The prevalence of malocclusion and oral health-related quality of life among 12- and 15-year-old schoolchildren in Shanghai, China: a cross-sectional study

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Abstract

Background Malocclusion is one of the three major oral diseases and may cause deterioration in oral health-related quality of life (OHRQoL). This study aims to determine the prevalence of malocclusion by gender and its impact on quality of life among 12- and 15-year-old children in Shanghai.

Methods This study summarizes the data obtained in the Shanghai Oral Health Epidemiological Survey conducted in 2019. Random cluster sampling was used to select students in Shanghai. A total of 1591 12-year-old children and 747 15-year-old children were included. Each student underwent an oral examination and completed a questionnaire. The Index of Complexity, Outcome and Need (ICON) was adopted to measure the objective severity of malocclusion and Child Oral Health Impact Profile (COHIP) was applied to evaluate quality of life of schoolchildren. Comparisons of COHIP scores were performed among different treatment needs and difficulties by t-test and analysis of variance (ANOVA).

Results No significant difference was found between genders except that the prevalence of deep overbite in 12-year-old boys (1.11 ± 0.95) was significantly higher than that in girls (0.93 ± 0.88) while the prevalence of crossbite among 12-year-old girls (26%) is significantly higher than boys (20%). Malocclusion in 15-year-old children was descended compared with 12-year-old. 15-year-old students demonstrates larger impact of malocclusion on oral health than 12-year-old group except self-image. Health impacts (COHIP) increase significantly as the malocclusion becomes severer except self-image in 12-year-old group.

Conclusions In Shanghai, the severity of malocclusion in 15-year-old children was less than 12-year-old children. Malocclusion has greater influence on oral health of 15-year-old children than 12-year-old children. Severer malocclusion generally correlates with higher level of oral health impacts in schoolchildren.

Keywords Prevalence, Malocclusion, Oral health impact, Quality of life, Schoolchildren

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Background

Malocclusion is defined as dentofacial deformity, which includes deformities of teeth, jaws and craniofacial structures, affecting maxillofacial growth and oral functions [1]. It has been ranked as one of the three major oral diseases in the 21st century by World Health Organization [2]. The prevalence of malocclusion is more than 70%, both in the western and eastern countries [1, 3, 4]. Shanghai is one of the most economically developed cities located in the south-east of China. As the living standard in Shanghai continues to improve, more consumption of soft, refined or processed foods may lead to deteriorated masticatory function and higher malocclusion rate [5].

Malocclusion could be ascribed to multiple factors including economic conditions [6], dietary [5, 7], systemic diseases [8], oral habits [9], race [10, 11], ethnic groups [12], etc. In addition, children are at an important stage of physical and mental development, and their mental health and quality of life are easily affected by their own internal physical factors and external environmental factors [5, 13]. Plenty of studies have report the negative influence of malocclusion on different aspects of oral health related quality of life (OHRQoL) [3, 14–18], including dental conditions [13, 19], oral functions [13], social interactions [19], emotion [13] or self-esteem [19], etc. A cohort study also found that early childhood malocclusion is a risk factor for low OHRQoL in the future [20]. The age of 12 to 15 is the golden age for orthodontic treatment. Therefore, lack of reasonable prevention and timely intervention may have led to the increasing prevalence of malocclusion [1, 5]. Early diagnosis may facilitate the prevention of malocclusion and promotion of OHRQoL through interceptive orthodontic treatment on children [20, 21].

The current study reports the prevalence of malocclusion by gender and OHRQoL among 12- and 15-year-old children in Shanghai to explore the impact of the malocclusion on OHRQoL. We discussed the oral health impact in a detailed way by comparing different aspects of OHRQoL in children with different severity of malocclusion.

Methods

Data collection

This study summarizes and analyzes the data obtained in the Shanghai Oral Health Epidemiological Survey conducted in 2019. The subjects of this study are 12-year-old and 15-year-old schoolchildren in Shanghai. For both age groups, random cluster sampling was used to randomly select one primary school and one secondary school from each of the 15 districts and 2 subdistricts (east and west subdistricts of Huangpu District) in Shanghai. For age of 12, 6th grade in primary school was selected, and for age of 15, 3rd year of secondary school was selected. Both are within the 9-year compulsory education period. Children with facial trauma or surgery history, orthodontic history, systematic diseases were excluded. A total of 1591 12-year-old children and 747 15-year-old children were included. Each student underwent an oral examination and completed a questionnaire. The Index of Complexity, Outcome and Need (ICON) [22] was adopted to measure the objective severity of malocclusion and Child Oral Health Impact Profile (COHIP) [23–26] was applied to evaluate the impact of malocclusion on schoolchildren. Informed consents were obtained from all participants and their guardians.

Prevalence of malocclusion

The ICON index proposed by Daniels et al. [22] was used to record 5 items including aesthetics, upper dental arch crowding/spacing, overbite/open bite, crossbite, and anteroposterior molar relationship for evaluation. The 5 items were listed as follows,

• Aesthetics (IOTN aesthetic component [27–29]), 1–10 points.

• Upper dental arch crowding degree: the maximum value of upper dental arch crowding or spacing, 0–5 points.

• Overbite: The maximum value of open bite/deep overbite of the anterior teeth, 0–4 points.

• Crossbite: 0 points if not existed, 1 point if present.

• Molar relationship: 0–4 points (0–2 points each side, and 0–4 points added together).

A higher score indicates severer malocclusion. In this study, the children scored 0 in each item was considered negative for the symptom, and the standards for greater than 0 points are listed in Table 1. Moreover, according

Table 1 Prevalence of malocclusion calculated by the proportion of samples scored over 0 points

	Definitions [22]	12-year-old			15-year-old		
		Male (51.1%)	Female (48.9%)	Total	Male (49.9%)	Female (50.1%)	Total
Crowding	Larger than 2 mm crowding	46.3%	45.4%	45.9%	39.9%	42.2%	41.0%
Overbite	More than 1/3 lower incisor coverage	70.7%	65.0%	68.1%	55.4%	56.5%	55.9%
Crossbite	Crossbite present	20.0%	26.1%	22.9%	22.5%	24.4%	23.4%
Molar relationship	Any cusp relation up to and including cusp to cusp	67.9%	68.2%	68.0%	57.1%	65.3%	61.1%

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to the total score of ICON, the index also divide treatment need by no treatment need (under 43 points) and with treatment need (43 points or larger). Treatment difficulty was defined as easy (under 29 points), mild (29 to 50 points), moderate (51 to 63 points), difficult (64 to 77 points), very difficult (over 77 points) [22].

Oral health-related quality of life (OHRQoL)

To evaluate self-perceived quality of life, the Chinese version of COHIP was used [23–26]. The questionnaires were completed in the form of face-to-face interviews and were asked and recorded by calibrated orthodontic specialists. The questionnaire applies a 5-level Likert scale with 34 questions in total which was divided into 5 dimensions: oral health (10 questions), functional health (6 questions), social-emotional health (8 questions), school environment (4 questions) and self-image (6 questions). Each question is self-evaluated as 1 to 5 points according to the severity of the corresponding problem. Higher scores refer to more negative symptoms. The sum of the scores of each question in the corresponding dimension is recorded as the total score of the specific dimension. The sum of the scores of all questions is regarded as the total score of the questionnaire.

Statistical analysis

EpiData 3.0 (The EpiData Association, Odense, Denmark) was used to record data. Statistical analysis was conducted using SPSS 26.0 (IBM Corporation, Armonk, NY, USA). The examiners were all orthodontic practitioners for more than 5 years and calibrated for malocclusion examination and unified the standard before the investigation. Kappa value was calculated to test the consistency of scoring. Outliers detected automatically in SPSS software were checked one by one and deleted if recorded or entered incorrectly.

The total score of the ICON index is a weighted summation of the scores for 5 items including aesthetics, upper dental arch crowding, overbite, crossbite, and molar relationship and the calculated method was proposed by Daniels et al. [22].

The total scores of COHIP could not be directly compared since the total number of questions and the total score ranges of each dimension are different [23, 30], a weighted sum was calculated. The rough score (RS) was the direct summation of the scores of each question in the dimension, and the standardized score (SS) was defined as.

$$SS = (RS/n-1)/4*100,$$

(n represents the number of questions in the dimension [31].)

In this way, the scores of all dimensions were converted into a weighted score ranging from 0 to 100 so as to compare the differences between dimensions.

In the case of mean comparisons, t-test was performed to compare the malocclusion variables and health impact variables between different genders or age groups if conforming to a normal distribution and Mann-Whitney test was used if otherwise. Chi-square test was applied in comparison of the crossbite prevalence as it is a binary variable.

According to the total score of ICON index, the samples were divided into 2 groups by treatment need and 5 groups by treatment difficulty respectively. Mean comparison (t-test) and analysis of variance (ANOVA) were conducted on the rough score (RS) of COHIP total score and each of the five dimensions to compare the impact of the severity of malocclusion on children's personal life.

The significance level was $p < 0.05$.

Results

Demographic characteristics and scoring consistency

A total of 1591 12-year-old children and 747 15-year-old children were included. In 12-year-old group, a total of 808 (51.1%) boys and 773 (48.9%) girls were included, while in 15-year-old group, 373 boys (49.9%) and 374 girls (50.1%) were included.

Inter-examiner reliability was detected by Kappa values which were over 0.8 in this study.

Prevalence of malocclusion (ICON index)

All the variables were unconformable to normal distribution implied by Kolmogorov-Smirnova and Shapiro-Wilk normality tests ($p < 0.01$), then non-parametric tests were performed.

The prevalence of different categories of malocclusion was listed in Table 1. In 12-year-old children, overbite, reflecting vertical discrepancy, was the most common malocclusion, followed by discrepancy in molar relationship, crowding and crossbite while in 15-year-old children, molar relationship discrepancy was the most common malocclusion (Table 1).

The prevalence of malocclusion was compared between genders and two age groups (Table 2). The total score of ICON index is a weighted summation of the scores of the 5 variables including esthetics (IOTN AC), upper dental arch crowding/spacing, overbite/open bite, crossbite and molar relationship [22].

In children of 15 years old, no significant difference was displayed between genders in all the malocclusion indicators.

In 12-year-old group, overbite of the boys was significantly greater than those of the girls (Table 1, $p = 0.002$). We addressed the overbite variable separately since it is a comprehensive indicator including deep overbite and open bite. Among the 12-year-old, 22 boys and 32 girls had varying degrees of open bite, but no significant difference was found between genders. For deep overbite,

Table 2 Group statistics on the prevalence of malocclusion

	Gender	12-year-old		15-year-old		P (age)
		Mean ± Std.	P (gender)	Mean ± Std.	P (gender)	
ICON total score	Male	45.29 ± 20.62	0.269	39.83 ± 21.73	0.585	
	Female	44.10 ± 20.34		38.96 ± 19.25		
	Total	44.71 ± 20.52		39.4 ± 20.55		< 0.001**
Esthetics	Male	4.56 ± 1.89	0.125	4.06 ± 2.11	0.483	
	Female	4.41 ± 1.88		3.95 ± 1.8		
	Total	4.48 ± 1.89		4.01 ± 1.96		< 0.001**
Crowding	Male	0.68 ± 0.98	0.996	0.56 ± 0.89	0.949	
	Female	0.68 ± 0.98		0.57 ± 0.86		
	Total	0.68 ± 0.98		0.57 ± 0.87		0.008*
Overbite	Male	1.12 ± 0.95	0.002**	0.85 ± 0.91	0.260	
	Female	0.96 ± 0.86		0.77 ± 0.82		
	Total	1.05 ± 0.92		0.81 ± 0.87		< 0.001**
Crossbite	Male	0.20 ± 0.40	0.006**	0.23 ± 0.42	0.563	
	Female	0.26 ± 0.44		0.24 ± 0.43		
	Total	0.23 ± 0.42		0.23 ± 0.42		0.784
Molar relationship	Male	1.55 ± 1.40	0.750	1.36 ± 1.46	0.917	
	Female	1.56 ± 1.38		1.35 ± 1.29		
	Total	1.55 ± 1.39		1.35 ± 1.38		0.002**

*$p < 0.05$

**$p < 0.01$

Table 3 Dimension division and score statistics of COHIP scale

		12-year-old		15-year-old		P (age)
Dimensions	Raw Score Range	Raw Score (RS)	Standardized Score (SS) (0-100)	Raw Score (RS)	Standardized Score (SS) (0-100)	
Oral health	10–50	20.07 ± 5.28	25.16 ± 13.20	21.07 ± 5.39	27.68 ± 13.48	< 0.001**
Functional well-being	6–30	7.31 ± 2.10	5.45 ± 8.74	7.8 ± 2.42	7.5 ± 10.09	< 0.001**
Social-emotional well-being	8–40	10.49 ± 4.26	7.77 ± 13.3	11.00 ± 4.44	9.38 ± 13.86	0.012*
School environment	4–20	4.23 ± 1.03	1.45 ± 6.45	4.38 ± 1.12	2.34 ± 7.00	< 0.001**
Self-image	6–30	13.02 ± 5.70	29.26 ± 23.75	12.81 ± 5.77	28.36 ± 24.05	0.289
Total score	34–170	54.96 ± 13.23	68.52 ± 46.21	56.74 ± 14.2	74.16 ± 49.79	0.007**

*$p < 0.05$

**$p < 0.01$

the severity of boys (1.11 ± 0.95, not shown) was significantly greater than that of girls (0.93 ± 0.88, $p < 0.001$, not shown). The prevalence of open bite and deep overbite were also analyzed separately in 15-year-old group and in neither did we find significant difference between genders ($p = 0.503$ for deep overbite, $p = 0.913$ for open bite).

The prevalence of crossbite among 12-year-old girls is 26%, which is significantly higher than that among boys at 20% ($p = 0.006$).

In comparison between the two age groups, the prevalence of esthetics (IOTN AC), upper dental arch crowding/spacing, overbite/open bite and molar relationship significantly descended in 15-year-old children (Table 2). However, the prevalence of crossbite remains the same (Table 2)..

Oral health-related quality of life (COHIP scale)

It can be seen from the mean standardized score SS in Table 3 that the oral problems with the highest scores for 12-year-old children in Shanghai are self-image and oral health, and least complains were found in school environment. Social-emotional and functional health scores, as well, indicates low level of concerns for 12-year-old children in these aspects. The above tendency is consistent with that of 15-year-old children.

Compared with the 12-year-old, 15-year-old students reflected higher level of impact on oral health, functional well-being, social-emotional well-being, school environment and COHIP total score. The impact on self-image remains almost unchanged (Table 3).

Correlation between ICON and COHIP indexes

Mean comparison and analysis of variance were done on the rough score (RS) of COHIP total score and each of

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Table 4 ICON malocclusion index and its impact on COHIP for 12-year-old children

		COHIP total score	HEALTH	FUNCTION	EMOTION	SCHOOL	IMAGE
ICON treatment need							
no	≤43	53.4±12.87	19.53±5.06	7.19±2.01	10.17±3.99	4.25±1.09	12.28±5.47
yes	>43	**56.7±13.61****	**20.56±5.42****	7.38±2.06	**10.92±4.60****	4.21±0.98	**13.86±5.89****
ICON complexity							
easy	<29	52.72±12.71	19.48±5.00	7.20±2.00	9.99±3.77	4.25±1.03	11.80±5.26
mild	29∼50	54.17±12.81	19.84±5.11	7.17±1.99	10.31±4.13	4.26±1.21	**12.73±5.65***
moderate	51∼63	**56.3±14.03****	20.14±5.45	7.32±1.98	**10.78±4.6***	4.18±0.79	**13.88±5.95****
difficult	64∼77	**56.91±12.93****	**21.00±5.65****	7.45±2.05	**10.94±4.18***	4.20±0.87	**13.66±5.74****
very difficult	>77	**60.2±15.08****	**20.82±5.57***	**7.82±2.45****	**12.18±5.65****	4.21±0.76	**15.54±5.82****

*$p<0.05$

**$p<0.01$

The bold values represent data with statistical significance

Table 5 ICON malocclusion index and its impact on COHIP for 15-year-old children

		COHIP total score	HEALTH	FUNCTION	EMOTION	SCHOOL	IMAGE
ICON treatment need							
no	≤43	54.54±12.98	20.44±5.12	7.57±2.25	10.55±4.01	4.31±1.02	12.18±5.61
yes	>43	**60.56±15.21****	**22.18±5.47****	**8.18±2.57****	**11.89±5.1****	**4.51±1.25***	**13.99±5.97****
ICON complexity							
easy	<29	55.07±13.66	20.52±5.3	7.59±2.21	10.59±4.06	4.31±0.96	12.44±5.88
mild	29∼50	55.19±13.1	20.82±5.04	7.78±2.46	10.81±4.33	4.37±1.15	12.2±5.49
moderate	51∼63	**59.16±13.96***	21.64±5.38	7.58±2.17	11.21±4.84	4.37±1.08	**14.24±6.03****
difficult	64∼77	**61.35±15.94****	22.04±5.78	**8.57±2.83****	**12.16±4.59***	**4.73±1.56***	13.53±5.77
very difficult	>77	**64.43±17.39****	**23.49±5.66****	**8.7±2.69****	**13.41±5.83****	4.49±1.15	**14.62±5.9****

*$p<0.05$

**$p<0.01$

The bold values represent data with statistical significance

the five dimensions to compare the impact of the severity of malocclusion on children's personal life (Tables 4 and 5). As mentioned in the Methods section, standardized score (SS) was calculated to compare the differences between dimensions.

For 12-year-old children (Table 4), except school environment, severe malocclusion renders children's concerns in almost every aspect of OHRQoL. Basically, COHIP scores increase significantly as the malocclusion becomes severer.

Unlike the age of 12, the school environment of 15-year-old children was also significantly impacted by malocclusion. Similar trend of the relationship was also inspected in other aspects of oral health impact (Table 5).

Discussion

This study analyzed and summarized the prevalence of malocclusion and its impact on OHRQoL among 12- and 15-year-old schoolchildren in Shanghai.

The prevalence of crowding in this study is similar to another study conducted in Shanghai but a bit lower than previous studies conducted in northern China [7, 32]. In our study, ICON index was used and crowding of 0–2 mm was also recorded as 0 point which may decrease the proportion of crowded samples.

This study found that the prevalence of deep overbite in 12-year-old boys was significantly higher than that in girls at the same age, which coincides with Yin et al. [32]. Regarding the gender difference in deep overbite, we analyzed that it may be because the boys establish a stable permanent dentition later than girls. At the age of 12, second molars of some boys have not yet fully erupted [33]. Therefore, for boys, the temporary deep overbite during the tooth replacement period may have not been completely corrected [3, 33]. It is vindicated by the statistically equal prevalence of deep overbite in 15-year-old group.

There is currently no evidence that there is a gender difference in the prevalence of crossbite between boys and girls, but studies have found more common anterior crowding in girls than boys [32, 34]. Therefore, the significant difference in prevalence seen in this survey may be due to local crossbites caused by crowded dentition or disorder of tooth replacement, not necessarily by underdevelopment of the maxilla or overdevelopment of the mandible.

The decrease in the prevalence of malocclusion in 15-year-old schoolchildren may be attributed to growth and development of maxilla and mandible. The growth in the space of alveolar bone and the eruption of second

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molars may contribute to spontaneous correction of malocclusion to some degrees [33]. However, crossbite, whose prevalence remains the same, cannot be corrected during growth, suggesting the necessity of early orthodontic intervention.

To solve the inequality of score range among COHIP dimensions, we proposed standardized score (SS). Through SS, it can be found that the oral problems that trouble the 12-year-old children in Shanghai most are self-image and oral health, while the school environment was hardly influenced, as well as social-emotional and functional well-being. Similar trend was observed in 15-year-old children, except significant impact on the school environment. It is noteworthy that COHIP scores in 15-year-old children was significantly larger than in 12-year-old ones in most dimensions and the COHIP total score except the self-image dimension. This change is consistent with the findings of Sun et al. [30]. We conjectured that children around puberty period may experience psychological or emotional fluctuations, rendering them more sensitive and vulnerable to physical discomfort [30].

A large number of previous studies have shown that OHRQoL of children with malocclusion are significantly lower than those of healthy children [4, 11, 35–38]. Alike, our study found that children's self-perceived health impact ascended as the severity of malocclusion increased, urging the attention from clinicians and parents [10]. Moreover, the more prominent impact on age of 15 prompted the necessity of earlier intervention in malocclusion for children in permanent dentition [21, 39].

However, there are also some limitations. First, although the samples we chose were all during the nine-year compulsory education, it does not rule out that a small number of 12-year-old or 15-year-old children may drop out of school. These children are not included in the survey. Second, the respondent may give inaccurate answers, occasionally, due to inaccurate recall, or the results may be biased due to unwillingness to answer truthfully.

Conclusions
The severity of malocclusion in 12-year-old children was less than that in 15-year-old children in Shanghai. The incidence of deep overbite is higher in boys than in girls, while the incidence of crossbite in girls is higher than that of boys. Malocclusion has greater influence on OHRQoL of 15-year-old children than 12-year-old children. The most prominent oral health impacts for 12- and 15-year-old children in Shanghai are self-image and oral health. The impact on school environment was significant only for 15-year-old children. Severer malocclusion generally correlates with higher level of oral health impacts in school children in Shanghai.

Abbreviations
OHRQoL	Oral Health-Related Quality of Life
ICON	Index of Complexity, Outcome and Need
IOTN	Index of Treatment Need
COHIP	Child Oral Health Impact Profile
RS	Rough score
SS	Standardized score

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