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A cross-sectional investigation on oral health and hygiene among children aged 7–10 years in extremely high altitude areas of China

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To investigate the oral health status and awareness of oral hygiene practices among children aged 7–10 years in Ngari, Tibet province, China. A cross-sectional study of first grade children aged 7–10 years, investigated for dental examination from March 2021 to September 2021. The decayed-missing-filled tooth index (DMFT) was used to describe the severity of caries in the first molar. Oral hygiene, occlusion, dentition, and caries were analyzed. Questionnaires were distributed to investigate their oral health awareness, and 698 valid questionnaires were collected. Children's oral hygiene is poor at this high altitude. The DMFT of the first molar was 0.57 ± 0.924 for males and 0.65 ± 0.924 for females. Additionally, the DMFts were 0.44 ± 0.785, 0.64 ± 0.920, 0.67 ± 0.926, and 0.61 ± 1.055 for aged 7–10, respectively. There was no statistically significant difference between gender and age in first molar caries. The analysis of the results found significant differences ($p < 0.01$) in the oral health status of children aged 8–9 who were poor, with better results in girls. Dentition crowding differed among the different age groups ($p < 0.05$). Importantly, the age of 8 was significant, but no difference in gender was observed. The occlusal relationship had no statistical difference in age and gender. The qualification rate of brushing teeth twice a day was still infrequent: 28.9% brushed less than once, 28.2% once a day, and 42.8% brushed twice daily. Brushing frequency was different ($p < 0.01$) between the age groups. Local children had poor oral hygiene at this high altitude. Therefore, reasonable health education and intervention measures should be taken seriously.

Keywords Oral health, Dental caries, Child, Tibet, Epidemiology

Oral health is integral to human health and depends on good health behaviors and awareness. Poor hygiene leads to dental caries, periodontitis, halitosis, and the digestive and respiratory diseases[1–4]. Dental caries, a common prevalent disease, is the primary cause of tooth loss and toothache, often resulting from inadequate brushing, infrequent dental check-ups, and a lack of oral health knowledge[2,5–7]. Dental caries are also associated with socioeconomic status, nationality, education, income, and cultural background[8–10]. Consequently, children are at high risk of dental caries and its associated inequalities[11]. The 2017 Chinese survey showed that the prevalence of deciduous teeth in children aged 5 was 71.9%. Moreover, the percentage of permanent teeth in children aged 12 was 38.5%, a significant increase over the previous decade[12]. Childhood dental caries intervention is urgently needed, as this period is critical for cultivating oral health behaviors and concepts[13,14].

Ngari, located in the western part of the Qinghai-Tibet Plateau, has a population of 123,000 within an area of 337,170 square kilometers. The residents are primarily nomadic herders living at altitudes exceeding 4000 m. Additionally, the region has limited external communication, and its religious beliefs and dietary taboos differ significantly from other areas[15]. According to social investigations, Ngari has fewer than 10 certified dentists per 100,000 people, significantly fewer than Japan's 70 per 100,000[16]. Epidemiological studies in this region face considerable challenges. National data indicate that Tibetans have a higher caries rate than Han children

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aged 10–12 years, with Tibetans' DMFT score at 2.17 versus 0.97 for Han children[17]. However, these oral health behaviors and awareness were not invested in children aged 7–10. Compared with urban and developed areas, due to its geographical location and dispersed population this area's intervention is hard to implement[7]. A 2020 survey showed that the filling rate of adult Tibetans is only 1–2%[18]. suggesting that poor oral health awareness among adults may negatively impact children's outcomes[4]. While most dental caries studies in high-altitude zones (3000–3500 m) include locations like Lhasa, Nagqu, Nepal, and India. However, there are no relevant data for studies above 4000 m in this area. And all current data are limited to population concentrations; none are available for herders at these high altitudes.

The first molar plays a pivotal role in establishing the occlusion, which has always been emphasized by dentists. At the age of 7–10 years, the first molar has erupted, and children's cognitive abilities and attention have significantly improved. Therefore, intervening in this age group can lay a strong foundation for their future oral health. Due to the inequalities of caries in children and the inadequacy of children surveys in these extremely high altitude areas, our team conducted a cross-sectional survey on caries, oral health status, and oral health awareness of 7–10 children.

Material and methods

General information

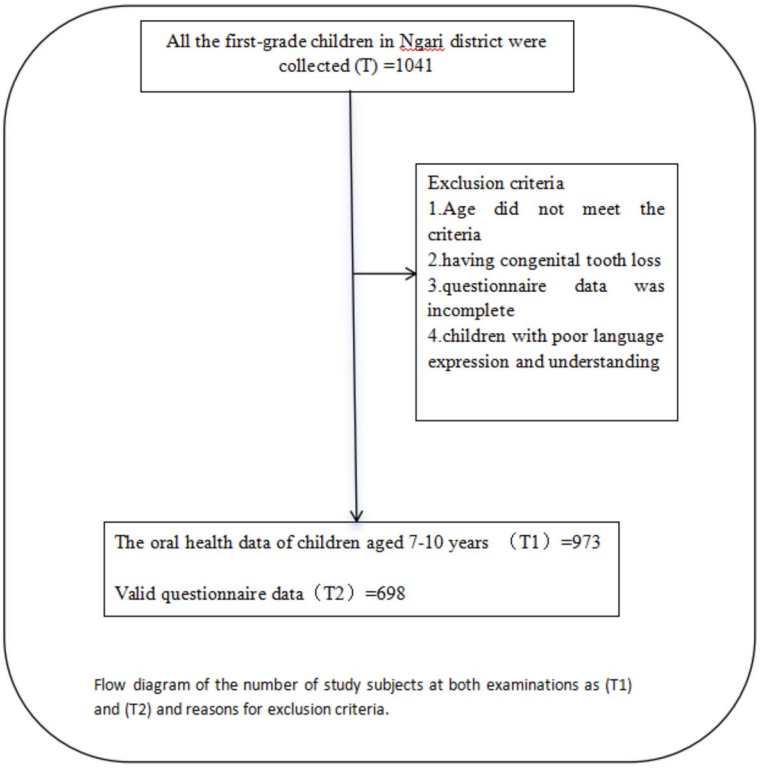
This study collected oral health data from children living in Ngari, Tibet Province, China. It is from seven counties in the Ngari region: Gaer, Ritu, Gaize, Pulan, Cuoqin, Geji, and Zada. We did a general census of children in grade one of local primary schools. A total of 1041 children were collected.

Epidemic survey population

Overall, 973 children aged 7–10 years were included in this study. Subsequently, we conducted a primary questionnaire on oral health awareness for these children and collected 698 valid responses. The effective questionnaire recovery rate was 71.7%. The questionnaire was accompanied by their parents or under the guidance of their teachers, all child surveys and questionnaires were authorized by their guardians. Elimination criteria for questionnaire screening: ① Age did not meet the criteria; ② having congenital tooth loss; ③ the questionnaire data was incomplete; ④ children with poor language expression and understanding (such as: slow mental development and inability to use language accurately).

The collected questionnaires will be deemed invalid if any single-choice question is answered with multiple options, or if all questions are answered with the same single option.

This study has been approved by the Medical Ethical Committee of Ngari Prefecture People's Hospital (aldqrmyy[2019]No.003).



Flow diagram of the number of study subjects at both examinations as (T1) and (T2) and reasons for exclusion criteria.

Survey methods

We performed oral examinations on Tibetan children aged 7–10 years in Ngari which was in grade one of local primary schools. Two certified dentists conducted the assessment using an oral mirror and portable dental chairs

equipped with artificial lights were used in our survey. A dental probe was necessary and followed the inspection standards the World Health Organization (WHO) set forth. Inspectors received training to ensure consistency and accuracy, inter-examiner reliability was tested and kappa values were higher than 0.85. Data including name, age, gender, oral hygiene status, malocclusion type, and severity (overbite/overjet/cross-bite) were collected. The standard of oral hygiene uses the gingival index (GI score): 0–1 means good, 2 means Medium, and 3 means bad. All entries were recorded and assigned separately. We collected 698 valid samples, all completed with parental accompaniment or under the guidance of teachers. The survey was conducted voluntarily and administered through questionnaires with informed consent from guardians or proxy guardians about the Fourth National Oral Epidemiology Survey Report in China (2016)[19].

Data analysis

We converted the data to count samples by EXCEL and used IBM SPSS Statistics 19 for analysis. Descriptive tables and graphs were constructed. The data conforms to a normal distribution. Bivariate analyses were performed using the chi-square test, and a p value of less than 0.05 was considered statistically significant. Fisher's exact probability method was used if more than 20% of the cells have a theoretical frequency of less than 5. Each statistical test was 2-sided with a significance level of 0.05.

Results

General information

We obtained oral health information from 973 Tibetan children aged 7–10, 51% boys and 49% girls. The 7–10 age groups were represented by the following percentages: 16.9%, 33.1%, 35.2%, and 14.6%. The children completed oral general health questionnaire, the number of valid questionnaires was 698, with a gender distribution of 51.6% boys and 48.4% girls, while the age groups were represented by the following percentages: 16.2%, 27.6%, 35.7%, and 20 0.5%.

Oral health

From oral examinations, we found that the oral health in 7–10 Tibetan children in the Ngari area significantly differed by age and gender ($p < 0.01$), the Cramér's V is 0.120 and 0.159, it is meant to be statistically significant. Their oral hygiene improved as they got older, and girls generally had better oral hygiene. Regarding the degree of dentition crowding, we found a statistical difference in the incidence of misfits among children of different ages. Still, there was no difference in gender, but aged 8–9. From the occlusal relationship, we found no statistical difference between normal occlusion and malocclusion in age and gender (Table 1).

There was no significant difference between gender and age in first molar caries. The Mean and Standard deviation (SD) of DMFT were 0.57 ± 0.924 for males and 0.65 ± 0.924 for females. DMFT were 0.44 ± 0.785, 0.64 ± 0.920, 0.67 ± 0.926, 0.61 ± 1.055 for children aged 7–10. Notably, dental caries increased with age (Tables 2 and 3).

Oral health behavior and awareness

The brushing rate of children in the Ngari region was 92.0%, among which 28.9% brushed less than once, 28.2% once daily, and 42.8% twice daily. For the brushing method, the horizontal brush method accounted for 42.3%, and vertical brush method accounted for 25.2%, and the rotation method accounted for 17.6% (Table 4).

The frequency of brushing, not brushing, and different brushing methods demonstrated no differences between gender and age group, except for the frequency between age groups (Tables 4 and 5).

	Age (year)					Sex		
	7 (n = 164)	8 (n = 323)	9 (n = 343)	10 (n = 143)	p	Male	Female	p
Dentition								
Normal	156	294	324	141	0.029*	464	451	0.364
Crowded	8	29	19	2		33	25	
Occlusion								
Normal	141	293	304	135	0.083	439	434	0.171
Malocclusion	23	30	39	8		58	42	
Overbite	6	4	21	2		16	17	
Overjet	5	6	1	4		14	2	
Cross-bite	12	20	17	2		28	23	
Oral hygiene (GI)								
Good	72	166	170	41	0.00**	201	248	0.00**
Medium	74	137	155	90		245	211	
Poor	18	20	18	12		51	17	

Table 1. Statistics of dentition, occlusion, oral hygiene between genders and ages in Ngari, Tibet. Chi-square test, * are significant ($p < 0.05$). ** are significant ($p < 0.01$). *GI* gingival index.

Sex	Caries	Caries-free	*p*	N	%	DMFT	
						Mean	SD
Male	173	324	0.178	497	51.1	0.57	0.924
Female	193	283		476	48.9	0.65	0.924

Table 2. Statistics of caries and DMFT between genders in Ngari, Tibet. $p > 0.05$ means no statistical significance.

Age	Caries	Caries-free	*p*	N	%	DMFT	
						Mean	SD
7	49	115	0.021*	164	16.9	0.44	0.785
8	131	192		323	33.2	0.64	0.920
9	146	197		343	35.2	0.67	0.926
10	40	103		143	14.7	0.61	1.055

Table 3. Statistics of caries and DMFT between ages in Ngari, Tibet. * are significant ($p < 0.05$).

	Male	Female	*p*
Do you brush your teeth?			
Yes	333	309	0.676
No	27	29	
How many times do you brush your teeth a day?			
Less two times	205	194	0.468
Two or more times	155	144	
Which method do you use to brush your teeth?			
Correct brushing			
Vertical (25.2%)	147	153	0.598
Rotation (17.6%)			
Incorrect brushing			
Horizontal (42.3%)	210	188	
Unfixed (14.6%)			

Table 4. Statistics of oral health behavior between genders in Ngari, Tibet. $p > 0.05$ means no statistical significance.

	Age (year)				*p*
	7 (n = 114)	8 (n = 193)	9 (n = 249)	10 (n = 142)	
Do you brush your teeth?					
Yes	108	171	229	134	0.154
No	6	22	20	8	
How many times do you brush your teeth a day?					
Less two times	45	120	155	80	0.00**
Two or more times	69	73	94	62	
Which method do you use to brush your teeth?					
Correct brushing	39	83	107	70	0.146
incorrect brushing	75	110	142	72	

Table 5. Statistics of oral health behavior between ages in Ngari, Tibet. * are significant ($p < 0.05$). ** are significant ($p < 0.01$).

Discussion

Oral health in plateau areas is an exciting topic that has not received much attention. Due to plateau regions' unique geographical characteristics, epidemiological investigations in these areas are challenging.

In comparison with low-altitude regions, humans exhibit significant physiological and phenotypic changes in extreme high-altitude environments, such as altered metabolic processes, which may profoundly impact individual health[20]. Changes in ultraviolet light, air pressure, temperature, and oxygen content may have a great impact on the oral microbiome, thereby affecting oral health[21,22]. Studies have shown that the incidence of dental caries and periodontal disease in extremely high altitude areas is significantly higher than that in low altitude areas[23].

In this paper, a cross-sectional survey of children in the Ngari area was conducted to explore the oral health conditions of local children and the preservation of first molar teeth. As known in the field, the first molar is the key to occlusion. Therefore, the presence of the first molar is significant for the change in the oral occlusal relationship. Children aged 7–10 years are in a mixed dentition stage, during which temporary malocclusions, such as anterior crowding, frequently occur. With age, the dentition crowd will be relieved after the development of jaw bone. We found no difference in occlusion between gender and age. Notably, cross-bite is a relatively dangerous malocclusion, requiring early intervention[24]. Lombardo et al. reported that cross-bite incidence in Africa and Europe was 7.1% and 36%, respectively[25]. Additionally, a Belgian study found that anterior and posterior Cross-bite incidence were 7.8 ± 6.5% and 9.0 ± 7.34%, respectively[26]. Furthermore, we discovered that cross-bite incidence in the Ngari region was 5.2%. Although this is a low incidence level, intervening is still necessary.

In our research, the oral health of children aged 7–10 in the Ngari area was found to be extremely poor. The decay rate of their first molars is high, with almost half of their teeth having varying degrees of decay. Studies have also shown that geographical factors remained significantly associated with dental caries; people living in rural areas were more likely to have caries than cities[17,18]. Additional Chinese research showed that the standardized prevalence rates of caries were 40.58% and 47.67% among Han and other populations, respectively. The average DMFT scores were 0.97 and 1.28 for Han and minority groups, respectively[17]. The prevalence of caries experienced in Han children is significantly lower than that in Tibetan children in rural Qinghai. Moreover, Han children's proportion of caries-free (DMFT = 0) was higher than in Tibetan[27]. Zhang et al. reported that the prevalence rate of caries was 37.50%, and the average DMFT was 0.84 ± 1.53[28].

Our study found no significant gender differences in DMFT scores, occlusal relationships, or brushing habits among children. Specifically, a study conducted in Changdu, Tibet, revealed no meaningful differences in caries prevalence or mean DMFT values between boys and girls aged 3–5 years. Notably, factors such as sweet consumption, buttered tea intake, and access to oral examinations were identified as risk indicators for dental caries[29]. However, contradictory evidence exists: some research indicates that girls demonstrate a higher susceptibility to dental caries than boys[30]. Similarly, other studies reported no statistically significant gender-based differences in DMFT indices or toothbrushing behaviors among children[17]. The lack of statistical difference in occlusal relationship and dmft may be due to factors such as chewing and eating habits of children in the region. Tibetans usually prefer to eat tough meat, zanba, and milk tea. Long-term residence in plateau areas may also lead to physiological changes different from those in low-altitude areas[23,31]. Further investigations are warranted to elucidate these mechanismsContrary to these findings, a Beijing-based study suggested weaker-than-expected gender influences on children's oral health behaviors[23]. However, our study showed that Tibetan girls had better oral hygiene, and cultural norms that assign greater responsibilities for household sanitation to women, indirectly enhancing their oral care awareness.

To reduce the incidence of dental caries, effective oral hygiene habits and health awareness are essential. However, these factors remain insufficient in Ngari, with significant age and gender disparities observed. Studies have shown that children with severe dental caries in the early stages have lower oral and maxillofacial development than general children[32]. Thus, brushing teeth is the most basic, effective, and economical way of health care for oral health maintenance[5]. We also found that although the brushing rate in the Ngari region reached 92.0%, its brushing frequency was poor, and only 42.8% of children developed the brushing habit of twice a day. Qian et al. investigated children's oral health behavior in the Luoguo region of Qinghai province. They found that the brushing rate of children in this region was 81.3%, but only 42.0% were twice a day[33]. Moreover, 80.5% of dentists brush their teeth twice daily in Nepal[34], while other health professionals are at 56%[35]. Therefore, there is no difference between the undeveloped areas and the medical workers. Furthermore, the children's tooth brushing behaviors are insufficient, and the effective brushing frequency of children in the Ngari region was significantly lower.

Effectively brushing twice a day is the fundamental measure of dental care. Notably, the bass or circle brushing method is an effective way to clean teeth[36]. In this study, the horizontal brush method accounted for 42.3%, accounting for the highest proportion. In comparison, the vertical brush and circle brushing methods accounted for 25.2% and 17.6%, respectively (a sum equal to 42.8%). The proportion of sum was lower than 58.89% in the vertical brushing method by Urumqi[37], Lanzhou 67.7%[38], and the Weifang city area. In contrast, the proportion of the sum was 74.2% (economically developed areas in the south)[39] in China. Therefore, special attention should be paid to improving and optimizing the frequency and methods of tooth brushing for children in Ngari, Tibet.

Improving parents' awareness of oral health care can also significantly reduce the incidence of dental caries in children and vice versa[8]. From the analysis of boys and girls in the Ngari area, we found that the awareness rate of pit and fissure sealing is low, and the cognition is unclear. The pit and fissure sealing rate in the Ngari area was only 0.14%, which was lower than the 3.77% sealing rate in Lhasa[40]. Notably, it is also lower than the national average (2017) pit and groove closure rate of 6.9%[19]. The sealing rate is very low, similar to the study by Fukuhara et al.[41].

To sum up, children aged 7–10 in the Ngari area of Tibet have a high degree of dental caries, poor oral health awareness, and less effective brushing. Improving oral publicity in remote and underdeveloped regions is urgent, and the epidemiological investigation of regional caries should be paid attention to. Through the questionnaire, we found that intuitive transmission methods such as the Internet and TV may improve people's awareness of the region.

In the future, oral knowledge should be popularized in this region. As such, schools can effectively improve the oral health awareness of the whole population in this region through the reverse awareness output of children to their parents.

Limitations

Our research focuses on the DMFT of the first molar and oral hygiene. Data on oral hygiene, such as the dental scale index and the community periodontal index, have not been collected. The availability of oral hygiene, fluoride toothpaste, and fluorine content in the water is also unknown. Thus, the knowledge level of oral health has been preliminarily explored, and more data are required.

Conclusion

We found that children's oral health in remote plateau areas was poor. Notably, these regions had high rates of caries, less frequent teeth brushing, lack of oral health knowledge, and limited sources of oral knowledge.

Data availability

The data are available from the corresponding author on reasonable request.

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References

1. Scannapieco, F. A. & Cantos, A. Oral inflammation and infection, and chronic medical diseases: Implications for the elderly. *Periodontol 2000* **72**(1), 153–175 (2016).
2. Peres, M. A. et al. Oral diseases: A global public health challenge. *Lancet* **394**(10194), 249–260 (2019).
3. Papageorgiou, S. N. et al. Inflammatory bowel disease and oral health: Systematic review and a meta-analysis. *J. Clin. Periodontol.* **44**(4), 382–393 (2017).
4. Memon, M. A. et al. Aetiology and associations of halitosis: A systematic review. *Oral Dis.* **29**(4), 1432–1438 (2023).
5. Worthington, H. V. et al. Home use of interdental cleaning devices, in addition to toothbrushing, for preventing and controlling periodontal diseases and dental caries. *Cochrane Database Syst. Rev.* **4**, CD012018 (2019).
6. Neves, E. T. B. et al. Association of oral health literacy and school factors with untreated dental caries among 12-year-olds: A multilevel approach. *Caries Res.* **55**(2), 144–152 (2021).
7. Lertpimonchai, A., Rattanasiri, S., Arj-Ong Vallibhakara, S., Attia, J. & Thakkinstian, A. The association between oral hygiene and periodontitis: A systematic review and meta-analysis. *Int. Dent. J.* **67**(6), 332–343 (2017).
8. Collins, C. C., Villa-Torres, L., Sams, L. D., Zeldin, L. P. & Divaris, K. Framing young childrens oral health: A participatory action research project. *PLoS ONE* **11**(8), e0161728 (2016).
9. Roncalli, A. G., Sheiham, A., Tsakos, G., Araujo-Souza, G. C. & Watt, R. G. Social factors associated with the decline in caries in Brazilian children between 1996 and 2010. *Caries Res.* **50**(6), 551–559 (2016).
10. Rouxel, P. & Chandola, T. Socioeconomic and ethnic inequalities in oral health among children and adolescents living in England, Wales and Northern Ireland. *Commun. Dent. Oral Epidemiol.* **46**(5), 426–434 (2018).
11. van Meijeren-van Lunteren, A. W., You, Y., Raat, H., Wolvius, E. B. & Kragt, L. Caries preventive interventions and oral health inequalities: A scoping review. *JDR Clin. Transl. Res.* **8**(4), 311–325 (2023).
12. Cheng, L. et al. Expert consensus on dental caries management. *Int. J. Oral Sci.* **14**(1), 17 (2022).
13. Henry, J. A., Muthu, M. S., Swaminathan, K. & Kirubakaran, R. Do oral health educational programmes for expectant mothers prevent early childhood caries?—Systematic review. *Oral Health Prev. Dent.* **15**(3), 215–221 (2017).
14. Naidu, R. S. & Nunn, J. H. Oral health knowledge, attitudes and behaviour of parents and caregivers of preschool children: Implications for oral health promotion. *Oral Health Prev. Dent.* **18**(1), 245–252 (2020).
15. Zhou, C. et al. Food consumption and dietary patterns of local adults living on the Tibetan Plateau: Results from 14 countries along the Yarlung Tsangpo River. *Nutrients* **13**(7), 2444 (2021).
16. Okawa, Y., Hirata, S., Okada, M. & Ishii, T. Geographic distribution of dentists in Japan: 1980–2000. *J. Public Health Dent.* **71**(3), 236–240 (2011).
17. Wu, S. C. et al. Ethnic disparities in dental caries among adolescents in China. *J. Dent. Res.* **100**(5), 496–506 (2021).
18. Guan, L. et al. Status of dental caries and associated factors in Tibetan adults: Findings from the fourth China National Oral Health Survey. *BMC Oral Health* **20**(1), 248 (2020).
19. Lu, H. et al. The 4th national oral health survey in the mainland of China: Background and methodology. *Chin. J. Dent. Res.* **21**(3), 161–165 (2018).
20. Dong, K. et al. Comparative study of oral bacteria and fungi microbiota in Tibetan and Chinese Han living at different altitude. *Tohoku J. Exp. Med.* **254**(2), 129–139. https://doi.org/10.1620/tjem.254.129 (2021).
21. Liu, F. et al. Effects of altitude on human oral microbes. *AMB Express* **11**(1), 41 (2021).
22. Li, J. et al. Comparative analysis of oral saliva microbiomes and metabolites in Han population at different altitudes. *Front. Microbiol.* **15**, 1468365 (2024).
23. Guo, D., Shi, Z., Luo, Y., Ding, R. & He, P. Association between oral health behavior and chronic diseases among middle-aged and older adults in Beijing, China. *BMC Oral Health* **23**(1), 97 (2023).
24. Wong, M. L. et al. Role of interceptive orthodontics in early mixed dentition. *Singap. Dent. J.* **26**(1), 10–14 (2004).
25. Lombardo, G. et al. Worldwide prevalence of malocclusion in the different stages of dentition: A systematic review and meta-analysis. *Eur. J. Paediatr. Dent.* **21**(2), 115–122 (2020).
26. De Ridder, L., Aleksieva, A., Willems, G., Declerck, D. & Cadenas de Llano-Perula, M. Prevalence of orthodontic malocclusions in healthy children and adolescents: A systematic review. *Int. J. Environ. Res. Public Health* **19**(12), 7446 (2022).
27. Leung, W. K. & Chu, C. H. Dental caries and periodontal status of 12-year-old school children in rural Qinghai, China. *Int. Dent. J.* **53**(2), 73–78 (2003).
28. Zhang, R. et al. Brick tea consumption is a risk factor for dental caries and dental fluorosis among 12-year-old Tibetan children in Ganzi. *Environ. Geochem. Health* **41**(3), 1405–1417 (2019).

29. Zhang, J. L., Yao, J., Ren, Q. C. & Xu, Y. H. Analysis of dental caries and the impact factors of caries in children aged 3–5 years old in Changdu, Xizang. *Hua Xi Kou Qiang Yi Xue Za Zhi* **39**(1), 53–57 (2021).
30. Zhu, F. et al. Caries prevalence of the first permanent molars in 6–8 years old children. *PLoS ONE* **16**(1), e0245345 (2021).
31. AlShahrani, I. et al. High altitude as a possible factor for dysbiosis of salivary microbiome in orthodontic patients. *Arch. Oral Biol.* **119**, 104917 (2020).
32. Hazar Bodrumlu, E., Demiriz, L. & Toprak, S. Relationship between severe early childhood caries and dental development. *Eur. J. Paediatr. Dent.* **19**(2), 156–160 (2018).
33. Qian, C. et al. Survey on oral health of 12-year-old children in Guoluo Prefecture, Qinghai Province. *Shanghai J. Prev. Med.* **34**, 1–10 (2022).
34. Wagle, M., Trovik, T. A., Basnet, P. & Acharya, G. Do dentists have better oral health compared to general population: A study on oral health status and oral health behavior in Kathmandu, Nepal. *BMC Oral Health* **14**, 23 (2014).
35. Merchant, A., Pitiphat, W., Douglass, C. W., Crohin, C. & Joshipura, K. Oral hygiene practices and periodontitis in health care professionals. *J. Periodontol.* **73**(5), 531–535 (2002).
36. Harnacke, D., Mitter, S., Lehner, M., Munzert, J. & Deinzer, R. Improving oral hygiene skills by computer-based training: A randomized controlled comparison of the modified Bass and the Fones techniques. *PLoS ONE* **7**(5), e37072 (2012).
37. Yuan, Y. & Jing, I. Oral health behaviors of children aged 6–7 years in Urumqi and its influencing factors. *Gen. J. Stomatol.* **5**(18), 16–18 (2018).
38. Xuan, F. Z. et al. Investigation and analysis of children's oral health concern in Lanzhou city. *Appl. Prev. Med.* **27**(02), 134–137 (2021).
39. Pang, Y. L. & Hao, F. Zhang H-l, Cold A, Zhijie M, Li X: Investigation and analysis of preschool children's oral health related behaviors. *Matern Child Health Care China* **30**(29), 5037–5039 (2015).
40. Yizhou, L. xin Z, Aijin Z, ZhengHui R, yingying Z, Bo F, Jizhi Z, Yaqun K, AnPuGen, Yang W-d: A Sampling Survey of the Oral Health Status and Awareness among Primary School Students in Lhasa. *Acta Acad Med Sin* **43**(04), 590–594 (2021).
41. Fukuhara, D. et al. Relationship between oral hygiene knowledge, source of oral hygiene knowledge and oral hygiene behavior in Japanese university students: A prospective cohort study. *PLoS ONE* **15**(7), e0236259 (2020).

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Author contributions
F.Y. and C.C wrote the main manuscript text and prepared Figs. 1, 2, 3, 4 and 5. L.S and M.G Collected data. All authors reviewed the manuscript.

Declarations

Competing interests
The authors declare no competing interests.

Ethics approval and consent to participate
This study had been approved by the Medical Ethical Committee of Ngari Prefecture People's Hospital.

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