Oral Health Status and Oral Health Care Model in China

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Objective: *To review the current oral health status and oral health care models in China in an effort to provide recommendations for the future implementation of these models.*
Methods: *A systematic literature review was conducted. The Medline, EMBASE, CNKI and Wanfang databases were searched for English and Chinese articles reporting relevant data from 1949 to the present. Data from three national oral health epidemiology surveys, Chinese government reports and national statistics yearbooks from 2011 to 2015 were also included.*
Results: *The oral health status of preschool children were significantly improved over the past 10 years, while caries experience among 35 to 45-year-old and 65 to 74-year-old groups showed an increase in 2005. The status of poor oral hygiene was observed for both adolescent and elderly groups. The ratio of dentist-to-population in China was reported as 1:10,000 in 2009, which was much lower than that of developed countries. The workforce of the dental service is distributed unevenly and remains insufficient for such a highly populated country. Although the need for dental treatment was perceived as high, the true demand for dental service in China was relatively low and not seen as critical. This situation clearly did not reflect so well with true oral disease conditions. There are several basic social medical insurance systems available in China, which covered most of the population's need for medical attention, but seldom covered dental treatment.*
Conclusion: *National oral health policy in China should emphasise oral health promotion, especially in school education for children and young adults, to further strengthen daily toothbrushing, use of fluoride toothpaste and dental floss, and actively promote annual oral health examination. Oral health management should focus on cost-effective primary and secondary prevention with the long-term goal of maintaining oral health.*
Key words: *China, oral health care model, oral health status, literature review*
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Oral disease conditions are prevalently chronic and collectively affect 3.9 billion people globally[1]. In the People's Republic of China, a country with 9,600,000 square kilometers of territory and a population of 1.37 billion, oral disease has a large burden on the government healthcare system and is an even greater economic burden on individuals[2]. Unlike preventive-orientated dental care in many developed countries, seeking oral health care in China is mostly driven by disease-induced pain and suffering. The dental care in China is insufficient not only because of individual awareness but also due to the shortage of dental professionals[3]. While the national strategy for healthcare has been changing gradually towards prevention-orientated care, oral health care should also follow this lead and transform from a treatment-orientated care to a prevention-orientated care. In order to reduce the burden of oral diseases, it is essential to understand the current oral health care model in China. Such an approach will aid efforts in designing a

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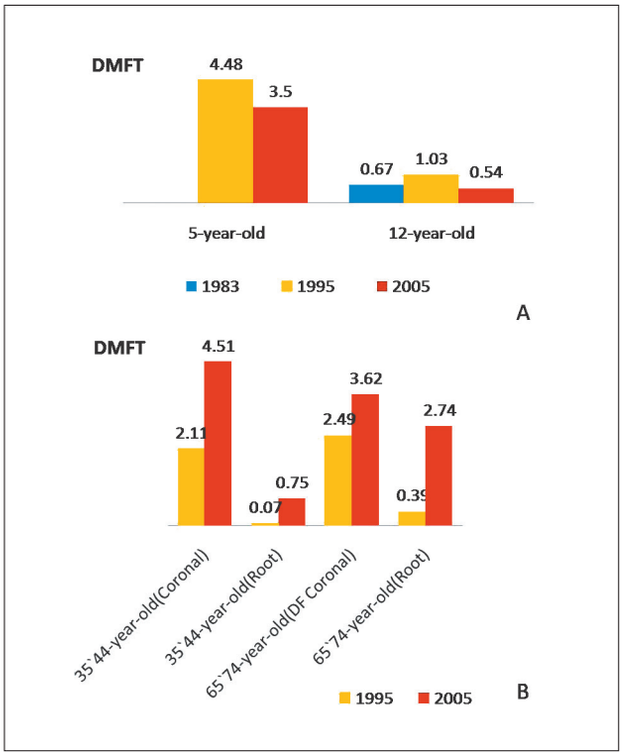

Fig 1 Caries experience (DFMT) among 5- and 12-year-olds in 1983, 1995 and 2005 (A) and the 35 to 44- and 65 to 74-year-old groups in 1995 and 2005 (B).

new system to better serve the future[4]. The aim of this paper is to review the current oral health status and oral health care models in China, and to provide recommendations for the future implementation of new models.

Materials and methods

A literature review of published studies, previous oral health epidemiology survey reports, government reports and statistical yearbooks was conducted to gather information on oral health status and oral health care models in China. Electronic databases including Medline, EMBASE, CNKI and Wanfang were searched with keywords such as 'oral health care', 'oral health status', 'dental care', 'oral health care model' and 'China' from English and Chinese articles. Government reports and yearbooks of national statistics were further scanned for relevant information. National survey reports and reference lists were hand-searched to add valuable information. Articles published between 1949 and 2016 were included, and relevant information was extracted from the selected studies. The results summarised the current oral health status and oral health care model. The problems of the current system and prospects of oral health care in China were further discussed.

Results

Oral health status in China

Three national oral health surveys were conducted in China over the last three decades. As shown in Table 1, the first survey was conducted in 1983, which included 383,265 students (7, 9, 12, 15 and 17-year-olds) from 29 provinces[5]. Oral examination was clinically focused on information regarding Caries, Periodontal Diseases, Dental Fluorosis and Tetracycline-Stained Teeth. The second National Oral Health Survey was conducted in 1995. In total, 140,712 subjects, with ages between 5, 12, 15, 18, 35 to 44 and 64 to 75 years, from 11 provinces were evaluated[6]. Information was collected by oral health examination and a questionnaire survey. The results showed that after 10 years of oral health promotion, the oral health knowledge amongst 12-year-old children was better than other age groups. However, permanent teeth caries amongst 12-year-old children increased, with a DMFT score of 0.89, a caries prevalence of 46%, of which 90% were pit and fissure caries. Based on the findings the Chinese government began the pilot project of caries prevention with pit and fissure sealant[6]. The third National Oral Health Survey , which included 93,826 subjects (5, 12, 35 to 44- and 64 to 75-year-olds) from 30 provinces was carried out in 2005[7]. In addition to oral health examinations and a questionnaire survey, data about fluoride concentration for the sampled regions were also collected. The third National Oral Health Survey examined oral mucosa status for the 35 to 44-year-old and the 64 to 75-year-old groups, which had not been investigated before[7]. The oral health status of preschool children had significantly improved over the past 10 years based on preliminary findings from the on-going survey. The fourth National Oral Health Survey was started in 2015, for which data collection is now being conducted.

Figure 1 shows the comparison of caries experience among 5, 12, 35 to 44 and the 65 to 74-year-old groups in 1983, 1995 and 2005, respectively. Caries prevalence and the DMFT score of primary teeth among 5-year-old children was 76.6% and 4.48 in 1995, which decreased to 66.0% and 3.50 in 2005, respectively. However, when compared with the developed countries, the caries experience level in China remained higher, especially given that more than 80% of the caries teeth would need treatment. It was clear that the prevention and

Table 1 Population and information collection for the three National Oral Health Surveys.

	The First National Oral Health Survey (1983)	The Second National Oral Health Survey (1995)	The Third National Oral Health Survey (2005)
Population	Students from 29 provinces 7/9/12/15/17-year-old 26268 people/age group.	11 provinces; 5/12/15/18/35 to 44/65 to 74-year-old; 23452 people/age group.	30 provinces; 23365 people for the 5-year-old group; 23508 people for 12-year-old group; 23538 people for 35 to 44-year-old group; 23415 people for the 65 to 74-year-old group.
Data collection	Oral health examination: Caries (Coronal); Periodontal diseases (Community Periodontal Index); Dental fluorosis; Tetracycline-stained Teeth.	Oral health examination: Caries (Coronal/ Root); Periodontal diseases (Community Periodontal Index); Dental fluorosis; Oral hygiene status; Missing teeth and restoration	Oral health examination: Caries (Coronal/ Root); Periodontal diseases (Gingival bleeding, calculus, pocket depth, attachment loss); Oral mucosa status; Dental fluorosis; Oral hygiene status; Missing teeth and restoration.
		Questionnaire survey: Oral Health knowledge/ beliefs/ behaviour; Oral Health education in school; Dental service utilization.	Questionnaire survey: Oral Health knowledge/ belief/ behavior; Diet habits; Dental service utilization; Oral health related quality of life.
			Fluoride concentration

treatment of dental caries continued to be critical. The findings suggested that the caries prevention should focus on one-third of children with severe caries to improve the effect of prevention. The caries experiences of 12-year-old children remained at a low level since 1983 and continued to decrease over the past 10 years. Most of the caries lesion involved the first molar, which provided positive evidence caries can be prevented with pit and fissure sealant treatment. When compared with the results from the second National Oral Health Survey in 1995, caries experience including coronal and root caries among 35 to 45-year-old and 65 to 74-year-old groups increased after 10 years, indicating the prevention of caries among adults and elderly people should be strengthened. The primary results of the third National Oral Health Survey (2005) were summarised in Table 2, where poor oral hygiene status was observed for both adolescent and elderly people, indicating a higher calculus and gingival bleeding rate, which suggested the inclusion of oral health promotion in good oral hygiene habits. As shown in Table 2, all age groups developed a habit of brushing teeth at least once per day, which was a significant improvement compared to 10 years ago. Furthermore, the proportion of fluoride toothpaste usage for 12-year-old, 35 to 44-year-old and 65 to 74-year-old groups were increased from 18.5% to 45.9%, 5.5% to 46.3% and 4.1% to 26.5%, respectively. Despite the great improvement, a large number of individuals did not use fluoride toothpaste.

Health resources and health expenditure in China

In 2011, in total there were 954,389 health institutions in China, including 21,979 hospitals, 918,003 grassroots health care institutions, 11,926 specialised public health institutions and 2,481 other health institutions[8,9]. In 2014, the number of health institutions increased to 981,432, comprised of 25,860 hospitals, 917,335 grassroots health care institutions, 35,029 specialised public health institutions and 3,208 other health institutions[10]. The distribution of health institutions were similar from 2011 to 2014. There were more health institutions in the eastern areas (354,503) than those located centrally (314,396) and in the western areas (312,533) of China in 2014[10].

From 2004 to 2014, the number of health care professionals in China was increased from 6,332,739 to 10,234,213[10]. In 2014, the number of health professionals was 5.56 per a population of 1000 in China, which was higher in urban areas (9.70) than in rural areas (3.77). There was only 1.74 registered doctors per a population of 1000, with 3.29 in urban areas and 0.95 in

Table 2 Oral health status of 5, 12, 35 to 44, 65 to 74-year-old group people in 2005.

	5 years old	12 years old	35 to 44 years old	65 to 74 years old
Caries prevalence	66.0%	28.9%	88.1%	98.4%
dmft/DMFT	3.50	0.54	4.51	14.65
Missing teeth per person	/	/	2.60	11.30
Edentulous prevalence	/	/	0.06%	6.82%
Gingival bleeding	/	57.7%	77.3%	68.0%
Calculus	/	59.0%	97.3%	88.7%
Pocket depth more than 4 mm	/	/	40.9%	52.2%
Attachment loss more than 4 mm	/	/	38.9%	71.3%
Prevalence of abnormal oral mucosa	/	/	4.9%	8.0%
Prevalence of malignant tumour	/	/	1.7	3.0
Tooth brushing (once per day)	80.0%	82.0%	89.0%	75.0%
Toothpaste with fluoride	39.0%	46.0%	46.0%	27.0%

rural areas. The number of physicians and nurses per a population of 1000 in China was 1.74 and 2.20 respectively, which was lower than those in other developed countries, e.g. 2.8 and 8.8 in UK, 2.5 and N/A in USA, and 3.9 and 11.5 in Germany (2007 to 2013)[10].

In 2012, the proportion of health expenditure measured in GDP was 5.4% in China, which was lower than that in the UK (9.3%), the US (17.0%) and Germany (11.3%). Among the health expenditure, the proportion of government health expenditure was 56.0%, which was higher than in the US, with 47.0% of the health expenditure paid by government and 53.0% paid by individuals[6]. The government health expenditure occupied 12.5% of total government expenditure in China, which was still lower than in the UK (16.2%), the US (20.0%), and Germany (19.3%). The health expenditure for each person was 322 US$ per year in China in 2012, which was much lower than in the US (8845 US$/person/year),but higher than in India (58US$/person/year)[10]. Data regarding dental expenditure was not available (Table 3).

Dental health resources in China

The dental department is present in most of the general hospitals, including Traditional Chinese Medical hospitals. However, dental departments were seldom found in the grassroots health care institutions, and fewer dentists were employed by institutions with a dental department. In 2009, there were 286 dental hospitals in China[11], including 134 public dental hospitals, 92 private dental hospitals and 60 collective dental hospitals or others. The majority of the dental hospitals (276) were built at the provincial and municipal level and only 10 dental hospitals were at the county level. In 2009, there were 113 dental prevention and treatment institutions in China, amongst which 90 were established at the provincial and municipal level and 23 at the county level. Other institutions, such as Maternal and Child Health (MCH) centers also had dental departments, which mainly focused on improving oral health for women and children[11].

In 2002, the dentist-to-population ratio was 1:25,000 in China[12]. The number of dental health personnel increased to 136,520 until 2009, with a dentist-to-population ratio of 1:10,000[11]. However, the ratio was still much lower than that of Australia (15:10,000) and the US (16:10,000)[13]. According to the WHO, the number of dentistry personnel per a population of 10,000 in the regions of the US and Europe were 12 and 5, respectively, which were higher than the Eastern Mediterranean region and Western Pacific region (2 dentistry personnel per a population of 10,000), and much higher than that of the Southeast Asia and African regions (< 0.5 dentistry personnel /10,000 population). The number

Table 3 Health expenditure in China and several developed countries (2012).

	China	UK	USA	Germany
Proportion of the health expenditure occupied in GDP (%)	5.4	9.3	17.0	11.3
Proportion of government health expenditure (%)	56.0	84.0	47.0	76.7
Proportion of government health expenditure occupied in total government expenditure (%)	12.5	16.2	20.0	19.3
Health expenditure for each person (US$)	322	3595	8845	4717

of dentistry personnel (per a population of 10,000) varied among the income groups, which was 10 for high income groups, 7 for upper middle income groups, 1 for lower middle income group and < 0.5 for the low income group[13]. In China, the dentistry personnel in the hospitals of stomatology and dental prevention and treatment institutions were 24,668 and 2,737, respectively, in 2009[11].

The distribution of the dentistry personnel in China was not even. For the registered dentists/assistant dentists, there were more males (56.3%) than females (43.7%) in 2009[11]. Most of the dentistry personnel were amongst 35 to 44 years old (35.2%) or 45 to 54 years old (31.3%); 18.1% of the dentistry personnel were 25 to 34 years old and 12.4% were 55 to 59 years old. The percentage of dentistry personnel that had worked for less than 5 years was 10.3%. Furthermore, 15.5% had worked between 5 to 9 years, 33.9% 10 to 19 years, 20.8% 20 to 29 years, and 30.1% for more than 30 years. There were 36.1% of registered dentists/assistant dentists that graduated from colleges, 27.0% graduated from secondary technique schools, 26.5% graduated from universities and 6.5% had Masters degrees or Doctorates in dentistry. In terms of professional titles, 43.4% of the registered dentists/assistant dentists were residents or assistant dentists, 28.8% of them were visiting staff, and 2.3% and 8.2% of them were chief physicians and associate chief physicians, respectively[11].

Dental education in China

It was estimated that China would need 136,000 to 400,000 dentists to satisfy the oral health care requirement by 2030[14,15], and there were only 2,500 students enrolled annually[16]. An improvement in dental health education is essential to solve the issue of shortage of dental personnel.

The process of training dentists and assistant dentists had progressed significantly in China since the establishment of the People's Republic of China in 1949. There were only four Departments of Stomatology in 1949 but by 1996, a total of 34 educational institutions were able to train dental health professionals, with 10 Schools of Stomatology and 24 Departments of Stomatology. The numbers continued to increase rapidly and by 2007, there were 179 educational institutions that could provide formal dental training, in which 94 institutions offered a bachelor degree in Dentistry or above and 85 institutions offered 3 years of training for assistant dentists or dental technicians. These dental personnel were unevenly distributed in different areas, and mostly centralised in eastern China. The majority of the educational institutions were located in Beijing (15.85%), followed by Shanghai (11.08%), Jilin (9.24%) and Tientsin (8.45%)[17].

In the Chinese dental education system, a trained dentist graduated from dental school after 5 years and would receive a bachelor's degree in Dentistry. A master's degree would be awarded after an additional 2 to 3 years of additional training in dental research or dental clinical practice. A doctorate would be awarded after further study, 2 to 3 years after receiveing a master's degree. Both master's and doctorate degree training would require a thesis dissertation and/or clinical examination. A total of 8 to 10 years would be needed to train a fully qualified dentist depending on the type of degree received. In order to practice dentistry, all dentists or assistant dentists need to pass national examinations, which included written and practical parts to acquire the license of qualification issued by the provincial health authorities. The national license examination was organised annually. Once they had obtained their licenses, they would need to register in a hospital or clinic at local health authorities to practice independently.

A clinical team is comprised of dentists/assistant dentists, dental nurses and dental technicians. Dentists are usually assisted by dental nurses in their clinical

Table 4 Dental service utilisation in China (from the Third National Oral Health Survey, 2005).

Age Groups (years)	Utilisation of dental services		Reasons for dental service utilisation		
	Proportions of filling teeth (dt/DT) in dmft/DMFT (%)	Use dental service in recent 12 months (%)	Acute toothache	Chronic toothache	Regular check-up
5	2.8	15	32	19	22
12	10.6	21	24	14	28
35 to 44	8.4	16	47	32	2
65 to 74	1.9	19	43	38	1

work, and dental technicians work in dental laboratories. There were no dental hygienists in China since there was no such professional training in the education system. Dental nurses and dental technicians were trained in educational institutions related to dentistry after they graduated from secondary school, with the training program for dental nurses/technicians usually lasting 3 years. Some of them did not have the experience of such professional training, and underwent a short period of related training courses in the hospitals after they graduated from the technical medical schools, because they do not need a special dental license to work as dental nurses or dental technicians.

Utilisation of dental services in China

The utilisation of dental services was very limited in China. According to the third national oral health survey (2005), only 1.9% to 10.6% of caries were filled in different age groups, most caries in China were still untreated or did not receive proper treatment[8] (Table 4). Dental health in China is predominantly provided by hospital-based public health services at the province, county and rural level; this includes community healthcare centers, school dental clinics and some factory clinics[18]. Over 80% of all treatments are carried out by these facilities[19](Table 3).

Although the need for dental treatment was high, the demand for dental services from the Chinese was relatively low and not recognised as urgent, which was did not correspond well with oral health status. The utilisation of a dental service in different age groups was very limited in general. In the child group, the percentage of dental services with a 12-month period was only 15%, with the proportion of the urban population (21%) being higher than that in the rural area (9%). The proportion of utilisation of dental services ranged from 16% to 21% only in other age groups. The reasons for a limited use of dental services were mainly for acute/chronic toothache, and seldom appeared to be requests for preventive care[7]. As for the treatment therapy subjects received during their last visit to the dentists, this included extracting teeth or filling decayed teeth, and for elderly subjects, in most cases, prosthodontics therapy to receive movable or fixed dentures[7].

There were three main reasons for the low utilisation of dental services. Firstly, knowledge of dental health care was still not sufficient, especially for the child's dental care. Most parents would consider that their children's teeth were good (70%) or not so bad (17%), and did not need to receive dental treatment. Some parents believed that their children's primary teeth would not need to be treated because they will be substituted by permanent teeth later (13%). Other reasons reported for parents included "have no time" (6%), "have no money" (4%) or "not convenient to see a dentist" (4%). Secondly, the "economic problem" was the main reason for the 35 to 44-year-old adults (20%) and for the 65 to 74-year-old adults (34%) who had not received any dental services in the last 12 months. The other two reasons were "their teeth had no problems" (51% for 35 to 44-year-olds and 36% for 65 to 74-year-olds) and "their teeth were not so bad" (38% for 35 to 44-year-olds and 40% for 65 to 74-year-olds). Thirdly, as a chronic condition, some adults did not prioritise their dental health among other health issues, as they would not see the clinician because they were too busy at work and did not have time to go to a hospital (11% in the 35 to 44-year-old group)[7].

All of the information above indicated that there is a long way to go to improve the oral health status of Chinese residents in China and a proper oral health care model is urgently needed.

Basic social medical insurance systems in China

There are several basic social medical insurance systems in China which cover most of the population. The "Basic Medical Insurance of Urban Population" (BMIUP) is for the urban employees and urban residents. In 2011, a total of 252.26 million urban employees and 220.66 million urban residents were enrolled in BMIUP, which accounted for 24.3% of the total population. The "New Rural Cooperative Medical System" (NRCMS) was aimed at people in the rural areas. In total 2,637 counties and 832 million subjects had been involved in NRCMS, and the proportion of enrollment was nearly 97.5% in the rural areas in China in 2011, which covered 69.5% of the total national population. "Government Medical Insurance" is for government officials covering 0.7% of the total population and 0.3% Chinese residents who were enrolled in other kinds of social medical insurance. Only 5.2% of the total population were not covered by basic social medical insurance[9]. The status of commercial insurance was reported less.

The features of basic medical insurance in China include "maximum coverage" and "minimum guarantee". With regard to dental health care, the basic medical insurance can cover only a small part of the expenditure in China. Most people are uninsured against oral diseases. Over 85% of total dental costs are paid out of pocket[20]. Some basic treatment, such as extraction of teeth, restoration of caries using amalgam or some cheaper composite resin, and procedures for several simple dental surgeries, were covered by the basic insurance. If new materials or instruments were used in the dental treatment, patients need to pay out-of-pocket for themselves. Only a small fraction would be paid by social medical insurance. As for the treatment of orthodontics and prosthodontics, it will be paid fully by the patients themselves. With the efforts of dental professionals and given that there were extensive patient needs, dental scaling began to be included in the basic medical insurance. The proportion of the dental expenditure covered by insurance was higher for in-patients than that of out-patients according to the insurance policy. Therefore the dental treatment placed huge economic burden for people in China, especially for those economically disadvantaged.

Discussion

The prevalence of dental diseases was high amongst the Chinese, especially for caries and periodontal diseases. The distribution of dental diseases and the need for services differed greatly between regions due to diversity in socioeconomic situations. Therefore, serious consideration for oral health care was urgently needed in China. While there are limited resources available, most of the dental care institutions are found in the eastern and middle regions of the country, which add more difficulty for those in the less-economically developed western region. As a developing country with a huge population, prevention of dental diseases should be considered to be more important than regular treatment. More attention should be given to people who are in greater need of oral care, especially those with minimal access to the limited dental health resources due to geographical and financial reasons.

Although the dental education system has expanded greatly in recent years, the quality of education needs further improvement. Among the licensed dentists or assistant dentists, the educational level varies significantly, with 36.1% graduating from colleges and 27.0% graduating from technical schools, among those who were at the same level as resident dentists or assistant dentists (43.4%). There is no doubt that dental education clearly needs to be sharpened and strengthened, which includes improving entrance requirements for candidate dentists, truly enforcing the regulations of teachers and students in dental schools, strengthening the evaluation system, and implementing an effective education system to keep licensed dentists up to date with professional development.

From the available data, utilisation of dental service for different age groups in the last 12 months was notably low. The predominant reason for such a phenomenon was the lack of awareness of oral health in the majority of the population. Oral health education and health promotion are immensely needed nationally to improve the oral health awareness for the Chinese. Although national campaigns such as the "National Love Teeth Day" have been running for many years, there is still a greater need to emphasise and promote further, in order to educate and persuade people to truly care about their oral health[21].

China must promote large scale cost-effective oral disease prevention. For example, the program to promote fluoride prevention on dental caries is quite ineffective. Although tap water may contain fluoride, it is not in a sufficient concentration (< 0.5 ppm F) in most areas, however drinking water is the main source of fluoride exposure[22,23]. Since 2008, a series of government-led oral health prevention programmes have been successfully conducted. The Mid-Western program aimed to prevent oral disease in 7 to 9-year-old children in the Mid-Western provinces. The program consisted of oral health promotion, oral examination and preven-

tive treatment, such as fit and fissure sealing to the first permanent molars. In 2012, the fluoride application project for 3 to 5-year-old children was started in some of those areas. Nearly 200 oral health education centers were established which provided training to dental personnel specialised in oral health prevention and offered regular oral health promotion to children. This included universal education regarding oral health knowledge, attitude and behaviour for all members of the family. These projects have shown great benefits to the population in serviced area and should be strongly supported by the government, financially and politically, to facilitate a change in the oral health system, which is prevention-oriented and offers oral health education to more people.

Another major reason for low utilisation of the dental service was due to economic burden, especially for adults and the elderly population, indicated by the high prevalence of oral diseases. The health expenditure for each person per year remained low in general compared to other economically developed countries. The available basic medical insurance did not cover the cost of dental treatment and the patients had to pay a large proportion of dental treatment out of their own pocket. The economic burden contributed to the inequality in dental care distribution. People who need dental services may have restricted access to adequate dental care due to financial hardships. The government needs to consider the need of this population and allocate a limited healthcare resource proportionally, based on their needs. More investment is needed for people with high treatment needs and cost-effective preventive strategies should be implemented. National health policy relevant to investing in high treatment requirements and developing a preventive strategy in specific population groups is urgently needed.

In conclusion, the oral health of Chinese residents has improved in recent years, but the prevalence of caries and periodontal diseases are still high. The dental workforce was distributed unevenly and is still insufficient considering the size of the population in need of services. While the number of dental educational institutes has indeed increased significantly, the quality of dental education will require continual improvement. Although dental care placed a significant economic burden on the Chinese population, there is a lack of an appropriate dental insurance system in the country. In order to systematically set up an effective mechanism for oral health care in China, national oral health policy should emphasise oral health promotion, especially in primary and middle school children and young adults, to promote good habits such as daily toothbrushing, the use of fluoride toothpaste and dental floss, and recommending annual oral health examination. Oral health management should emphasise the primary and secondary prevention, which are more cost-effective, and reduce government expenditure, the manpower involved and the time spent for later treatment. Further studies are needed regarding the education of the dental workforce, social-economic evaluation and the dental service inequality assessment, to provide more qualitative evidence to fundamentally improve the oral health care status in China.

Conflicts of interest

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

Author contribution

Dr Jian Liu, Dr Shanshan Zhang and Dr Yan Si for the study design, data collection and analysis, and writing the manuscript; Dr Shuguo Zheng, Dr Yan Si and Dr Tao Xu for the direction of the research.

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