

# Eruption Status and Caries Condition of the First Permanent Molars in Chinese Children

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**Objective:** *To determine whether the targeting age should be adjusted for the National Children's Pit and Fissure Sealant (PFS) Programme.*

**Methods:** *Statistical analysis was conducted on the results of oral health examination results of school-aged children in regions covered by the National Children's Oral Disease Comprehensive Intervention Programme (NCODCIP) in 2018. We analysed the eruption status and dental caries condition of the children's four first permanent molars (FPMs) and performed statistical tests for the data.*

**Results:** *Data analysis from 811,855 children aged 6 to 9 years showed that the complete eruption rate (CER) of the FPMs in Chinese children aged 6 years was 67.2%, and reached 94.1% by age 9. Before the implementation of the PFS Programme, the prevalence of dental caries in 6-year-olds was 11.0%, and 23.2% by age 9. Caries prevalence was higher in girls than boys. The growth rate of caries prevalence slowed with age.*

**Conclusion:** *Our study indicated that the eruption time of FPMs in Chinese children has been earlier than predicted, and the caries prevalence was more severe than expected. Therefore, it is recommended that the targeting age for the National PFS Programme be lowered from 7 years old to 6 years old.*

**Keywords:** *caries prevalence, complete eruption rate, first permanent molars, pit and fissure sealant*

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Dental caries is one of the most common chronic diseases worldwide.<sup>1</sup> Although its prevalence in 12-year-old children in China is still low,<sup>2</sup> there has been a significant increase over the past few decades, from 28.9% in 2005 to 38.6% in 2015.<sup>3,4</sup> Around 60% to 80% of dental caries occur in the first permanent molars (FPMs), making preventing caries lesions in these teeth extremely important.<sup>5-7</sup> In 2008, the Chinese government launched its first major public health programme related to oral

health: a school-based free oral examination and Pit and Fissure Sealant (PFS) Programme aimed at reducing the prevalence of dental caries among children. By 2018, the programme had been in operation for 10 years. The programme consists of two steps: the first involves conducting free oral examinations for school-age children, and the second involves applying fissure sealants to children whose FPMs have fully erupted and meet the criteria for fissure sealing. Oral examinations are conducted annually, and children whose FPMs have not fully erupted at the time of examination will be re-examined a year later. Since it is generally believed that the FPMs of 6-year-olds rarely fully erupt, the programme has primarily targeted children aged 7 to 9 years (typically second to fourth graders in China) since its inception in 2008. Due to oral examinations being typically conducted at the class level, we also had the opportunity to record data from some additional age groups, mainly on the eruption and caries status of 6-year-old children.

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This study aimed to analyse the eruption status and dental caries conditions of the FPMs of children aged 6 to 9 years in China in 2018, to understand the changes and trends in the caries of FPMs in Chinese children and to explore the appropriate age for conducting the PFS Programme among school-aged children in China, providing valuable information for caries prevention.

## Materials and methods

### Data resources

This study utilised oral examination data collected in 2018 from all 6 to 9-year-old children in areas covered by the National Children's Oral Disease Comprehensive Intervention Programme (NCODCIP). In 2008, the central government initially launched the Children's Oral Disease Comprehensive Intervention Project in the central and western regions of China. By 2014, the project had expanded to cover the entire country, and by the end of 2018, it had been in operation for 10 years. In 2018, the project covered 1,213 project counties (cities and districts) across 31 provincial-level administrative units nationwide, including the Xinjiang Production and Construction Corps, involving a total of 12,153 schools.

### Clinical examinations

The study followed the Basic Method for Oral Health Survey (5th edition) recommended by the World Health Organization (WHO).<sup>8</sup> The parents of the participating children all signed informed consent forms. The oral examination included the eruption status and caries conditions of the four FPMs. Trained dental professionals conducted oral health examinations on the participating children under artificial light, using a combination of visual inspection and probing. The examination instruments included a plane mirror and a Community Periodontal Index (CPI) probe, and a cotton swab was used when necessary to remove soft deposits from the tooth surface. To ensure the quality of the project, all examiners involved were required to undergo rigorous standard training. After training, the examiners were assessed by the training institution using a consistency test between the reference examiner and the examiners themselves. Only those whose Kappa value exceeded 0.8 in the consistency test passed the assessment and were allowed to participate in oral examinations.

The overall caries status and experience was assessed by calculating the decayed, missing, and filled teeth (DMFT) index, including separate calculations of

decayed teeth (DT), missing teeth (MT) and filled teeth (FT) for permanent teeth.

### Indicator definition

The complete eruption rate (CER) for FPMs was the percentage of individuals in whom all four FPMs had fully erupted at the time of oral examination; caries prevalence for FPMs was the percentage of individuals with at least one decayed FPM among all examined individuals; and DMFT for FPMs was the mean number of FPMs that were decayed, missing due to caries and filled due to decay per person.

### Statistical analysis

Data analysis was performed using SAS 9.4 software (SAS Institute, Cary, NC, USA). Categorical variables were presented as numbers (percentages), and continuous variables were expressed as mean  $\pm$  standard deviation (SD). The mean DMFT of the FPMs showed a skewed distribution, and a Mann-Whitney U test (Wilcoxon Rank-Sum Test) was used for group comparisons. The complete eruption rate and caries prevalence of the FPMs were compared between groups using a chi-square test. A *P* value of less than 0.05 was considered statistically significant.

## Results

### Demographic characteristics

A total of 811,855 children were examined in this study. The age distribution was as follows: 40,967 children (5.0%) were 6 years old, 274,950 (33.9%) were 7 years old, 350,190 (43.1%) were 8 years old and 145,748 (18.0%) were 9 years old. In terms of sex distribution, there were 427,247 boys (52.6%) and 384,608 girls (47.4%) (Table 1).

### Eruption status of FPMs

The CER of the FPMs was 67.2% (95% confidence interval [CI] 66.7% to 67.7%) at the age of 6, 78.7% (95% CI 78.5% to 78.8%) at the age of 7, 89.2% (95% CI 89.1% to 89.3%) at the age of 8 and 94.1% (95% CI 94.0% to 94.3%) at the age of 9. With the exception of the age 9 group, the CER of the FPMs was higher in girls than boys across other age groups, with statistically significant differences ( $P < 0.0001$ ) (Table 2).

**Table 1** Demographic information for children aged 6 to 9 years by sex and age group.

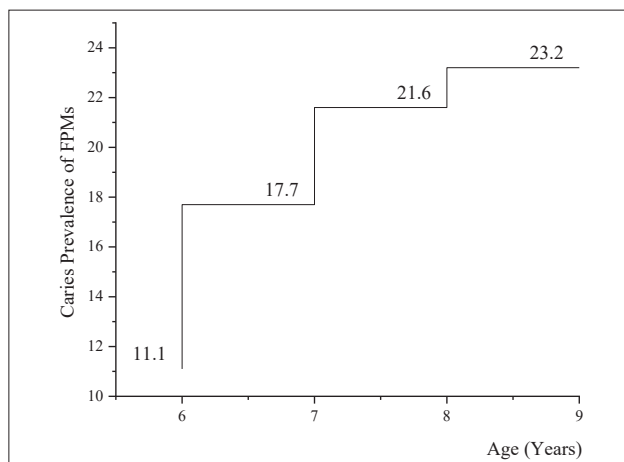
| Variable      | n       | %       |
|---------------|---------|---------|
| Total         | 811,855 | 100.0   |
| Sex           | Male    | 427,247 |
|               | Female  | 384,608 |
| Age group (y) | 6       | 40,967  |
|               | 7       | 274,950 |
|               | 8       | 350,190 |
|               | 9       | 145,748 |

**Table 2** CERs of the FPMs in children aged 6 to 9 years by sex and age group (%).

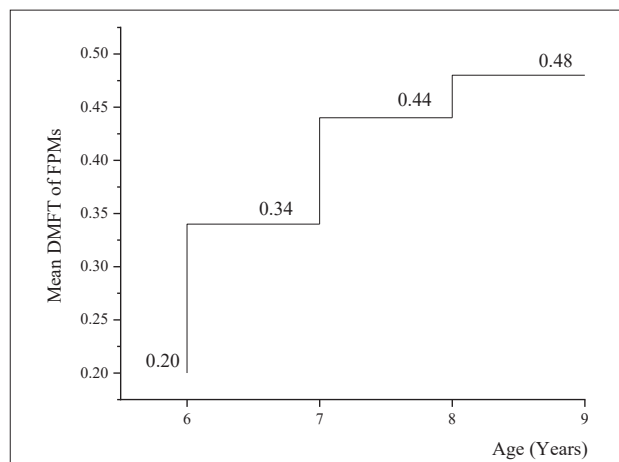
| Age (y) | 6                 | 7                 | 8                 | 9                 |
|---------|-------------------|-------------------|-------------------|-------------------|
| Total   | 67.2 (66.7, 67.7) | 78.7 (78.5, 78.8) | 89.2 (89.1, 89.3) | 94.1 (94.0, 94.3) |
| Male    | 65.8 (65.2, 66.5) | 77.5 (77.3, 77.7) | 88.7 (88.6, 88.9) | 94.1 (94.0, 94.3) |
| Female  | 68.4 (67.8, 69.1) | 80.0 (79.8, 80.2) | 89.8 (89.7, 90.0) | 94.1 (94.0, 94.3) |
| Pvalue  | < 0.0001          | < 0.0001          | < 0.0001          | 0.7931            |

**Table 3** Caries prevalence in the FPMs of children aged 6 to 9 years by sex and age group.

| Age (y) | 6                 | 7                 | 8                 | 9                 |
|---------|-------------------|-------------------|-------------------|-------------------|
| Total   | 11.1 (10.7, 11.4) | 17.7 (17.6, 17.9) | 21.6 (21.5, 21.8) | 23.2 (23.0, 23.5) |
| Male    | 10.1 (9.7, 10.6)  | 15.9 (15.7, 16.0) | 19.3 (19.1, 19.5) | 21.1 (20.9, 21.4) |
| Female  | 11.9 (11.5, 12.4) | 19.7 (19.5, 19.9) | 24.3 (24.1, 24.5) | 25.7 (25.4, 26.1) |
| Pvalue  | < 0.0001          | < 0.0001          | < 0.0001          | < 0.0001          |



**Fig 1** Trend for caries prevalence in the FPMs of children aged 6 to 9 years (%).



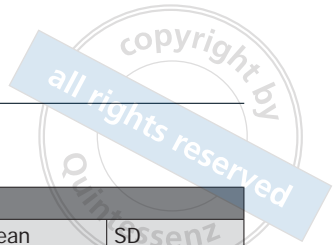
**Fig 2** Trend for mean DMFT in the FPMs of Chinese children aged 6 to 9 years.

### Caries condition of FPMs

The caries prevalence in the FPMs of children aged 6, 7, 8 and 9 years was 11.1% (95% CI 10.7% to 11.4%), 17.7% (95% CI 17.5% to 17.9%), 21.6% (95% CI 21.5% to 21.8%) and 23.2% (95% CI 23.0% to 23.5%), respectively. In all age groups, the prevalence of dental caries in the FPMs was higher in girls than in boys, with statistically significant differences (Table 3). The caries prevalence increased significantly between the ages of 6 and 7 years

and 7 and 8 years, while the increases were smaller between ages 8 and 9 years (Fig 1).

The mean DMFT of the FPMs gradually increased with age; for children aged 6, 7, 8 and 9 years, it was  $0.20 \pm 0.65$ ,  $0.34 \pm 0.85$ ,  $0.44 \pm 0.97$  and  $0.48 \pm 1.01$ , respectively. The mean DMFT of the FPMs in girls was significantly higher than in boys across all age groups ( $P < 0.05$ ) (Table 4). The trend in the increase of the mean DMFT was similar to that of the caries prevalence; that was, the growth rate slowed with age (Fig 2).



**Table 4** Mean DMFT of the FPMs in children aged 6 to 9 years by sex and age group.

| Age (y) | 6        |      | 7        |      | 8        |      | 9        |      |
|---------|----------|------|----------|------|----------|------|----------|------|
|         | Mean     | SD   | Mean     | SD   | Mean     | SD   | Mean     | SD   |
| Total   | 0.20     | 0.65 | 0.34     | 0.85 | 0.44     | 0.97 | 0.48     | 1.01 |
| Male    | 0.19     | 0.63 | 0.30     | 0.80 | 0.38     | 0.91 | 0.43     | 0.96 |
| Female  | 0.22     | 0.66 | 0.39     | 0.90 | 0.51     | 1.04 | 0.54     | 1.07 |
| P value | < 0.0001 |      | < 0.0001 |      | < 0.0001 |      | < 0.0001 |      |

## Discussion

Permanent tooth decay has always been one of the most common chronic diseases in the world, affecting hundreds of millions of people and imposing a heavy economic burden on governments and society.<sup>9,10</sup> Compared to data from a previous study<sup>11</sup> conducted in 2014, the present study showed that the caries prevalence of FPMs increased from 12.2% to 17.7% in 7-year-old children, from 16.8% to 21.6% in 8-year-old children, and from 19.6% to 23.2% in 9-year-old children. The present authors also found that the caries prevalence in the FPMs in 6-year-old children had reached approximately 11.1%, indicating that some permanent teeth develop caries soon (within a year) after eruption. Therefore, it is crucial to closely monitor the crucial period from FPM eruption to caries occurrence and to implement appropriate preventive and intervention measures during this stage.

Our findings indicated that the eruption time of permanent molars was associated with their caries incidence, which was consistent with previous studies.<sup>12,13</sup> The caries prevalence and mean DMFT in girls were significantly higher than in boys, aligning with the trend of earlier eruption of permanent teeth in girls. Additionally, differences in dietary habits and oral hygiene practices between sexes may also contribute to this disparity. The eruption characteristics and caries prevalence of the FPMs observed in our study were consistent with recent findings in other regions, such as African areas.<sup>6</sup> Thus, it is important to monitor the eruption patterns of FPMs and identify factors that influence them.

Although most permanent teeth develop caries 2 to 4 years after eruption, the onset of caries begins when the teeth first erupt. Monitoring changes in eruption time is crucial for implementing effective public health programmes. Previous studies have indicated that children’s FPMs begin to erupt at around the age of 6 years. One study reported the mean eruption time of FPMs to be 6.3 years.<sup>14</sup> In 2008, the eruption rate of the FPMs in 6-year-old children in China was only 22.09%.<sup>15</sup> Based on these findings, China launched a free school-based

oral examination and PFS programme in 2008 targeting children aged 7 to 9 years, excluding 6-year-olds. However, the eruption time of FPMs is not fixed and is influenced by various factors, including genetics, sex, oral and nutritional status, and external environment.<sup>13</sup> Previous reports have suggested obesity is related to tooth eruption, including the eruption times of the first and second permanent molars.<sup>12</sup> Other studies have pointed out that socioeconomic status, body composition and other factors could affect tooth eruption times.<sup>16</sup>

Our study showed that the eruption time of permanent teeth in Chinese children has become earlier, with 67.2% of 6-year-olds having all four FPMs fully erupted. This change indicates that the risk period for dental caries in children has also become earlier, necessitating adjustments in preventive measures and strategies.

School-based PFS programmes have proven effective and cost-efficient in preventing dental caries.<sup>17-19</sup> Applying sealants when FPMs have just fully erupted is most effective. With the development of China’s economy and the increasing health demands of its citizens, the Chinese government has implemented a series of public health projects to promote health. In 2008, the central government began to invest annually in a national comprehensive oral health intervention programme for children that aimed to promote oral health, control oral diseases and explore and establish mechanisms for the construction of regional oral health teams. This was the first national oral health project supported by the Chinese government, marking a significant milestone. The project provides free dental examinations for children aged 7 to 9 years and offers free pit-and-fissure sealing for the FPMs for those who meet the indications. Although the coverage of the pit-and-fissure sealing programme is not as high as in some other developing countries, the incidence of caries in areas covered by the programme is significantly lower than in areas not covered, fully demonstrating its effectiveness.<sup>20</sup> Applying pit-and-fissure sealing measures when the FPM has just fully erupted is most effective; however, the existing programme targets children aged 7 to 9 years, which means that many

6-year-old children miss the optimal timing for intervention. By the time they reach the eligible age, some children have already developed caries. Given that most 6-year-olds now have erupted FPMs, it is necessary to adjust the target age range of the programme to include younger children.

In response to these findings, similar policy recommendations have been made in other countries,<sup>21,22</sup> and the central government has now adopted this suggestion, expanding the target age range of the school-based PFS programme to include children aged 6 to 9 years. This adjustment aims to enhance the effectiveness of the programme by providing timely interventions during the critical period of FPM eruption.

Despite the proven effectiveness of the programme, challenges remain. School-based oral public health programmes are usually conducted once a year, and parents often do not pay sufficient attention to their children's oral health or are not in the habit of taking them for regular dental check-ups. This situation makes it difficult to accurately and promptly determine the eruption time of children's FPMs, limiting the timeliness of pit-and-fissure sealing. To address this issue, we suggest increasing the frequency of oral examinations from once a year to once a quarter. This change would allow children to receive pit-and-fissure sealant within a short period (within 3 months) after the FPMs have fully erupted. Additionally, with advancements in artificial intelligence technology, digital and intelligent oral health screening methods can be adopted to promptly remind parents to take their children for dental check-ups and pit-and-fissure sealing immediately after FPM eruption.

Moreover, the prevention and treatment of FPM caries cannot rely solely on school-based PFS interventions. Comprehensive measures should be strengthened, such as actively preventing and treating primary tooth caries before FPM eruption and maintaining good oral hygiene during the tooth replacement period.<sup>23,24</sup> Strengthening oral health education for parents is crucial; by encouraging them to value, supervise and monitor their children's oral hygiene, preventive interventions can become more routine and family orientated.

Considering that girls' teeth usually erupt earlier and our study found higher caries rates in girls, oral health education should focus more on them. Parents of girls should closely monitor the eruption of the FPMs. Providing targeted oral health education to parents and utilising digital technology to inform them promptly about relevant information can encourage them to pay more attention to their daughters' tooth eruption and caries status. Cultivating good dietary and oral hygiene

habits in children and ensuring timely PFS can significantly reduce the risk of caries.

Our study emphasised the need for earlier and more comprehensive preventive measures to address the rising caries prevalence in FPMs in children. By adjusting existing programmes to include younger children, increasing examination frequency, leveraging technological advancements and strengthening parental education, we can better protect children's oral health and reduce the burden of dental caries on society.

## Conclusion

This study showed that 67.2% of 6-year-old children had fully erupted FPMs, and the caries prevalence in FPMs in 6-year-olds had reached 11.0%. Given that the eruption time of the FPMs among Chinese children has advanced compared to previous years, including 6-year-old children (mainly first graders in China) in the school-based PFS programme and increasing the frequency of oral examinations would be of great importance for preventing caries in children's FPMs.

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## Conflicts of interest

The authors declare no conflicts of interest related to this study.

## Author contribution

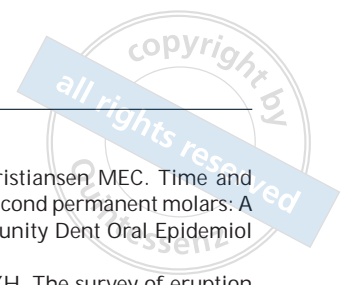
Dr Yang YANG conducted the statistical analysis and drafted the manuscript; Dr Xue Nan LIU supervised the research and provided valuable guidance; Dr Chun Xiao WANG designed the study, drafted and revised the manuscript. All the authors read and approved the final version.

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