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The prevalence of and risk factors for non-carious cervical lesions in adults in Hubei Province, China

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***Objectives*:** To describe the prevalence of non-carious cervical lesions (NCCLs) and to assess the relative affects of risk factors on NCCLs in middle-aged and elderly people in Hubei Province, China. ***Design*:** A sample of 2,160 adults, aged 35-44 years and 65-74 years and balanced by age, gender, and urbanization, participated in the cross sectional epidemiological survey. Non-carious cervical lesions were examined using a modified Tooth Wear Index. Data were collected based on structured questionnaires that assessed general information as well as oral health. ***Results*:** The prevalence of non-carious cervical lesions was 38.8% for 35-44-year-olds and 56.6% for 65-74-year-olds. The first premolars, canines, and second premolars showed the highest prevalence of lesions, while the second molars demonstrated the least. Several risk factors such as age (OR=2.45, p<0.001), location (OR=1.68, p=0.001), frequency of toothbrushing (OR=1.33, p=0.016), bruxism (OR=1.37, p<0.001), and family income (OR=1.44, p<0.001) were found to be associated with lesion occurrence. ***Conclusions*:** The prevalence of non-carious cervical lesions was relatively high in the middle-aged and elderly persons in China and was also associated with socio-behavioural risk factors.

Key words: China, non-carious cervical lesions, prevalence, risk factors

Introduction

Non-carious cervical lesions (NCCLs) are characterized by a loss of tooth structure at the cemento-enamel junction (CEJ). Frequently, these can result in aesthetic problems and hypersensitivity. If allowed to progress, the lesions might even jeopardize pulp vitality and the structural integrity of the tooth. A variety of forms can be present, including shallow grooves, broad, dished-out lesions, and large, wedge-shaped defects with sharp line angles (Bartlett and Shah, 2006).

In the available literature, the prevalence of NCCLs ranges from 5% to 85% (Telles *et al*., 2006, Bartlett and Shah, 2006, Wood *et al*., 2008). Previous studies have been largely confined to European countries and have tended to be primarily experimental investigations or case studies based on a small number of patients. Although there is a high prevalence of these types of lesions, the number of epidemiological studies of NCCLs is surprisingly small. However, these types of data are essential for assessing dental health and are becoming increasingly more important with increasing life expectancy, a greater proportion of individuals retaining more teeth and increasing oral health awareness.

Most previous studies have reported that increased age of an evaluated group is correlated with increased prevalence of lesions. Furthermore, the first premolar was found to be the tooth most commonly affected (Borcic *et al*., 2004, Wood *et al*., 2008). However, conflicting results have been reported, such as a study that included younger individuals in which the first molar was considered as the most affected, while the number of lesions fell in higher age ranges (Telles *et al*., 2006). Numerous investigations have also indicated that gender may have no influence on the prevalence of NCCLs, although males might be expected to apply greater force during tooth brushing (Bartlett and Shah, 2006).

Scientific interest on the aetiology of NCCLs has dramatically increased over the past decade. Attrition, abrasion, and erosion are believed to be causative factors in the formation of NCCLs at the CEJ (Bartlett and Shah, 2006, Wood *et al*., 2008). Brushing technique, frequency, and force applied to the teeth are related to NCCLs (Wood *et al*., 2008). Litonjua and colleagues (2000) concluded that toothbrushing alone can induce wedge cervical lesions. However, Dyer and colleagues (2000) observed that toothpaste had more relevance than did the toothbrush itself. Some studies reported that the chemical erosion resulting from both exogenous and endogenous factors is the aetiologic agent. Grippo (1992) proposed that abfraction might be the basic cause of all NCCLs. Using finite elemental analysis, Goel and colleagues (1991) reported that occlusal force might be related to NCCLs. In contrast, Estafan and colleagues (2005) found no relationship between occlusal force and NCCLs. Variable risk factos, such as occlusion, saliva, age, gender and diet, might also be associated with NCCLs (Bartlett and Shah, 2006). Based on the findings of previous studies, it is possible that the aetiology of NCCLs is multifactorial. A combination of all of these factors may be responsible for the genesis of all various non-carious hard tooth substance losses.

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In China, modern standards of living have changed both dietary habits and socio-behaviours. Consequently, it is not surprising that other risk factors for NCCLs, including socio-behaviour, have been proposed. However, at this point in time, there is little information regarding the role of socio-behavioural processes and NCCLs. The purposes of this study were therefore to describe NCCL status among middle-aged and elderly people in Hubei province and to assess the relative effects of risk factors on NCCLs.

Materials and methods

The study protocol was approved by the Ethics Committee, School and Hospital of Stomatology at Wuhan University.

The study was carried out as a cross-sectional survey at the end of 2005. The survey employed a multistage, stratified, non-geometric proportional, randomized sampling method, representing civilians aged 35-44 (middle age group) and 65-74 (elderly age group) (World Health Organization standard age group), living in both urban and rural areas in Hubei Province. The sample size required was 1,066 per each age group. The size of the sample was calculated to have a 3% acceptable margin of error and an alpha level 0.05, if the estimated proportion of NCCLs in the study population was as high as 40%. In actual fact, each age group consisted of 1,080 participants, evenly divided into male and female groups (Figure 1). Hubei, the heart of Central China, covers an area of 185,900 km^2. At the end of 2004, Hubei had a population of about 60 million people, 56% of whom lived in rural areas. The final sample was comprised of 2,160 individuals. To be included in the sample, adults who were regarded as part of the permanent population had to live in the locality for more than six months. Edentulous subjects were excluded from the study.

In brief, 36 sampling sites, comprising of 18 urban sites and 18 rural sites, were selected through multi-stage stratified sampling. In the first stage, three cities and three counties of Hubei were chosen. Cities were divided into large, medium, and small size, according to their population. Wuhan City, Shiyan City, and Xiantao City were randomly selected to represent each level of the urban

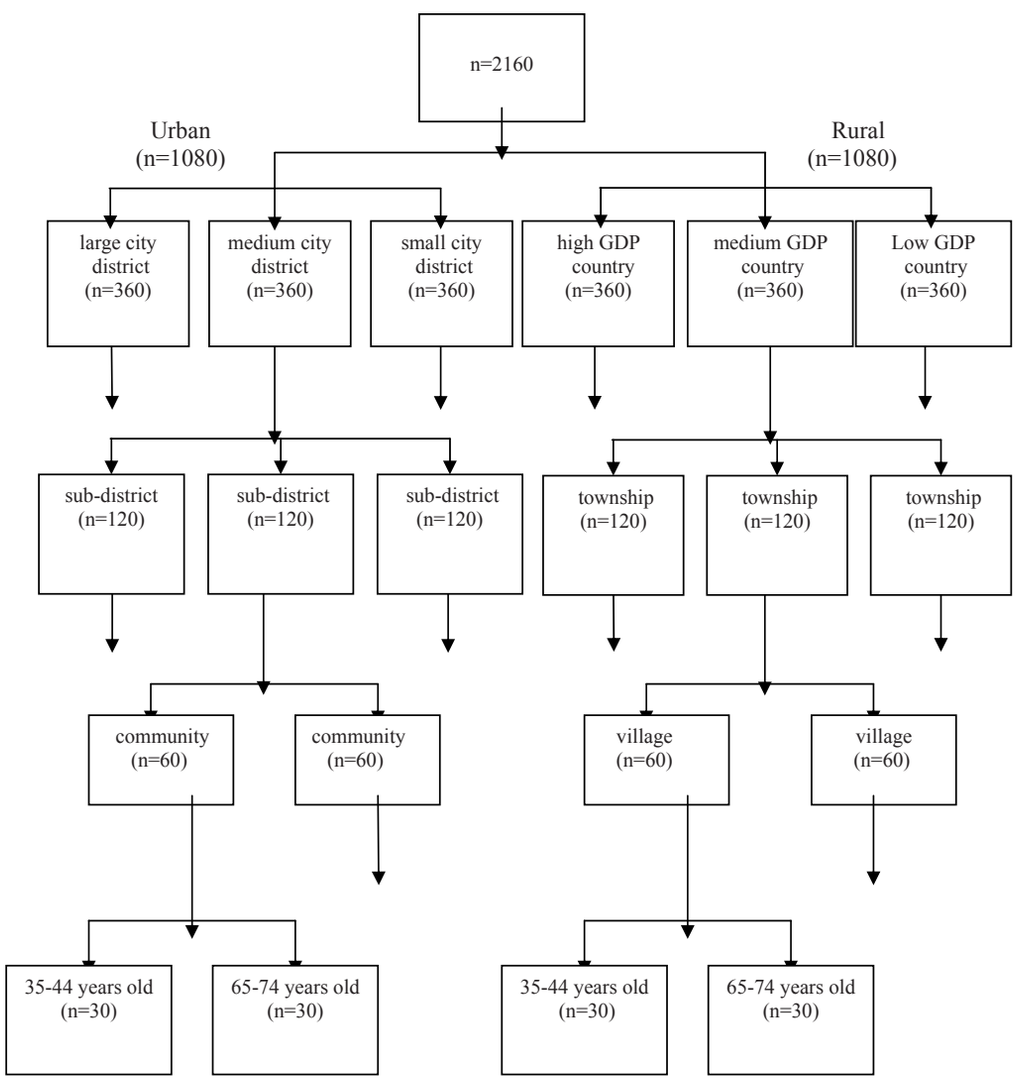

Figure 1. *Sampling flow diagram*

areas. One district was randomly chosen from each of the three cities. Counties were divided according to high, medium, and low Gross Domestic Product (GDP) levels. Songzi, Qichun, and Wufeng were selected to represent each level in the rural areas. Then, by two-stage stratified simple random sampling, three urban sub-districts and three rural townships were chosen, while two resident communities and two villages were selected from each sub-district and township. In the third stage, 30 subjects were randomly included from each resident community/ village among each of the two age groups. The sample list was delivered to the local Community Neighborhood Committee/ Rural Committee three weeks prior to the initiation of the study.

In order to recruit 30 subjects, replacement sampling strategies were used. If some subjects were absent, the samples were randomly drawn from the same sampling pool to guarantee that 30 subjects participated in the study at each survey site. Each subject received and signed an informed consent form prior to the beginning of the survey, which explained the study's purpose and procedures.

A face-to-face interview was conducted via a structured questionnaire to collect a range of information, including demographic data, income levels, education levels, brushing frequency, chewing habit (unilateral mastication), and bruxism. The participants were also asked about intake of soft drinks and fruit juices.

The dental examinations were performed by four examiners, all dentists, who were requested to participate in an initial calibration trial. The kappa statistic was used to assess inter-examiner reliability; final kappa scores exceeded 0.85. To test inter-examiner reliability during the survey period, about 10% of the subjects were randomly chosen each day to be re-examined between two examiners. Kappa values ranged from 0.75 to 0.91 for the severity score of NCCLs.

The clinical examination was conducted in a portable dental chair under artificial light, with the use of a mouth mirror and a periodontal probe with a millimeter mark. Food debris around the teeth obscuring visual inspection was removed, then the teeth were dried with a cotton roll. The NCCLs were recorded in a full mouth design, excluding the third molars. The extent of NCCLs was assessed using the Tooth Wear Index (TWI) designed by Smith and Knight (1984) as reported in a previous study (Borcic *et al*., 2004). However, since the TWI does not include filled NCCLs scores, we used a modified TWI to evaluate the severity of the lesions. Score criteria were as follows: Score 0-no change in contour; Score 1-minimal loss of contour; Score 2-defect <1 mm deep; Score 3-defect 1–2 mm deep; Score 4- defect >2 mm deep, or pulp exposure or secondary dentine exposure; Score 5-filled NCCLs. Regardless of whether a cervical restoration was performed because of a NCCL or a cervical caries, a cervical restoration was considered to be a filled NCCL when the margin of the restoration was limited to tooth cervix. A score of 1 indicated a mild lesion while a score between 2 to 4 denoted manifest lesions.

Data from the paper questionnaires and clinical examinations were entered into a computer using Windows SPSS 12.0. For further descriptive statistical analysis of NCCL distribution, mean values (the number of teeth with NCCLs per subject) and standard deviations were calculated and subdivided for different age groups and teeth types. The prevalence of NCCLs was defined as the proportion of individuals with teeth containing NCCLs (scores 1-5) in the study population. The differences in NCCLs among the different groups were tested using the nonparametric Mann-Whitney U-test. The level of statistical significance was set at 0.05.

All participants in the two groups had more than four natural teeth and further analysis was performed using the Chi-square test and multiple logistic regression analysis. One additive index, based on sum scores, was constructed in order to study the associations between intake of soft drinks and fruit juices and NCCLs (scores 2~12). In the final analysis, the various scales were categorized empirically as either low or high. All explanatory variables found to be significant in a bivariate analysis were included in a multiple logistic regression analysis, in order to determine the independent effect of each explanatory variable on the dependent variable, while controlling for other variables. Odd ratios (ORs) with 95% confidence intervals (95% CI) were calculated for the discrete variables in the logistic regression model.

Results

The severity, number, and prevalence of NCCLs in 35-44 year-old and 65-74 year-old adults, according to the location and gender, are given in Table 1. Of the total, 38.8% subjects of the 35-44-year-olds had at least one tooth with NCCLs, while this was 56.6% for the 65-74-year-olds. The mean number of NCCLs per subject was 2.04 for the middle-aged and 5.26 for the elderly. Both the prevalence and mean number of teeth affected increased with age. In the 65-74 year stratum, the prevalence in urban areas was 71.9%, which was higher than that in rural areas (41.3%; $P<0.001$).

Both the middle-aged and the elderly possessed a high proportion of manifest lesions (modified TWI scores 2-4) at 50.3% (1.02/2.04) in the middle-aged group and 66.7% (2.84/4.26) in the elderly. With increasing age, a greater number of serious lesions tended to be present. The participants who lived in urban areas had more filled NCCLs (score 5) than did those from the rural areas ($p<0.01$).

The proportions of NCCLs (modified TWI scores 1-5) in different teeth in the 35-44 year-olds and 65-74 year-olds in Hubei are shown in Figure 2 and Figure 3, respectively. The first premolars were the most vulnerable teeth in both groups. The canines and second premolars were also frequently affected, while the second molars had the lowest possibility of being affected. No statistical difference was found between the maxilla and mandible ($p>0.05$), or between the left and right sides in any of the groups ($p>0.05$).

Table 2 shows the results of Chi-square tests, indicating associations between various factors and the numbers of respondents with NCCLs. The occurrence of NCCLs was significantly associated with age, location, ethnicity, frequency of toothbrushing, family income in the last year, and bruxism.

Table 3 shows results of the multiple logistic regression analysis. Only statistically significant associations

Table 1. The number, severity and prevalence of NCCLs according to location and gender in 35-44 year and 65-74 year old adult

	n	*NCCLs score Mean±SD*					*Mean number of NCCLs (SD)*	*Prevalence of NCCLs (%)*
		1	*2*	*3*	*4*	*5*		
35-44 yrs								
Urban	540	0.93±1.81	0.76±1.61	0.22±0.77	0.04±0.24	0.10±0.91	2.05±3.52	40.0
Rural	540	1.00±1.98	0.74±1.76	0.25±0.86	0.04±0.26	0.00±0.04**	2.03±3.74	37.6
Male	540	0.99±1.97	0.86±1.81	0.30±0.96	0.06±0.31	0.06±0.81	2.26±3.92	40.0
Female	540	0.94±1.81	0.64±1.55*	0.16±0.62*	0.03±0.18	0.04±0.42	1.81±3.31	37.6
Total	1080	0.96±1.89	0.75±1.69	0.23±0.81	0.04±0.25	0.05±0.64	2.04±3.63	38.8
65-74 yrs								
Urban	540	1.66±2.38	2.01±2.48	1.19±2.00	0.41±1.00	0.19±0.89	5.46±5.26	71.9
Rural	540	0.98±2.03**	1.08±1.98**	0.63±1.52**	0.36±1.29*	0.01±0.15**	3.06±4.78**	41.3**
Male	540	1.33±2.27	1.62±2.34	0.99±1.86	0.46±1.38	0.13±0.77	4.52±5.42	55.6
Female	540	1.31±2.20	1.47±1.24	0.83±1.72	0.31±0.99	0.08±0.48	4.00±4.89	57.6
Total	1080	1.32±2.23	1.55±2.29	0.91±1.80	0.39±1.20	0.10±0.65	4.26±5.17	56.6

*p<0.05 **p<0.01

Table 2. Background variables associated with the presence of NCCLs among Chinese adults.

Variables		*n*	*Percentages of respondents with NCCLs (n=1029)*
Age	35-44-yrs	1080	38.8
	65-74-yrs	1038	58.8*
Gender	Male	1064	48.5
	Female	1064	48.3
Location	Urban	1071	56.4
	Rural	1057	40.3*
Ethnic	Han	1775	50.3
	Minority	353	39.1*
Education	9 years or more	984	47.4
	0-8years	1144	49.3
Frequency of toothbrushing	Twice a day or more	600	55.0
	Less than twice a day	1528	45.8*
Family income in the last year	Less than 6000 yuan	822	43.1
	6000 yuan or more	1306	51.8*
Consumption of soft drinks and fruit juices	Low (scores 2~4)	1022	47.7
	High (scores 5~12)	1106	49.0
Unilateral mastication	Yes	468	48.3
	No	1660	48.4
Bruxism	Never	1515	45.5
	Sometimes	455	54.5
	Often and always	158	58.1*

* p<0.01

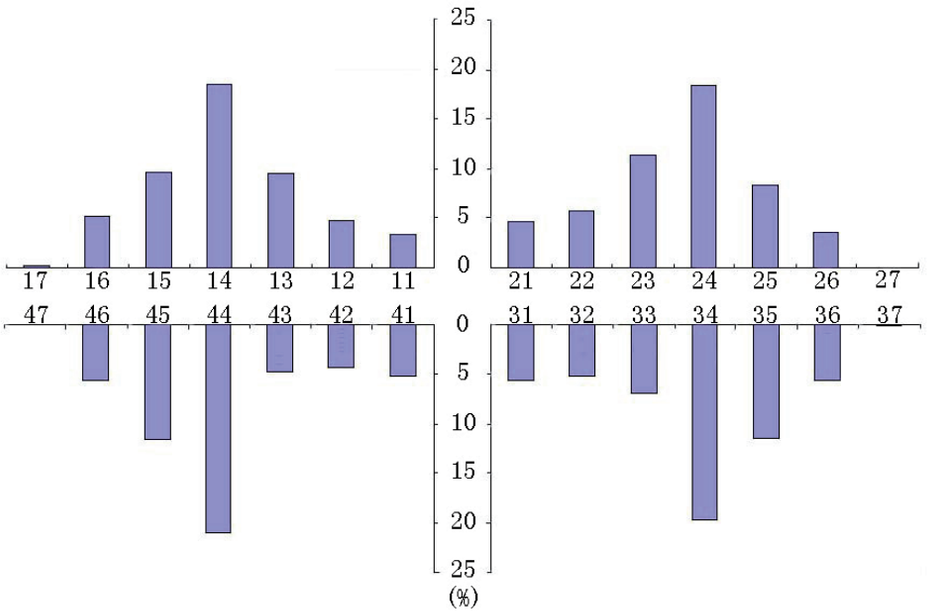

Figure 2. *Proportion of NCCLs in different teeth in 35-44 year-old adults*

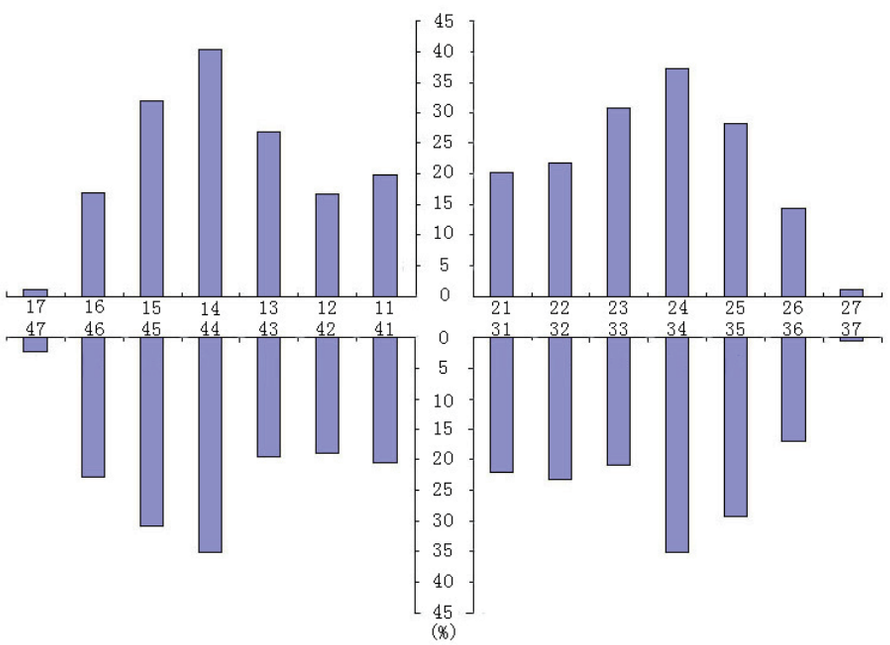

Figure 3. *Proportion of NCCLs in different teeth in 65-74 year-old adults*

Table 3. Logistic regression analysis of odds for the occurrence of NCCLs among Chinese adults (n=2128)

Independent variable		*p*	*OR*	*95% CI*
Age	65-74-yrs	<0.001	2.45	2.01, 2.98
	35-44-yrs		1	1
Location	Urban	0.001	1.68	1.39, 2.02
	Rural		1	1
Frequency of toothbrushing	Twice a day or more	0.016	1.33	1.09, 1.64
	Less than once a day		1	1
Bruxism	Often and always	<0.001	1.37	1.08, 1.75
	Sometimes	0.001	1.26	1.04, 1.58
	Never		1	1
Family income in the last year	6000 yuan or more	<0.001	1.44	1.18, 1.75
	Less than 6000 yuan		1	1

are presented. A higher prevalence was observed in the elderly (OR=2.45, p<0.001), urban (OR=1.68, p<0.001), and those who had a higher income (OR=1.44, p<0.001). In addition, people brushing their teeth twice a day or having frequent bruxism habits also tended to have a higher likelihood of NCCLs being present.

Discussion

In the People's Republic of China, few systematic data are available concerning adult NCCLs. The present study is thought to be the first attempt to describe the status of NCCLs in China. Emphasis has been placed on the assessment of the relative effect of risk factors on NCCLs. Since the prevalence of noncarious lesions tends to increase with age, it is possible that further studies on an older population may offer more insight into both NCCL etiology and risk factors. The present study does however provide useful information with regard to urban and rural population groups at the standard ages 35-44 and 65-74 in Hubei, which is among the moderate economically developed provinces in China.

In the present study, the prevalence of NCCLs was 38.8% and 56.6% in the middle-aged and the elderly, respectively, which is in accordance with previous studies (Hand *et al*., 1986). It is important to note that this prevalence was much lower than that reported by Chen *et al* (2002) for NCCLs in China. This large variation might be due to the differences in the age groups and the populations involved, as well as the techniques and evaluation criteria used. Both the middle-aged and the elderly, particularly the latter, were found to display high percentages of manifest lesions in the present study. Few teeth with NCCLs were restored in this Chinese population. Lesions assessed at level 3 or 4 in 35-44 year and 65-74 year old adults require therapy by filling, while those at lesser levels require regular check-up (Grippo, 1992).

Levitch and colleagues (1994) have confirmed that posterior teeth were the most susceptible to cervical lesions, possibly owing to the greater occlusal forces in these teeth, or to the natural relative anatomical morphology of teeth, periodontium, and vestibule. In the current study, the premolars were found to have the highest prevalence of NCCLs, while the second molar had the lowest. Conflicting findings have been reported in other studies. For example, Borcic and colleagues (2004) reported a similar high prevalence of premolars and molars, while incisors seemed to be the least affected. Telles (2006) revealed that the first molars were the most affected. Borcic *et al* (2004) reported that more lesions were found on the right side. Sognnaes (1972) found that mandibular teeth were the most frequently affected, based on the examination of 10,827 extracted teeth. In contrast, Levitch (1994) found that maxillary teeth were more affected, compared with those of the mandible. However, in our study, no significant difference was found between the upper and the low arches or between the left and right side with regard to the prevalence of NCCLs in either of the two age groups investigated.

Age, location, frequency of toothbrushing, and family income factors were related to the formation of NCCLs as determined by multiple logistic regression analysis. Age is a universal marker, because older patients and their teeth have been exposed to extrinsic or intrinsic factors for a much longer period, and thus the appearance of both more lesions and ones of greater severity is not unexpected (Lee and Eakle, 1984). Older age groups are also more likely to have gingival recession and bone loss, with more root surface and cementum exposure, which again increases the risk of NCCLs. No significant difference was observed in the subjects' gender, in agreement with other previous findings (Aw *et al*., 2002).

In our study, more than half of the participants (55%) brushed their teeth twice or more a day. These participants showed a 1.33-fold higher odds ratio for NCCLs compared to those who brushed their teeth once a day or less. It is not clear whether this association is caused by toothbrushing alone or the choice of toothpaste, so further studies are needed. Similar outcomes have been reported by other authors. For example, Bernhard et al (2006) showed odds ratios of 1.87 and 2.07 caused by brushing teeth twice a day and three times a day. Sangnes and Gjermo (1976) also indicated that those who brushed more than twice a day had a high frequency of wedge-shaped lesions. These previous studies have also

highlighted a relationship between oral health variables (caries, periodontal disease, dental erosion, etc.) and socio-economic status (Hobdell *et al*., 2003, Luo *et al*., 2005); however, no such analyses have previously been conducted regarding NCCLs. It is noteworthy that people in the present study who reported a higher income also had a higher odds ratio of developing cervical lesions.

Occlusal force might be related to NCCLs (Goel *et al*., 1991). The lateral stress generated during chewing and bruxism may be concentrated in the cervical region, close to the tooth fulcrum, which would cause flexure of the teeth. The present results revealed that bruxism was a significant factor for the prevalence of NCCLs. After controlling for other factors, the odds of frequent bruxism were 1.37, which was in accordance with the findings of a previous study (Bernhardt, *et al*., 2006). However, unilateral mastication was not associated significantly with the presence of NCCLs, in either the past or the present study. More research, particularly in a clinical setting, is therefore needed to assess the effect of abfraction on NCCLs.

There is substantial evidence that soft drinks and fruit juice are risk factors for the development of dental erosion. In particular, the level of damage increases with the frequency of drinks and juices consumed (Luo *et al*., 2005). In the present study, among Chinese middle-aged and the elderly, no significant association was found between the prevalence of NCCLs and consumption of soft drinks and fruit juices, and this may be due to the somewhat low consumption of these types of drinks overall. Traditionally, consumption of soft drinks and juices is still relatively uncommon and infrequent amongst middle-aged and elderly people in this region.

A limitation of this study arises from the lack of ability to distinguish whether a wedge-shape defect under a restoration was a NCCL or a cervical carious lesion. In the current study, all cervical restorations were considered to be filled NCCLs when the margin of the restoration was limited to the cervix of the tooth. Although the proportion of filled NCCLs is very low, the method used here may have led to the overestimation of the prevalence and severity of NCCLs.

In conclusion, the prevalence of non-carious cervical lesions was found to be relatively high in middle-aged and elderly persons in China. Although there was a high frequency of NCCLs in these age groups, the proportion of teeth that had received any treatment was low. The study confirmed that the aetiology of NCCLs might be multifactorial. Age, location, frequency of toothbrushing, bruxism, and family income were all factors that were associated with the presence of non-carious cervical lesions.

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