmann *et al.*, 1988; Liberatos *et al.*, 1988). This was done dividing the total household income by the square root of the number of individuals in the family (Buhmann *et al.*, 1988). After equivalisation, household income in Chinese Yuan was categorised into five groups: 0-4,999, very low; 5,000-9,999, low; 10,000-14,999, medium; 15,000-19,999, high and 20,000+, very high. These income brackets corresponded to 0-496, 497-993, 994-1,489, 1,490-1,986 and 1,987+€ as of June 2005. Children's ethnicity was self-assigned by parents from the list of officially recognised ethnic groups in China. Responses were regrouped as Han (the main ethnic group in the country representing slightly over 90% of the entire population) and non-Han (including 55 ethnic minorities). Ethnic minority groups in China are culturally and linguistically diverse, speaking over 80 languages, of which 30 have distinct written forms (Zhang *et al.*, 2015; Zhou, 2000).

Parents also reported information on children's dental behaviour. Toothbrushing frequency was collected using a 3-point ordinal scale. Last dental visit (for any reason) was collected using a 5-point ordinal scale and responses regrouped as never, more than a year ago and within the last year. Parents also reported their children's intake frequency of five categories of sweets and snacks (biscuits, cake or sweet bread; candy or chocolate; sugared water; soft drinks; and fruit juice) on six-point ordinal scales. Each category was scored as follows: 2, twice or more a day; 1, once a day; 0.28 (≈2/7) for 2-6 times a week; 0.14 (≈1/7) for once a week; 0.03 (≈1/30) for 1-3 times per month; and 0 for less or never. The weighted scores were chosen to match the lower frequency of consumption in each category (Bernabé *et al.*, 2014). A total score, ranging from 0 to 10, was generated by aggregating scores for the five categories. Based on this score, subjects were grouped into three bands: less than once a day, 1 to 4 times a day, and more than 4 times a day (WHO, 2003).

Clinical examinations were carried out under artificial light using plane mouth mirrors and a standard WHO/CPI probe. Dental caries was diagnosed according to the WHO (1997) criteria. To ensure the reliability and validity of the data collection, a pilot survey was conducted in Wuhan city, Hubei province. Unified trainings and calibrations were provided to survey examiners. For reliability assessment, 5% of the children were re-examined to calculate inter-examiner reliability using Kappa statistics. The overall Kappa score for the full survey was 0.94 among 5-year-olds. By provinces, Kappa scores varied between 0.89 and 0.91 in Shanxi, 0.80 and 1.00 in Jilin, 0.90 and 1.00 in Hubei, and 0.79 to 0.90 in Guangxi (Qi, 2008). The sum of decayed, missing and filled primary teeth (dmft index) was the outcome measure for this study.

The composition of the sample is first presented in terms of demographic (gender and ethnicity), socioeconomic (parental education and household income) and behavioural factors (toothbrushing frequency, last dental visit and sugar intake frequency). Levels of caries experience (dmft index) were then compared by socioeconomic, demographic, and behavioural factors using non-parametric tests; Mann-Whitney test for two-group comparisons and Kruskal-Wallis test for multi-group comparisons.

Negative binomial regression was used to examine the association between SEP indicators (family income and parental education) and children's dmft because the latter was a count variable with over-dispersion. Rate ratios (RR) were therefore reported (Cameron and Trivedi, 2013). The association of parental education and family income with children's dmft was explored in unadjusted and adjusted models. The adjusted model controlled for demographic factors, dental behaviours, the other SEP indicator and a dichotomous variable indicating who completed the questionnaire (father or mother). Robust standard errors and 95% confidence intervals (CI) were estimated from all regression models to adjust for the clustering of children within provinces and areas (rural/urban status). Multilevel modelling was deemed inappropriate for this analysis owing to the limited number of areas being analysed (i.e. only data for four provinces).

Results

Data from 1,732 children (50% boys and 50% girls) with complete data in the relevant variables were included in the study sample (76% of those who participated in the four provinces, 60% of those approached). The composition of the sample is presented in Table 1. Most commonly children were Han (82%), lived in families with low household incomes of 5,000 to 9,999 CNY (28%) and had parents who completed middle school (35%). Also, most children brushed their teeth once a day (63%), had never visited the dentist (81%) and ate sugary items less often than daily (56%).

Table 1. Characteristics of the study sample (n=1,732)

Variables	*n*	*%*
Gender of the child		
Male	862	50
Female	870	50
Ethnicity		
Han	1,428	82
Non-Han	304	18
Family income		
Very low	412	24
Low	489	28
Medium	437	25
High	182	11
Very high	212	12
Parental education		
Elementary school	204	12
Middle school	601	35
High school	520	30
College or above	407	23
Toothbrushing frequency		
Less often than daily	329	19
Once a day	1,086	63
Twice or more a day	317	18
Last dental visit		
Never	1,397	81
More than a year ago	99	5
Within the last year	236	14
Sugar intake frequency		
Less often than daily	973	56
≤4 times a day	681	39
>4 times a day	78	5

The comparison of caries levels by socioeconomic, demographic and behavioural factors is presented in Table 2. There were significant differences in dmft by all factors except gender. Children's dmft increased from 2.63 in the highest income group to 4.70 in the lowest income group whereas they increased from 3.07 for children whose parents had college education or above to 4.29 for children whose parents had elementary school only. Non-Han children had significantly higher dmft than Han children. Furthermore, children who ate sugary items less often than daily, those who brushed their teeth twice a day or more often and those who have never visited the dentist had lower dmft than their corresponding counterparts.

Household income, but not parental education, was negatively related to caries experience in unadjusted models (Table 3). These associations remained unchanged after adjustments for demographic factors (gender and ethnicity), dental behaviours (toothbrushing frequency, last dental visit and sugar intake frequency), the other SEP indicator and an indicator variable for the parent who completed the questionnaire. In the adjusted model, the dmft of children in families with low, medium, high and very high income was, respectively, 31% (95%CI: 5-50%), 32% (12-48%), 32% (4-52%) and 43% (25-56%) lower than that of children in families with very low income. Last dental visit was the only other variable significantly related to children's caries experience in the adjusted model. Similar results were found when modelling the number of decayed teeth separately (data not shown).

Table 2. Caries experience in 5-year-old Chinese children, by socio-demographic and behavioural factors (n=1,732)

Variables	*dmft index*		
	Mean (95% CI)		*p value*[a]
Family income (CNY)			**<0.001**
Very low	4.70	(4.21-5.19)	
Low	3.29	(2.91-3.67)	
Medium	3.04	(2.67-3.40)	
High	3.16	(2.54-3.77)	
Very high	2.63	(2.11-3.14)	
Parental education			**<0.001**
Elementary school	4.29	(3.64-4.95)	
Middle school	3.84	(3.46-4.21)	
High school	3.03	(2.67-3.38)	
College or above	3.07	(2.68-3.46)	
Gender of the child			0.761
Male	3.45	(3.17-3.74)	
Female	3.48	(3.18-3.77)	
Ethnicity			**<0.001**
Han	3.28	(3.06-3.50)	
Non-Han	4.34	(3.80-4.88)	
Toothbrushing frequency			**0.011**
Less often than daily	4.12	(3.62-4.62)	
Once a day	3.34	(3.08-3.60)	
Twice or more a day	3.23	(2.77-3.69)	
Last dental visit			**<0.001**
Never	2.92	(2.71-3.14)	
More than a year	5.35	(4.29-6.42)	
Within the last year	5.90	(5.32-6.48)	
Sugar intake frequency			**0.004**
Less often than daily	3.25	(2.98-3.52)	
≤4 times a day	3.62	(3.29-3.95)	
>4 times a day	4.86	(3.75-5.97)	

[a] Mann-Whitney test used for two-group comparisons (gender and ethnicity) while Kruskal-Wallis test was used for other variables.

Discussion

This study shows the presence of large social gradients in dental caries among Chinese 5-year-olds. Children's dental caries experience increased gradually as household income decreased. Children in households with the highest income had 43% lower dmft than those in households with the lowest income, after accounting for participants' demographic and behavioural characteristics. On the other hand, parental education was not significantly related to dental caries in these children.

Our results on the association between household income and children's dental caries are in line with those reported among preschool children in Hong Kong (Chu *et al.*, 1999), but disagree with those reported among young children in Xiamen city (Li *et al.*, 2011) and Guangzhou city (Gao *et al.*, 2011). On the other hand, the lack of association between parental education and preschool children's dental caries is consistent with those three previous studies. A number of factors could explain this finding. The first is sample size and the distribution of participants between education groups, which could explain the large confidence intervals for education in the regression models. A second explanation relates to the role of intermediate factors. Our finding could suggest that the effect of parental education on children's

Table 3. Association between socioeconomic factors (family income and parental education) and caries experience in 5-year-old Chinese children (n=1,732)

Variables	*Unadjusted RR[a] (95% CI)*	*Adjusted RR[a] (95% CI)*
Family income		
Very low	1.00 Reference	1.00 Reference
Low	**0.70 (0.45-1.08)**	**0.69 (0.50-0.95) ***
Medium	**0.65 (0.42-0.99)***	**0.68 (0.52-0.88) ****
High	**0.67 (0.41-1.11)**	**0.68 (0.48-0.96) ***
Very high	**0.56 (0.34-0.91)***	**0.57 (0.44-0.75) *****
Parental education		
Elementary school	1.00 Reference	1.00 Reference
Middle school	0.89 (0.58-1.37)	0.92 (0.62-1.37)
High school	0.70 (0.40-1.24)	0.74 (0.48-1.14)
College or above	0.72 (0.35-1.44)	0.73 (0.45-1.18)
Gender of the child		
Male	1.00 Reference	1.00 Reference
Female	1.01 (0.89-1.14)	1.01 (0.92-1.11)
Ethnicity		
Han	1.00 Reference	1.00 Reference
Non-Han	1.32 (0.74-2.36)	1.20 (0.72-1.99)
Toothbrushing frequency		
Less often than daily	1.00 Reference	1.00 Reference
Once a day	0.81 (0.55-1.19)	0.85 (0.63-1.14)
Twice or more a day	0.78 (0.51-1.20)	0.84 (0.62-1.14)
Last dental visit		
Never	1.00 Reference	1.00 Reference
More than a year	**1.83 (1.40-2.39)*****	**2.05 (1.70-2.49)*****
Within the last year	**2.02 (1.29-3.16)****	**2.45 (1.80-3.32)*****
Sugar intake frequency		
Less often than daily	1.00 Reference	1.00 Reference
≤4 times a day	1.11 (0.91-1.37)	1.05 (0.91-1.22)
>4 times a day	**1.50 (1.03-2.18)***	1.35 (0.96-1.90)

[a] Negative binomial regression was used and rate ratios (RR) reported. The adjusted models included as explanatory variables all factors listed in each column plus an indicator for who completed the parental questionnaire (mother/father); * $p<0.05$; ** $p<0.01$; *** $p<0.001$

caries experience goes through greater household income and children's access to dental care (last dental visit), which were related to caries experience in the final model. A third explanation is the role that education plays in societies with different economic circumstances (Lynch and Kaplan, 2000). China is enjoying a sustained period of economic growth which might explain differences in the education-caries relationship with Western countries. In China, mothers are responsible for taking care of children and their attitudes and knowledge influence their children's health behaviours and oral health status. Nevertheless, mothers with higher education might be busy working and spend less time with their children. Taken together, the above findings suggest that household income might be a stronger determinant of dental caries than parental education among 5-year-old Chinese children. However, this finding awaits corroboration from further longitudinal and/or nationally representative studies.

The present findings have some implications for policy and research. They reveal the existence of clear inequalities in preschool children's oral health by household income. Preventive and oral health promotion strategies should be universal but with a scale and intensity that is proportionate to the level of disadvantage (proportionate universalism). They should also take into account the different behavioural patterns of children in China (18% brushed their teeth twice daily, 56% ate sugar less often than daily and 81% had never visited the dentist) compared to Western societies and the differential exposure to natural water fluoridation in some parts of China. As for research, it would be worth exploring whether the present findings could be replicated in other Chinese provinces or in the entire Chinese sample that participated in the Third National Oral Health Survey.

Some limitations of this study need to be considered. First, only survey data from four of the 30 Chinese provinces were analysed for this study. Although the results are representative of the children aged 5 years living in the four provinces studied, they are not applicable to the general child population in China. Second, we analysed data only from children with complete information on both the clinical examination and the parental questionnaire, which reduced our sample by approximately 24%. However, there were no major socio-demographic differences between those in the full sample of participants and our study sample (data not shown). Third, we used two SEP measures (parental education and household income), but it is possible that other indicators, such as parental occupation or household wealth, may be relevant to explaining childhood oral health inequalities in China. Future studies should explore socioeconomic inequalities in childhood dental caries using nationally representative data and alternative socioeconomic measures.

In conclusion, this study shows significant gradients in dental caries by household income among 5-year-old children living in Guangxi, Hubei, Jilin and Shanxi provinces of China. However, parental education was not significantly related to childhood dental caries.

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