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Trends in the Burden of Periodontal Disease in China and Globally from 1990 to 2021 and 2035 Forecast: A GBD

2021 Study Analysis

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Abstract

Background: Periodontal disease is a widespread and severe public health issue globally. Using the latest data from Global Burden of Disease Study (GBD) 2021, this study conducted a systematic analysis of the burden of periodontal disease in China and worldwide from 1990 to 2021.

Methods: Data on number and age-standardized rates (ASR) of periodontal disease were extracted from GBD 2021 and stratified analyzed by gender, age group, and geographic location (China and globally). Temporal trends were assessed using joinpoint regression analyses, while the Bayesian age-period-cohort model with nested Laplace approximation was applied to predict the disease burden by 2035.

Results: Compared to 1990, the incidence number of periodontal disease in China and globally increased by over 70% in 2021, while prevalence and disability-adjusted life years numbers increased by more than 90%. The ASR of periodontal disease burden decreased in China but increased globally. In terms of age distribution, the burden of periodontal disease initially increased and then declined with age; from 1990 to 2021, the age peak of certain burden-related indicators shifted to older age groups. Concerning gender distribution, the burden was higher among younger and middle-aged men, whereas in women, the burden among middle-aged and elderly populations gradually surpassed that of men. By 2035, the burden of periodontal disease is expected to increase further.

Conclusion: Our findings indicate that the burden of periodontal disease continues to rise, which is associated with global population growth, lifestyle and dietary changes, and aging.

Keywords: Oral diseases, China, Global, Trend analysis, GBD 2021

Introduction

Oral diseases are one of the most common non-communicable diseases worldwide, affecting approximately 3.5 billion people. The annual economic loss caused by oral diseases globally amounts to 387 billion US dollars ^[1]. Periodontal disease is one of the most prevalent forms. It initially presents as gingivitis and then progresses to periodontitis. The clinical manifestations include the loss of periodontal supporting tissues, such as attachment loss, periodontal pockets, gingival bleeding, alveolar bone loss, ultimately leading to tooth loss, masticatory dysfunction, malnutrition and other complications in patients ^{[2],[3]}. Periodontal disease is also considered a systemic disease and is epidemiologically associated with various diseases, including cardiovascular diseases, type 2 diabetes, respiratory tract infections, etc. ^{[4],[5]}. In addition, periodontal disease is an age-related disease. Its prevalence and severity are positively correlated with age ^[6]. In the current era of population aging, this undoubtedly poses a huge challenge. According to the latest statistical data from the GBD, there were approximately 1.07 billion periodontal disease patients globally in 2021 ^[7]. It is predicted that the burden will further increase in the next few decades ^[8], indicating that periodontal disease remains a common and serious public health issue.

As an extremely common and far-reaching disease, periodontal disease not only reduces the quality of life of patients but also imposes a heavy economic burden on the healthcare system ^[3]. The report by Zhang et al. ^[9] shows that from 1990 to 2019, the incidence, prevalence, and Disability-adjusted life years (DALYs) of periodontal disease increased significantly globally. The number of new cases and DALYs globally were almost twice the numbers in 1990. In particular, the standardized burden of periodontal disease is higher in regions with low Socio-demographic Index (SDI). China, as a rapidly developing country with a large population, has unique advantages in public health research. Yu et al. ^[10] analyzed the current situation and development trend of periodontal disease in China using the data of the GBD from 1990 to 2019. The burden of periodontal disease among Chinese adults has been increasing over the past 30 years, and it is expected that the incidence of periodontal disease will continue to rise in the next 25 years. These studies provide important references for us to understand the current situation and development trend of periodontal disease.

However, global oral health has a low priority at the political decision-making level ^[11]. There is relatively little research on the epidemiology of periodontal disease. Compared with major diseases, there are deficiencies in scientific research funding, research depth, and breadth. This study selects the latest data from the GBD study in 2021 to systematically analyze the changing trends of the burden of periodontal disease in China and globally, as well as the characteristics of age and gender distribution, and predicts the future development dynamics. The aim is to provide data and information support for formulating scientific and reasonable

periodontal disease health policies, optimize the allocation and efficient utilization of medical resources, and promote the development of global public health.

Methods

Data Source

This study employed a research design combining cross-sectional and longitudinal analyses, with data obtained from the GBD 2021 database. Maintained by the Institute for Health Metrics and Evaluation at the University of Washington, the database utilizes a systematic methodological framework to integrate multiple data sources, including disease surveillance systems, demographic surveys, and medical records. It provides detailed estimates for 204 countries and regions, covering 371 diseases and injuries as well as 88 risk factors. For this study, key data related to periodontal disease from 1990 to 2021 were extracted, including incidence, prevalence, and DALYs. These indicators were presented in two forms: absolute numbers and age-standardized rates (ASR). The data were further stratified by gender, age group, and geographic location (China and globally) ^{[7],[12]-[14]}.

Disease Definition

According to the disease classification system of GBD 2021, periodontal disease is categorized under the subcategory of oral diseases within the broader group of non-communicable diseases. Its diagnostic definition aligns with the International Classification of Diseases, 10th Revision (ICD-10: K05.600) and 11th Revision (ICD-11: DA0C).

Statistical Analysis

Descriptive analysis was conducted to calculate the absolute values, proportions, and rates of change for each indicator. Joinpoint 5.1.0 software was used to apply a log-linear model to identify key turning points in the trends of disease burden from 1990 to 2021. Annual percent change (APC) for each time segment and the average annual percent change (AAPC) over the entire period were computed. The set model parameters are as follows: the minimum time interval is 2 years, the maximum number of joinpoints is 6, and the significance level $\alpha = 0.05$. The Bayesian Information Criterion is used for model selection. The Bayesian age-period-cohort (BAPC) model framework, integrated with the Integrated Nested Laplace Approximation (INLA) method, was employed to predict trends in disease burden from 2022 to 2035. The model accounted for demographic changes, historical trends, and uncertainties. All data processing, statistical analyses, and visualizations were performed using R software (version 4.4.1).

Results

Temporal Trends of the Burden of Periodontal Disease from 1990 to 2021

From 1990 to 2010, the age-standardized incidence rate (ASIR), age-standardized prevalence rate (ASPR), and age-standardized death rate (ASDR) of periodontal disease globally exhibited a downward trend, while from 2010 to 2021, an upward trend was observed (Figure 1). However, compared with 1990, the ASIR, ASPR, and ASDR in 2021 were still elevated. In contrast, the trends of periodontal disease in China was the opposite. Compared with 1990, the ASDR, ASIR, and ASPR in 2021 all declined, albeit with significant fluctuations during this period. There was a downward trend from 1990 to 2000, followed by a 5-year upward trend, then a 5-year downward trend, another 5-year upward trend, and a subsequent decline after 2020. The ASIR witnessed a rebound after 2019, while both the ASDR and the ASPR experienced a resurgence after 2020. In terms of numbers of incidence, prevalence, and DALYs, both China and the global situation demonstrated an upward trend. In 2021, the incidence numbers increased by more than 70% compared with 1990, while the prevalence and DALYs numbers increased by over 90% (Figure 1, and Table 1).

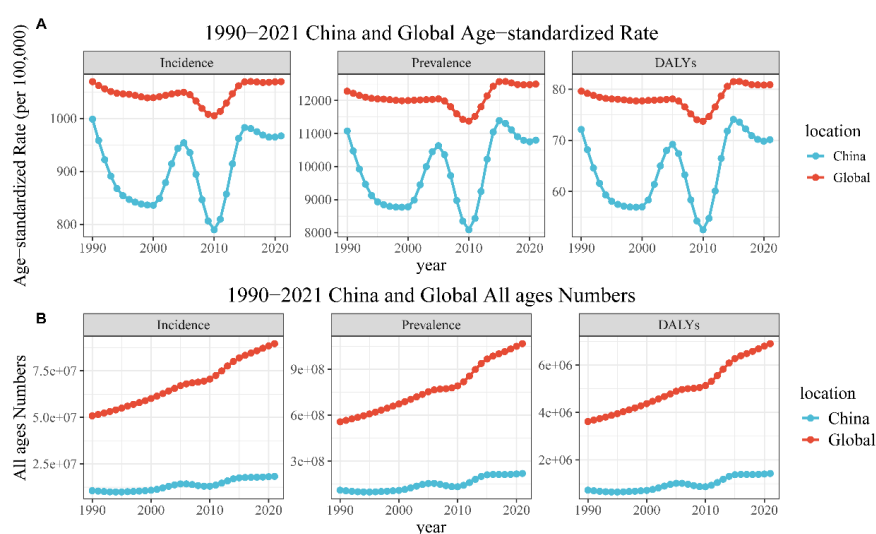


Figure 1 Temporal Trend Analysis of the Burden of Periodontal Disease in China and Globally from 1990 to 2021

A. Trends in the ASRs of incidence, prevalence, and DALYs of periodontal disease in China and globally; B. Trends in the numbers of incidence, prevalence, and DALYs of periodontal disease in China and globally.

Table 1 The Burden of Periodontal Disease in China and Globally from 1990 to 2021.

Measure	Location	Number			Rate		
		1990_numbers (95% UI)	2021_numbers (95% UI)	Percentage change in case (%)	1990_per 100 000 (95% UI)	2021_per 100 000 (95% UI)	Percentage change in ASRs (%)
Incidence	Global	50,823,934	89,613,534	76.32	1,069.38	1,069.44	0.01
		(39,615,908 to	(79,069,091 to		(852.99 to	(942.71 to	
		59,174,250)	101,005,642)		1,239.59)	1,204.58)	
Incidence	China	10,605,758	18,295,038	72.5	998.49	967.03	-3.15
		(8,290,110 to	(15,747,998 to		(791.22 to	(830.95 to	
		12,656,825)	20,729,598)		1,179.28)	1,100.24)	
Prevalence	Global	557,036,657	1,066,953,744	91.54	12,282.44	12,498.30	1.76
		(427,553,223 to	(896,546,186 to		(9,494.51 to	(10,526.80 to	
		683,752,829)	1,234,839,287)		15,063.91)	14,493.37)	
Prevalence	China	110,887,970	220,238,287	98.61	11,077.39	10,799.46	-2.51
		(83,432,920 to	(183,074,953 to		(8,383.08 to	(8,883.18 to	
		140,479,922)	258,996,015)		13,872.18)	12,782.71)	
DALYs	Global	3,620,518	6,903,284	90.67	79.62 (31.46	80.89 (32.47	1.6
		(1,421,409 to	(2,772,284 to		to 169.62)	to 165.37)	
		7,719,685)	14,106,182)				
DALYs	China	724,760	1,428,453	97.09	72.13 (28.83	70.15 (27.97	-2.75
		(287,789 to	(563,791 to		to 156.29)	to 144.15)	
		1,563,001)	2,917,317)				

Age Distribution Characteristics of the Burden of Periodontal Disease in 1990 and 2021

The data performance in China and globally was similar. The burden of periodontal disease exhibited a trend of first increasing and then decreasing with age (Figure 2). In China (Figure 2A - C), from 1990 to 2021, the peak value of incidence numbers shifted from the 35 - 39 age group to the 50 - 54 age group, while the peak values of prevalence and DALYs both emerged in the 50 - 54 age group. The peak value of ASIR appeared in the 45 - 49 age group, and the peak values of ASPR and ASDR were both in the 55 - 59 age group. Globally (Figure 2D - F), from 1990 to 2021, the peak value of incidence numbers remained unchanged in the 35 - 39 age group, while the peak values of prevalence and DALYs numbers changed from the 40 - 44 age group to the 50 - 54 age group. The peak value of ASIR shifted from the 50 - 54 age group to the 90 - 94 age group, and the peak values of ASIR and ASDR were both in the 55 - 59 age group.

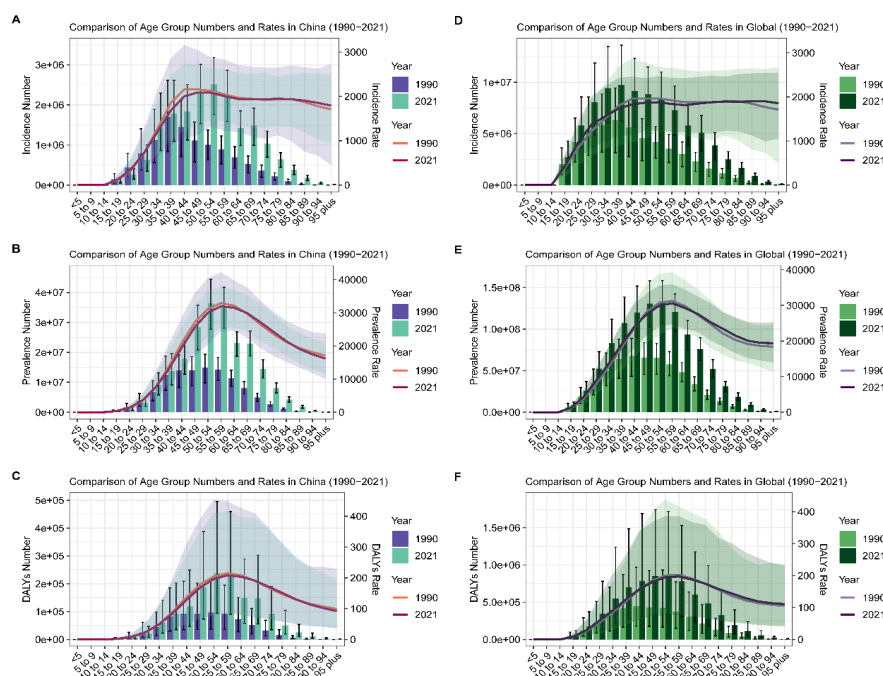


Figure 2 Comparison of the Age Distribution of the Burden of Periodontal Disease in China and Globally between 1990 and 2021

A. Comparison of the numbers and ASRs of the incidence of periodontal disease in different age groups in China; B. Comparison of the numbers and ASRs of the prevalence of periodontal disease in different age groups in China; C. Comparison of the numbers and ASRs of DALYs of periodontal disease in different age groups in China; D. Comparison of the numbers and ASRs of the incidence of periodontal disease in different age groups globally; E. Comparison of the numbers and ASRs of the prevalence of periodontal disease in different age groups globally; F. Comparison of the numbers and ASRs of DALYs of periodontal disease in different age groups globally.

Gender Distribution Characteristics of the Burden of Periodontal Disease in 2021

In China (Figure 3A - C), among the 15 - 74 age groups, the DALYs and prevalence numbers of periodontal disease in females were lower than those in males, while after the age of 74, females surpassed males. In the 15 - 64 age range, the incidence numbers of females were lower than those of males, whereas after the age of 64, they were higher. Globally (Figure 3D - F), the incidence, prevalence, and DALYs numbers of females were respectively lower than those of males in the 15 - 64, 15 - 49, and 15 - 49 age groups, and then were higher in the subsequent age groups.

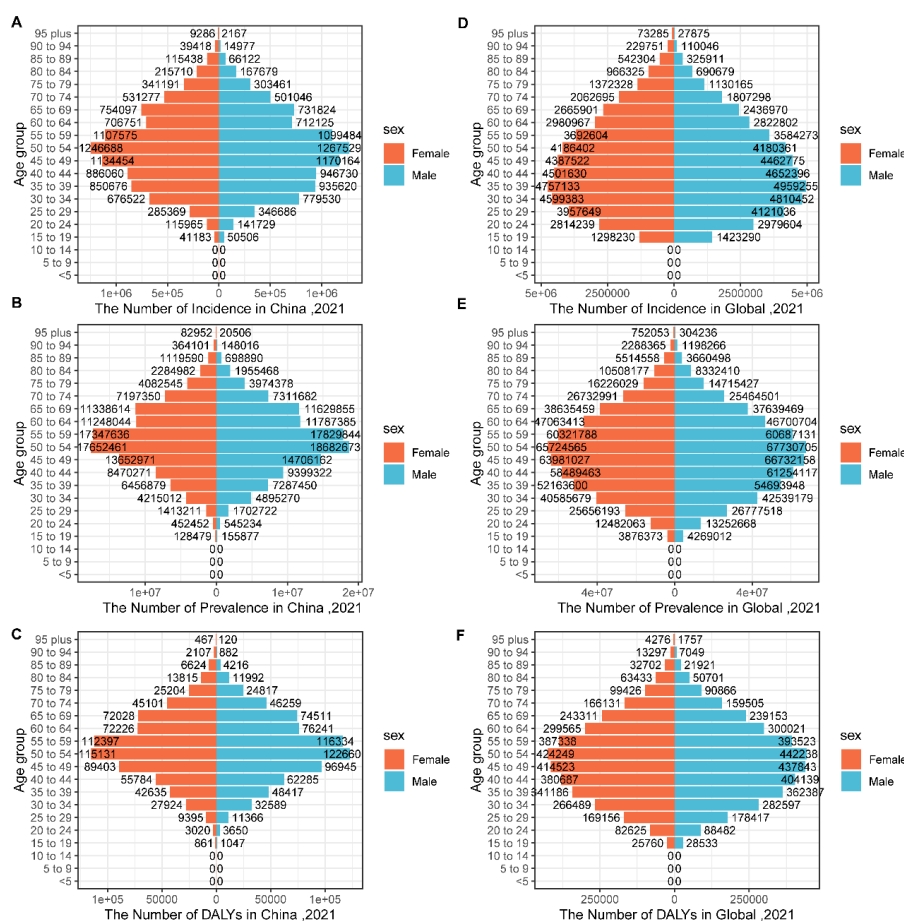


Figure 3 Gender and Age Stratification Analysis of Periodontal Disease in China and Globally in 2021

A. The incidence number of periodontal disease in different gender and age groups in China in 2021; B. The prevalence number of periodontal disease in different gender and age groups in China in 2021; C. The DALYs number of periodontal disease in different gender and age groups in China in 2021; D. The incidence number of periodontal disease in different gender and age groups globally in 2021; E. The prevalence number of periodontal disease in different gender and age groups globally in 2021; F. The DALYs number of periodontal disease in different gender and age groups globally in 2021.

Join-point analysis of Analysis of Periodontal Disease Burden from 1990 to 2021

In China (Figure 4A - C), both incidence and DALYs of periodontal disease

showed a significant decline from 1990 to 2000 and from 2005 to 2010. However, from 2000 to 2005 and from 2010 to 2014, both incidence and DALYs exhibited noticeable increases. After 2014, both incidence and DALYs showed a downward trend, although the decline in incidence was not as pronounced. Periodontal disease prevalence showed a trend of initial decline followed by an increase. There was a significant decrease from 1990 to 1994 and from 2006 to 2010, followed by a sharp rise from 2010 to 2015, and then a significant decline thereafter.

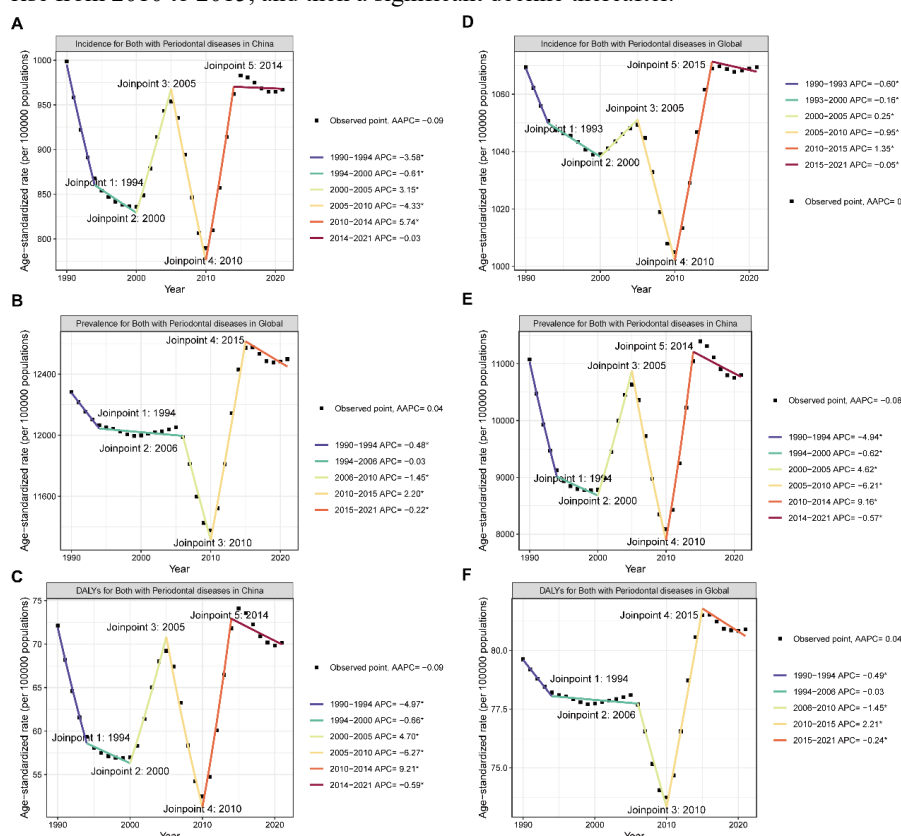


Figure 4 Joinpoint Regression Analysis of Periodontal Disease Burden in China and Globally (1990-2021)

A. Trend and turning points in the incidence of periodontal disease in China; B. Trend and turning points in the prevalence of periodontal disease in China; C. Trend and turning points in DALYs of periodontal disease in China; D. Trend and turning points in the incidence of periodontal disease globally; E. Trend and turning points in the prevalence of periodontal disease globally; F. Trend and turning points in DALYs of periodontal disease globally.

From the global data (Figure 4D - F), both incidence and prevalence showed

significant decreases from 1990 to 2000 and 2005 to 2010. Between 2000 and 2005, and after 2010, there were significant increases in both indicators. However, incidence significantly decreased in 2015, and prevalence showed a notable decline after 2014. Periodontal disease DALYs demonstrated a decreasing trend from 1990 to 2010 and 2015 to 2021, though the decrease from 1994 to 2006 was not significant. A sharp rise in DALYs was observed from 2010 to 2015.

Prediction of Periodontal Disease Burden

It is expected that the burden of periodontal disease in both China and globally will continue to increase by 2035 (Figure 5). Incidence, prevalence, and DALYs are projected to rise. In terms of age-standardized rates, both China and the global data show an increase in ASIR, ASPR, and ASDR, with China exhibiting a more pronounced upward trend.

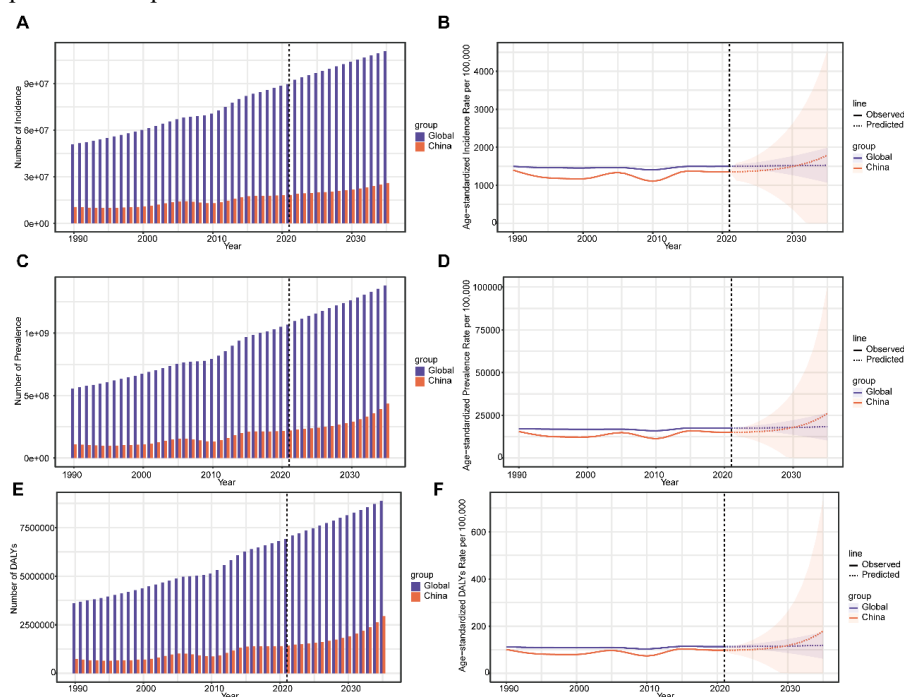


Figure 5 Future Prediction of Periodontal Disease Burden in China and Globally (2022-2035)

A. Predicted trend in the incidence number of periodontal disease in China and globally; B. Predicted trend in the age-standardized incidence rate of periodontal disease in China and globally; C. Predicted trend in prevalence number of periodontal disease in China and globally; D. Predicted trend in the age-standardized prevalence rate of periodontal disease in China and globally; E. Predicted trend in DALYs number of periodontal disease in China and globally; F. Predicted trend in the age-standardized DALY rate due to periodontal disease in China and globally.

Discussion

Periodontal disease, as a major public health issue, undoubtedly imposes a huge burden on both patients and the public health system. To further explore the epidemiological characteristics of periodontal disease, this study utilized the latest data from the GBD study to analyze the burden of periodontal disease in China and globally from 1990 to 2021. Strikingly, in 2021, the incidence numbers in China and globally increased by over 70% compared to 1990, while the prevalence and DALYs increased by over 90%. These data intuitively reflect the increasingly severe problem of periodontal disease. The results are consistent with studies by Zhang et al.^[9] and Yu^[10] et al. Since 1990, the burden of periodontal disease has been continuously increasing both in China and globally. From a global perspective, this is mainly due to global population growth^[9]. On the other hand, with the acceleration of urbanization, people's lifestyles have become faster-paced, leading to significant changes in diet and lifestyle. These are also important factors affecting periodontal disease^{[15],[16]}. The consumption of processed foods and beverages high in sugar, fat, and salt has been increasing. These high-carbohydrate foods promote the accumulation of dental plaque, thereby inducing gingival inflammation and facilitating the development of periodontal disease^[17]. Such foods can also drive the body's own inflammation, further promoting periodontal inflammation and damage^[18]. In contrast, a healthy diet can significantly reduce gingival and periodontal inflammation within clinically important limits^{[18],[19]}. In addition to diet, lifestyle also affects the occurrence and development of periodontitis. Tobacco use is another high-risk factor for the occurrence and progression of periodontal disease. Smoking promotes periodontal inflammation, impairs the host's protective response to dental plaque biofilm, and accelerates the loss of periodontal support^[20]. In addition, some studies have shown associations between alcohol consumption, sleep duration, physical activity, and periodontitis^{[21]-[23]}. These findings highlight the impact of eating habits and lifestyle factors on periodontal disease, and the current unhealthy diet and lifestyle contribute to its occurrence and progression.

Compared to 1990, the global ASIR, ASPR, and ASDR all increased in 2021. This indicates that, after accounting for population age structure, the incidence risk, severity, and disability burden of periodontal disease have worsened. Oral health has often been an overlooked issue in global health, with low political priority and limited action from most social groups and government agencies^[11]. Economically, there is significant inequality in dental care access across countries, with 22.5% of the population spending 88% of oral healthcare expenses^[1]. In economically underdeveloped regions, limited financial investment makes it difficult to widely promote oral health education. Many people lack awareness of periodontal disease and preventive measures. Additionally, economic constraints prevent some patients from affording necessary treatments, leading to delays in care and persistently high

levels of periodontal disease prevalence and severity ^[24]. In contrast, the ASIR, ASPR, and ASDR of China have shown a decrease, which is a relatively positive signal. This suggests that, through a series of oral health interventions amid China's demographic transitions, the relative severity of periodontal disease has been somewhat controlled across various age groups. As periodontal disease becomes an increasingly unavoidable burden, more groups and institutions have started to address this issue. For example, China launched the "Healthy Oral Action Plan (2019-2025)" ^[25], aiming to strengthen oral health work and improve the public's oral health awareness and behavior. The World Health Organization (WHO) also released the "Global Oral Health Status Report: Towards Universal Health Coverage for Oral Health by 2030" in 2022, with the goal of achieving universal coverage of oral health by 2030 ^[1].

The changes in age distribution characteristics reveal that, over time, the age peak for periodontal disease in both China and globally has shifted to older age groups, particularly after 50 years old, with an increasing burden of periodontal disease. In China, this shift could be attributed to factors such as improved public oral health awareness, which has helped control the incidence of periodontal disease in younger populations, thereby delaying the peak incidence. However, global data show that the peak of the ASIR has shifted to the 90-94 age group. On the one hand, this reflects the increased longevity of the elderly and the cumulative effects of periodontal disease over time. On the other hand, it highlights the growing need to focus on the oral health of the aging population amidst global demographic aging ^{[8],[26]}. Especially among the elderly, there is often insufficient awareness of oral health, leading to improper brushing practices and inadequate use of cleaning tools such as dental floss. Studies have shown that brushing can reduce the accumulation of interproximal dental plaque and prevent its progression, while also improving gum health in adults ^[27]. Furthermore, chronic diseases like diabetes, common in middle-aged and elderly populations, can exacerbate the susceptibility and severity of periodontal disease, which is related to chronic inflammation caused by these conditions ^[28]. Overall, both in China and globally, individuals aged 50 and above should be a key target for periodontal disease prevention and treatment efforts. It is essential to proactively develop prevention strategies and enhance oral health management for this population.

From a gender perspective, the burden of periodontal disease is generally higher in men than in women during the younger and middle-aged groups. This may be related to poorer oral hygiene habits in men and higher proportions of smoking, drinking, and other unhealthy behaviors ^{[29]-[32]}, which increase the risk of onset and exacerbate disease severity in early adulthood. Estrogen plays a critical role in maintaining bone density and regulating inflammation in women. However, as women reach middle age and menopause, estrogen levels gradually decline, leading to stronger inflammatory responses in the periodontium and accelerated bone loss.

As a result, the burden of periodontal disease in women gradually surpasses that of men ^{[33],[34]}. To address the gender-specific manifestations of periodontal disease in both sexes at different age stages, it is essential to strengthen oral health education for middle-aged and younger men and improve periodontal health monitoring and interventions for older women, particularly in relation to estrogen-related periodontal health. These measures would help balance gender differences in periodontal health and reduce the overall disease burden.

It is expected that by 2035, the burden of periodontal disease will continue to increase both in China and globally, affecting an increasing number of people. In China, the ASIR, ASPR, and ASDR for periodontal disease show a more pronounced upward trend, which may be attributed to China's rapid population aging and the large, fast-growing elderly population, thus serving as a wake-up call for the domestic oral health sector. Both China and the world are facing a severe burden from periodontal disease, making it urgent to strengthen prevention and treatment efforts. On one hand, there is a need to intensify oral health education, widely disseminate oral health knowledge, and raise public awareness of periodontal disease and prevention. On the other hand, efforts should be made to optimize the allocation of oral health resources and enhance the level of basic oral medical services. Additionally, establishing a robust national periodontal disease monitoring system is crucial. Long-term and systematic monitoring can help track the epidemiological trends and changing patterns of periodontal disease, providing scientific evidence for the development of targeted prevention and treatment strategies. Furthermore, strengthening international cooperation and exchanges, sharing experiences and technologies in periodontal disease prevention and treatment, is essential in jointly addressing this global health challenge.

Conclusion

In conclusion, periodontal disease remains a widespread and serious public health issue globally. Our research results indicate that the burden of periodontal disease continues to rise, which is closely linked to factors such as global population growth, lifestyle changes, dietary habits, and aging. Furthermore, in response to the increasing burden of periodontal disease, society and government agencies must further strengthen prevention and control efforts, promote health education, improve the rational allocation of oral health resources, and develop more effective prevention and treatment strategies tailored to different population groups.

Declarations:

Ethics approval and consent to participate: not applicable.

Consent for publication: agree to publish

Data availability statement: The data used for the analyses in the study are publicly available at <https://ghdx.healthdata.org/gbd-2021>.

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