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Eruption and caries status of first permanent molars in children aged 6–7 years in Shijingshan District, Beijing, China

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Abstract

Background Dental caries is still a major disease that affect the oral health of people in China. First permanent molars (FPMs) are the most caries-susceptible teeth among school-aged children. The aim of this study was to investigate the eruption and caries status of first permanent molars in children aged 6–7 years in Shijingshan District, Beijing, China, to provide information for oral health promotion.

Methods The study was a cross-sectional survey conducted in 6-7-year-old first grade children from public elementary schools in Shijingshan District, Beijing. Participants were invited to receive a clinical oral examination. The eruption status and caries experience of FPMs were recorded. Questionnaires assessing children's sociodemographic information and oral health-related behaviors were completed by the children's parents or guardians.

Results A total of 3,176 children, including 1,644 boys (51.8%) and 1,532 girls (48.2%) were included in the oral examination and questionnaire. Eruption status of FPMs was as follows: 37.5% fully erupted, 28.3% partially erupted, 34.2% not erupted. Girls had more erupted FPMs than boys (70.1% VS 61.8%, $P < 0.001$). The prevalence of dental caries in FPMs was 5.5% (174/3,176) in studied children. The mean decayed missing filled teeth score of FPMs was 0.11 and the mean decayed missing filled surface score of FPMs was 0.19. Binary Logistic regression analysis demonstrated that girls had more tooth decay than boys and father's educational background also associated with the caries experience of the studied children ($P < 0.05$).

Conclusions Around two-thirds of FPMs were fully erupted or partially erupted among children aged 6–7 years old in Shijingshan District, Beijing. Approximately 5% of the newly erupted FPM established dental caries. Effective intervention should be applied in this age group for oral health promotion.

Keywords Eruption, Caries, First permanent molars, Children, China

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Background

Dental caries is a worldwide chronic non-communicable disease [1]. According to the most recent National Oral Health Survey of China conducted in 2015, the mean decayed, missing and filled teeth (DMFT) score of Chinese 12-years-olds was 0.86 [2], which was still on the very low level from a global perspective. However, the prevalence of dental caries rocketed from 28.9% in 2005 [3] to 38.5% in 2015 [2], and the dental caries is still a major disease that affect the oral health of Chinese people [4]. From 2008, the central government of China started to invest annually in the National Oral Health Comprehensive Intervention Program (NOHCIP) for children, aiming to promote their oral health and control oral diseases [5]. The program provided a series of measures for oral health promotion, including training of dental workforce and conducting oral health education, regular oral health examination as well as pit-and-fissure sealants for 7-9-year-olds [5]. The expansion and extension of coverage of this national program was expected to be beneficial for improving oral health status in children and strengthening the dental workforce in some underdeveloped regions [5]. The program achieved some success in preventing dental caries. Data of 12-year-olds participating in the 4th National Oral Health Survey of China conducted in 2015 demonstrated lower prevalence of dental caries in regions covered by the national program than those not covered [5]. The Healthy China 2030 blueprint released by the Chinese government in 2016 aimed to decrease the prevalence of dental caries in 12-year-olds to 25% or lower by 2030 [6]. In addition, the General Office of State Council drafted and distributed the National Program for Chronic Disease Control and Prevention (2017–2025) (Chronic Diseases Program), another document for implementing the Healthy China 2030 Plan, aiming to reduce the prevalence of dental caries to 30% or lower in 2025 [7]. All these policies will guide mid-term to long-term efforts toward oral health promotion and provide good opportunities for the development of sustainable public oral health in China [8].

Beijing, China's capital, has always been the top performers in the control and prevention of dental caries nationwide. Since the pilot study of NOHCIP conducted in Beijing in 2005, the caries prevalence rate in 12-year-olds in Beijing was only 28.3% in 2015, 10% lower than the national average [9]. Unfortunately, there was some alarming trend in Beijing with the prevalence increased significantly to 31.6%, 32.2% and 34.9% in 2017, 2019 and 2021 respectively [10–12], making it a huge challenge to fulfill the dental caries prevention goal of the Healthy China 2030 Plan.

More than 90% of dental caries was confined to FPMs among school-aged children [2, 3]. The emergence of FPMs is an important developmental milestone

influencing caries risk and the timing of sealant placement [13]. A large scale epidemiological survey in 2015 reported that the percentage of fully erupted FPMs was 79.53%, 89.84% and 93.81%, and the prevalence of dental caries in FPMs was 12.18%, 16.83% and 19.61% among Chinese children aged 7,8,9 years, respectively [14]. Therefore, a considerable portion of FPMs have already been decayed before they can be sealed, and thus FPMs should be protected from the very onset of tooth eruption, earlier than 7–9 years old. The time of tooth eruption for FPMs was approximately six years of age. The majority of published epidemiological data on FPMs of 6–7 year old children focused on the prevalence of dental caries [15–17]. However, the eruption status are closely related to preventive interventions. Unfortunately, there were very few epidemiological surveys on the eruption and caries status of FPMs in children age 6–7 years [18].

The aim of the present study was to investigate the eruption and prevalence of dental caries of FPMs in children aged 6–7 years in Shijingshan District, Beijing, China, and to provide information for oral health promotion.

Methods

Study design and participants

The study was designed as a cross-sectional survey and conducted in Shijingshan District, Beijing, China from September 14th, 2022, through November 30th, 2022. There are 31 public elementary schools in Shijingshan District. Two of the schools are for children of migrant workers, which will be excluded from the study for the accuracy of local data. All non-migrant children in Grade One were invited to participate the study. Children with written informed consent from their parents or guardians were included. All procedures were performed in compliance with relevant laws and institutional guidelines and have been approved by the Ethics Committee of China Oral Health Foundation (approval number: COHF #2021-002).

Sample size

Based on previous report [14], the prevalence of dental caries on FPMs was estimated to be 10%. The minimal sample size needed was calculated to be 1,536 male or female participants, with a 95% confidence interval and a 5% margin of error. Therefore, the minimal sample size was required to be 3,072.

Caries examination

Clinical examinations were carried out under artificial light using dental mirrors and CPI (community periodontal index) probes. The eruption status, pit and fissure patterns and dental caries of FPMs were examined and recorded. The stage of eruption of FPM was recorded by

means of the following criteria: 1) unerupted; 2) partially erupted: erupted but not in full occlusion, and 3) full occlusion [19]. Pit and fissure patterns were categorized into (1) shallow pattern: Cuspal inclines meet at a wide angle. The base of the fissure is visible. No visible clefting between the cuspal inclines. (2) deep pattern: Cuspal inclines meet at a narrow angle. The base of the fissure is not visible. Slit-like clefting is visible between the cuspal inclines [20]. Dental caries was diagnosed according to the World Health Organization criteria [21]. Eight examiners completed training and were calibrated for clinical examination to ensure the validity and reliability of the data collection. 5% of the subjects were selected randomly for repeated tests by examiners to measure their consistency. The inter-and intra-examiner kappa values of all examiners were all greater than 0.7. Children were instructed by dentists to brush their teeth before the oral examination. The oral examination was carried out at school with children in a supine position. Examiners dried the surface of the teeth with cotton rolls and swabs. No radiography examinations were taken. After the oral examination, a report was sent to the child’s caretakers to inform them if the child needed treatment.

Questionnaire

The questionnaire was designed based on the National Oral Health Survey of China [2, 3] and included the following aspects: (a) children’s sociodemographic information (sex, the number of children in the family and parental educational background); (b) oral health-related behavior (frequency of toothbrushing, sweets intake and the use of dental floss). The questionnaire was completed by the parents or guardians of the participation children.

Data analysis

A statistical software package, SPSS Statistics (version 26, IBM), was used for data analysis. Descriptive statistics and frequencies of categorical variables, mean and standard deviation (SD) for continuous variables were reported on the individual level or tooth level. The prevalence of dental caries was the proportion of individuals with DMFT score ≥ 1 in the study population. Chi-square tests were used to analyze the relationship between the presence of caries and independent variables (sex, sibling, father’s educational background, mother’s educational background, frequency of toothbrushing habits, frequency of sweets intake and the use of dental floss).

All of the independent variables were included in binary logistic regression analysis to estimate the odds ratio (OR) and 95% confidence intervals (CI) for the association between caries and explanatory variables. *P* values less than 0.05 were considered statistically significant.

Results

Study population

In total, there were 3,204 non-migrant children aged 6–7 years in Grade One in public elementary schools in Shijingshan District. A total of 3,176 children, 1,644 boys (51.8%) and 1,532 girls (48.2%) were included in the study, who completed both the oral examination and the questionnaire. Those who were absent due to the Covid-19 pandemic, could not cooperate the oral examination or had no parental consent were excluded.

Eruption status of FPMs of the studied children

The eruption rate of FPMs was 65.8% (8,360/12,704). Girls had more erupted FPMs than boys (70.1% VS 61.8%, *P*<0.001) (Table 1). More than 70% of the mandibular FPMs had been erupted at the age of 6–7 years, while the eruption rate of the maxillary FPMs was approximately 60% (Fig. 1).

Caries experience of FPMs of the studied children

The prevalence of dental caries in FPMs was 5.5% (174/3,176) in studied children. The mean DMFT score of FPMs was 0.11 and the mean DMFS score of FPMs was 0.19. The caries prevalence of FPMs was 3.9% (64/1,644) among boys, while 7.2% (110/1,532) among girls. The caries experience was more severe in girls than in boys (*p*<0.05). Table 2 presents the distribution of dental caries in different locations and surfaces. The occlusal surfaces were the mostly affected surfaces of FPMs. Caries also often occurred on the buccal surface of lower teeth and the lingual surface of upper teeth.

The association between relevant variables and caries of FPMs

The response rate of questionnaire was 89.7% (2,849/3,176). The prevalence of dental caries of FPMs according to different contributing factors studied is shown in Table 3. It was found that fathers with higher educational background associated with a lower caries experience of FPMs in their children (*p*<0.001). Only 3.8% of the studied children used dental floss daily. The

Table 1 The percentage of first permanent molars according to the stage of eruption

Stage of eruption		total	boy	girl	<i>P</i> -value*
Non-erupted	No emergence in oral cavity	34.2%	38.2%	29.9%	<0.001
Partially erupted	Erupted but not in full occlusion	28.3%	28.1%	28.5%	0.79
Fully erupted	Full occlusion	37.5%	33.7%	41.6%	<0.001

* Chi-square test between se

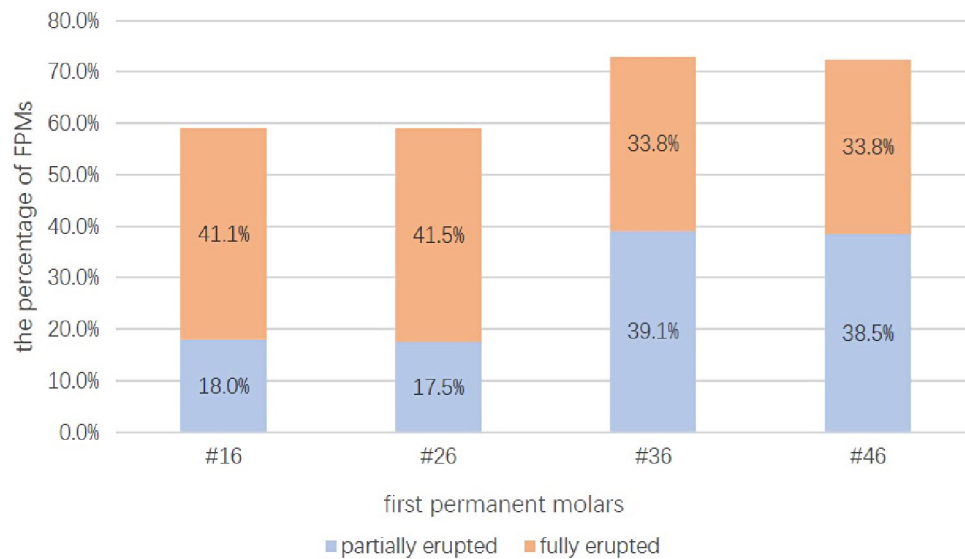


Fig. 1 The distribution of erupted first permanent molars

Table 2 The distribution of dental caries in different locations and surfaces

#16			#26			#36			#46		
O	P	MDB	O	P	MDB	O	B	MDL	O	B	MDL
1.5%	1.0%	0.4%	2.0%	1.5%	0.6%	3.6%	2.0%	0.7%	3.1%	1.8%	0.8%

O: Occlusal; P: Palatal; M: Missal; D: Distal; B: Buccal; L: Lingual

Table 3 The prevalence of dental caries of first permanent molars of the surveyed children according to different variables studied (N = 2,849)

Variable	N	Prevalence of dental caries of FPMs	P-value*
sibling	no	1,734	4.8%
	yes	1,115	6.4%
Father's educational background	High (college or above)	1,926	4.4%
	Low (senior school or below)	923	7.7%
Mother's educational background	High (college or above)	1,940	4.7%
	Low (senior high school or below)	909	6.9%
Frequency of toothbrushing	≥ 2/d	2,001	4.9%
	< 2/d	848	6.6%
Sweets intake	Everyday	234	6.4%
	Not everyday	2,615	5.4%
The use of dental floss	Everyday	109	1.8%
	Not everyday	2,740	5.6%

*Chi-square test

daily use of dental floss was found to be positively associated with a lower caries prevalence of PFMs ($P < 0.05$).

Children who brushed their teeth at least twice a day had lower caries prevalence of FPMs than those who brushed their teeth less than twice a day. A lower caries prevalence of FPMs was also found in children without siblings or daily sweets intake. However, no statistical significance was found in these variables ($P > 0.05$). Mother's educational background was found not significantly associated with the prevalence of dental caries of FPMs of the studied children ($P > 0.05$).

The results of the Binary Logistic regression analysis showed that sex and father's educational level contributed to the caries experience of FPMs of the studied children ($p < 0.05$). Girl exhibited a higher risk for FPM caries than boys ($P < 0.001$). It also showed that high educational level of father correlated with a lower caries experience of FPMs in their children ($p < 0.05$) (Table 4).

The eruption and caries status of the studied children

For all the FPMs emerged in oral cavity of the studied children, 43.0% of FPMs partially erupted and not yet been decayed. The rate of partially emerged mandibular

Table 4 Binary logistic regression analysis for the dental caries of first permanent molars of the surveyed children

Variables	OR	95%CI	P value
sex			
Boy*			
Girl	2.03	1.45–2.85	< 0.001
The only child in the family			
Yes*			
No	1.21	0.87–1.68	0.268
Father’s educational level			
High(college or above)*			
Low(senior high school or below)	1.71	1.16–2.52	0.007
Mother’s educational level			
High(college or above)*			
Low(senior high school or below)	1.08	0.73–1.61	0.697
Frequency of toothbrushing			
≥ 2/d*			
< 2/d	1.32	0.94–1.87	0.110
Sweets intake			
Everyday*			
Not everyday	1.02	0.58–1.79	0.942
The use of dental floss			
Everyday*			
Not everyday	2.51	0.61–10.32	0.203

* reference

FPMs was nearly twice that of the maxillary FPMs. In total, 37.8% of the erupted FPMs were in full occlusion and can be sealed. The percentage of fully erupted and sealable FPMs in the right maxillary, the left maxillary, the left mandibular and the right mandibular section was 47.3%, 47.7%, 29.6% and 30.3%, respectively. These teeth satisfied the indication for the pit and fissure sealants procedure. At the same time, 4.1% of the erupted FPMs had already been decayed or filled, including partially erupted and fully erupted ones. The distribution of the erupted FPMs with different stages of eruption and caries status of the surveyed children was shown in Table 5.

Discussion

This study has a large sample size, covering all non-migrant elementary schools in Shijingshan District of Beijing. Though there were very few children absent from the study, the studied sample can approximate the eruption and caries status of FPMs of the entire district. In addition, monitoring data from the past few years (2017,

2019 and 2021), the prevalence of dental caries in Shijingshan District has been similar to the average level in the city of Beijing [10–12]. Therefore, results based on children in the district may provide a glimpse into the conditions of the city of Beijing.

The time of eruption for FPMs of children is approximately six years of age [22] and erupted teeth are more susceptible to caries during the first one to three years after the eruption [23]. This study found that the prevalence of dental caries of FPMs was 5.5% among 6-7-year-old children. Therefore, the effective intervention should be applied closer to the very onset of tooth emergence.

This study showed that sex and father’s educational level correlated with the caries experience of the studied children. A higher prevalence of caries was found in girls and children from families with father of lower educational background. The 2005 and 2015 National Oral Health Survey of China also showed that girls exhibited more caries than boys in permanent dentitions [2, 3]. This may be greatly attributed to the earlier eruption of FPMs in girls than in boys [14]. It has been frequently reported that mother’s educational level associated with child’s caries status both in primary and permanent dentition [24, 25]. In our study, father’s education level showed a statistically significant correlation with caries experience among the studied children. Fathers may play more significant roles in their children’s dental hygiene practice in Beijing. Another study conducted in Wuhan, China, also found father’s education level plays an important role in their children’s oral health, mainly reflected due to on their responsibility on in managing financial issues for oral health care [26]. Studies have also suggested that low-education families are less diligent about dental care measures and regular preventive visits to dental professionals, resulting in the development of dental caries [26, 27]. Therefore, it is important to include fathers in oral hygiene promotion and education. It is also critical to do the promotion in low-income or families with lower parental education levels.

The contribution of pit and fissure sealants could effectively protect FPMs from caries [28, 29]. From a clinical perspective, it is noteworthy that the best indication for sealants is when FPMs have fully erupted. From our findings, the eruption rate of FPMs was 65.8% and only 24.9% of FPMs were fully erupted with no caries at the

Table 5 The distribution of the erupted first permanent molars with different stages of eruption and caries status of the surveyed children

Eruption status	Caries status	#16	#26	#36	#46	Total
Partially erupted	Non-decayed	30.4% (571/1,876)	29.7% (555/1,873)	53.7% (1,236/2,314)	53.2% (1,219/2,297)	43.0% (3,581/8,360)
	Decayed or filled	—	0.1% (2/1,873)	0.3% (6/2,314)	0.2% (4/2,297)	0.1% (12/8,360)
Fully erupted	Sealable	47.3% (887/1,876)	47.7% (893/1,873)	29.6% (686/2,314)	30.3% (697/2,297)	37.8% (3,163/8,360)
	Sealed or shallow fissures	19.5% (365/1,876)	19.0% (358/1,873)	11.6% (273/2,314)	12.0% (278/2,314)	15.1% (1,274/8,360)
	Decayed or filled	2.8% (53/1,876)	3.5% (65/1,876)	4.8% (113/2,314)	4.3% (99/2,297)	4.0% (330/8,360)

age of 6–7 years old. The main target population for the intervention of pit and fissure sealants in the ongoing NOHCIP was set at 7–9 years old. Although this may be beneficial in terms of saving time, manpower and resources, this may result in missed opportunity for the most optimal application of sealant and preventing potential tooth decay in some children. Our findings suggest that the sealant procedure should be performed at an earlier age among children in Beijing, which is consistent with findings from studies conducted in other cities in China [14, 30–33]. Furthermore, our results demonstrated that caries often occurred on the occlusal surface of maxillary and mandibular FPMs, the buccal surface of mandibular FPMs, and the lingual surface of maxillary FPMs, which is in agreement with the observations from a Chinese national survey in 2015 [14]. Therefore, when applying sealants, special attention should be paid to these high-caries risk tooth surfaces.

The stage of eruption and tooth-specific anatomy are two intra-oral factors for the occurrence and distribution of plaque accumulation [19]. The erupting FPMs are the most caries-prone teeth due to favorable conditions for plaque accumulation [19]. The complex fissures of FPMs are partially covered by gingiva for a considerable period of time [34]. The vulnerability is also attributed to incomplete post eruptive maturation of the enamel [35] and lack of awareness of the tooth emergence [36]. The time between eruption and full functional occlusion is the most important period for maintenance of tooth integrity. The preservation of these non-decayed partially and fully erupted FPMs is of prime importance for the control of dental caries in permanent dentition. Our study found a considerable number of partially erupted FPMs with no caries at this age. In terms of the difficulty in controlling humidity for erupting teeth, the topical application of fluoride on erupting FPMs is desirable to reduce the caries attack to FPMs both clinically and economically favorable [37–41]. In addition, it is necessary to strengthen oral health education and oral hygiene instruction for both children (both girls and boys) and their parents, including both fathers and mothers. This is also an important supplementary measure for oral health promotion. The vast majority of children in China go to elementary school at 6–7 years of age. From then on, children will receive more systematic education in school, which is also a critical period for the formation of oral health behavior.

Though the results of this study can provide some information for the prevention of dental caries in school-age children, there are inevitable some limitations. First and foremost, this survey was a local study. Whether the results of this local study can be generalized to other regions need further more studies for confirmation. Second, as the fissure pattern and eruption status were reported as the associated factors to dental caries [34, 42,

43], the result of our binary logistic regression analyzed association between caries and explanatory variables on subject level without adjusting the factor at tooth level (sealed or not sealed, partial erupt or fully erupt), which may contain certain bias. Last but not least, the cross-sectional study can only provide the distribution of conditions in a specific population at a specific time point and within a specific range, regular and extensive researches will be needed. Our future studies will concentrate on the severity of dental caries of FPMs and clinical trials for caries prevention .

Conclusions

In conclusion, around two-thirds of FPMs were fully erupted or partially erupted among children aged 6–7 years old in Shijingshan District, Beijing. Approximately 5% of the newly erupted FPM established dental caries. Effective intervention should be applied in this age group for oral health promotion.

Abbreviations

FPMs	First Permanent Molars
CPI	Community Periodontal Index
NOHCIP	National Oral Health Comprehensive Intervention Program
DMFT	Decayed, Missing and Filled Teeth
DMFS	Decayed, Missing and Filled Surfaces

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Author contributions

MZ did the literature review and drafted the manuscript. ZW conceived and designed the study, did the data analysis and substantively revised the paper. ML trained and calibrated the examiners. ZS, RW and LY organized and conducted the study. All authors reviewed the manuscript.

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Data availability

The datasets analyzed during the current study are not publicly available due to privacy but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The approval of the design and procedure of this study was obtained from the Ethics Committee of the China Oral Health Foundation (approval number: 2021-003). The informed consent was obtained from all participants in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

- WHO. Global status report on noncommunicable diseases 2014.
- Wang X. Report of the Fourth National oral health survey. 1st ed. Beijing. People's Medical Publishing House; 2018. p. 39.
- Qi X, Report Of The Third National Oral Health Survey. 2008. 1st ed. Beijing. People's Medical Publishing House. 16.
- Hu DY, Hong X, Li X. Oral health in China—trends and challenges. *Int J Oral Sci*. 2011;3(1):7–12.
- Yuan C, Wang XZ, Sun XY, et al. Oral Health Status of 12-year-olds from regions with and without Coverage of the National Oral Health Comprehensive Intervention Program for children in China. *Chin J Dent Res*. 2018;21(4):299–306.
- The State Council of China. The blueprint of health plan during the 13th five-year plan period. http://www.govcn/zhengce/content/2017-01/10/content_5158488.htm
- The General Office of State Council of China. National Program for Chronic Disease Control and Prevention. (2017–2025). http://www.govcn/zhengce/content/2017-02/14/content_5167886.htm
- Zhou X, Xu X, Li J, et al. Oral health in China: from vision to action. *Int J Oral Sci*. 2018;10(1):1.
- Beijing has sealed for more. Than 3 million school-age children, which is the best in the country. <https://baijiahao.baidu.com/s?id=1697089122879689943&is=spider&for=pc>, access 2018.9.20.
- Beijing Municipal People's Government. Report on hygiene and health of population in Beijing. Beijing. People's Medical Publishing House; 2018.
- Beijing Municipal People's Government. Report on hygiene and health of population in Beijing. Beijing. People's Medical Publishing House; 2020.
- Beijing Municipal People's Government. Report on hygiene and health of population in Beijing. Beijing. People's Medical Publishing House; 2022.
- Pahel BT, Vann WF Jr, Divaris K, Rozier RG. A contemporary examination of First and Second Permanent Molar Emergence. *J Dent Res*. 2017;96(10):1115–21.
- Chunxiao W, Yang Y, Qi Z, Xuenan L. Eruption and caries prevalence of first permanent molar in Chinese children aged 7–9 years. *Chin J Public Health*. 2016;32(5):599–601.
- Zhang Q, van Palenstein Helderman WH. Caries experience variables as indicators in caries risk assessment in 6-7-year-old Chinese children. *J Dent*. 2006;34(9):676–81.
- Wang Z, Rong W, Zhang Y, Zeng X, Li Z, Liu Z. Prevalence and contributing factors of dental caries of 6-year-old children in four regions of China. *PeerJ*. 2019;7:e6997.
- Jian Z, Xue L, Deyu H, Ximu Z, Songlin H. Caries status of primary and permanent teeth among 6-year-old children in Sichuan Province and their correlatio. *West China J Stomatology*. 2012;30(02):214–6.
- Yaegaki K, Masuda T, Suetaka T, Akamatu T. Correlations between first molar eruption, caries incidence and caries experience in primary school children. *Shigaku*. 1989;77(2):672–81.
- Carvalho JC, Ekstrand KR, Thylstrup A. Dental plaque and caries on occlusal surfaces of first permanent molars in relation to stage of eruption. *J Dent Res*. 1989;68(5):773–9.
- Symons AL, Chu CY, Meyers IA. The effect of fissure morphology and pretreatment of the enamel surface on penetration and adhesion of fissure sealants. *J Oral Rehabil*. 1996;23(12):791–8.
- World Health Organization. Oral health surveys- basic methods. 2013. 5th ed. Geneva. WHO.
- Ekstrand KR, Christiansen J, Christiansen ME. Time and duration of eruption of first and second permanent molars: a longitudinal investigation. *Community Dent Oral Epidemiol*. 2003;31(5):344–50.
- Abernathy JR, Graves RC, Greenberg BG, Bohannon HM, Disney JA. Application of life table methodology in determining dental caries rates. *Community Dent Oral Epidemiol*. 1986;14(5):261–4.
- Paula JS, Rodrigues PA, Mattos FF, Abreu M, Chalub L, Zina LG. Mother's education and family relations protect children from dental caries experience: a salutogenic approach. *Braz Oral Res*. 2022;36:e111.
- Verris GH, Kalsbeek H, Eijkman MA. Ethnicity and maternal education as risk indicators for dental caries, and the role of dental behavior. *Community Dent Oral Epidemiol*. 1993;21(4):209–14.
- Chen L, Hong J, Xiong D, et al. Are parents' education levels associated with either their oral health knowledge or their children's oral health behaviors? A survey of 8446 families in Wuhan. *BMC Oral Health*. 2020;20(1):203.
- Dumitrescu R, Sava-Rosianu R, Jumanca D, et al. The Impact of Parental Education on Schoolchildren's oral Health-A Multicenter cross-sectional study in Romania. *Int J Environ Res Public Health*. 2022;19(17):11102.
- Bravo M, Baca P, Llodra JC, Osorio E. A 24-month study comparing sealant and fluoride varnish in caries reduction on different permanent first molar surfaces. *J Public Health Dent*. 1997;57(3):184–6.
- Ahovuo-Saloranta A, Forss H, Walsh T, Nordblad A, Mäkelä M, Worthington HV. Pit and fissure sealants for preventing dental decay in permanent teeth. *Cochrane Database Syst Rev*. 2017;7(7):CD001830.
- Lei W, Jun L, Yanbo W, Songjie Z. Oral health status and pit and fissure sealant of children aged 7–9 years in Xi'an. 2018;39(10):1589–91.
- Fengjuan L, Jian H, Biansheng Y, Jing S, Xu W. The caries and fissure sealant of first permanent molars among children aged 7–9 years in Henan Province. *Chin J Sch Health*. 2017;38(04):586–8.
- Lin L, Buling W, Wenan X, Wanghong Z, Hui Z, Liang X. Eruption and caries of first permanent molars in children aged 6–10 years in Baiyun District, Guangzhou. *Chin J Conservative Dent*. 2013;23(04):275–7.
- Xue Y, Yuanbo Y, Qing D, Yan L. Eruption and caries of first permanent molars in children aged 6–9 years in Tangshan. *Chin J Conservative Dent*. 2015;25(12):739–42.
- Zenkner JE, Alves LS, de Oliveira RS, Bica RH, Wagner MB, Maltz M. Influence of eruption stage and biofilm accumulation on occlusal caries in permanent molars: a generalized estimating equations logistic approach. *Caries Res*. 2013;47(3):177–82.
- Driessens FC, Heijligers HJ, Borggreven JM, Wöltgens JH. Post-eruptive maturation of tooth enamel studied with the electron microprobe. *Caries Res*. 1985;19(5):390–5.
- Lynch RJ. The primary and mixed dentition, post-eruptive enamel maturation and dental caries: a review. *Int Dent J*. 2013;63(Suppl 2):3–13.
- Wang Z, Rong W, Xu T. Effect of Fluoride Varnish in preventing Dental Caries of First Permanent molars: a 24-Month Cluster Randomized Controlled Trial. *Int J Environ Res Public Health*. 2022;19(24):16656.
- Abreu-Placeres N, Garrido LE, Castillo Jáquez I, Félix-Matos LE. Does applying Fluoride Varnish Every three months better prevent caries lesions in Erupting First Permanent molars? A Randomised Clinical Trial. *Oral Health Prev Dent*. 2019;17(6):541–6.
- Suwansingha O, Rirattanapong P. Effect of fluoride varnish on caries prevention of partially erupted of permanent molar in high caries risk. *Southeast Asian J Trop Med Public Health*. 2012;43(3):808–13.
- Ladewig NM, Camargo LB, Tedesco TK, et al. Management of dental caries among children: a look at the cost-effectiveness. *Expert Rev Pharmacoecon Outcomes Res*. 2018;18(2):127–34.
- Schwendicke F, Splieth CH, Thomson WM, Reda S, Stolpe M, Foster Page L. Cost-effectiveness of caries-preventive fluoride varnish applications in clinic settings among patients of low, moderate and high risk. *Community Dent Oral Epidemiol*. 2018;46(1):8–16.
- Alves LS, Zenkner JE, Wagner MB, Damé-Teixeira N, Susin C, Maltz M. Eruption stage of permanent molars and occlusal caries activity/arrest. *J Dent Res*. 2014;93(7 Suppl):S114–9.
- Wang JD, Chen X, Frencken J, Du MQ, Chen Z. Dental caries and first permanent molar pit and fissure morphology in 7- to 8-year-old children in Wuhan, China. *Int J Oral Sci*. 2012;4(3):157–60.

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