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ORIGINAL RESEARCH

Edentulism Trends in Chinese Women vs US and Global Women: GBD 2021 Outlook

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Background: Edentulism, the complete loss of natural teeth, remains a major public health issue worldwide, particularly affecting women and older adults. This study aims to evaluate the disease burden of edentulism among women in China, the United States, and globally, addressing the gap that few prior studies have conducted sex-specific comparative analyses of edentulism to inform policy-making and resource allocation for women's oral health.

Methods: This retrospective, population-based study used data from the Global Burden of Disease (GBD) 2021, a worldwide program that evaluates and compares health outcomes—including mortality and disability—across diseases and populations. We analyzed the incidence and Years Lived with Disability (YLD) of edentulism among women in China, the United States, and globally from 2002 to 2021. Age-standardized rates (ASR), Estimated Annual Percentage Change (EAPC), and Bayesian Age–Period–Cohort (APC) models were applied to assess temporal effects and predict trends to 2046.

Results: China's age-standardized incidence rate (ASIR) remained consistently below the global average ASIR derived from the GBD 2021 dataset, with a brief period (2006–2012) where it exceeded that of the United States. Age-specific analysis revealed that edentulism incidence increased most prominently among younger women in China (20–29 years) and older women in the United States (65–84 years). The APC analysis revealed that edentulism in China peaked around age 75, while in the United States, it peaked at age 65. Predictions indicate that ASIR in both countries will continue to rise from 2022 to 2046.

Conclusion: The study highlights a concerning upward trend in the burden of edentulism, particularly among young women in China and elderly women in United States. Predictions suggest a sustained increase in incidence rates in these regions, underscoring the need for stronger healthcare policies and resource allocation toward preventive and rehabilitative dental care for women.

Keywords: edentulism, women's oral health, China, United States, Global Burden of Disease, age-period-cohort analysis, Bayesian prediction

Introduction

Dental health is a critical public health issue worldwide, affecting over 3.5 billion individuals globally, with 267 million cases identified as edentulism.[1] Edentulism, the complete loss of teeth, results from a complex interplay between oral diseases and other health conditions, significantly impacting both oral and general health.[2] The World Health Organization (WHO) identifies dental caries and periodontal disease as the primary causes of tooth loss.[3] Research consistently demonstrates that tooth loss and edentulism adversely affect quality of life, self-esteem, and nutritional intake.[4,5] For older adults, impaired chewing function reduces maximum bite force and oral motor function, potentially leading to cognitive decline.[6] Additionally, diminished chewing ability in edentulism can negatively impact physical and mental health, as patients with missing teeth often avoid harder, nutrient-rich foods like fruits, vegetables, and nuts, altering their dietary intake.[7,8]

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The incidence of edentulism is closely related to age and is particularly prevalent among older populations.[9] Older adults often experience the cumulative effects of tooth wear, periodontal disease, and other oral health problems that lead to gradual tooth loss.[10] Moreover, edentulism reflects social inequalities and is associated with inadequate education and income.[11,12] The 2011–2016 Oral Health Surveillance report by the CDC in the USA revealed that edentulism was present in 34% of the poor population, compared to 11% among those not classified as poor.[13] Global studies have highlighted variations in the prevalence and burden of edentulism across countries with differing Social Demographic Index (SDI) classifications, yet specific comparative analyses remain limited.[14] China and the United States, representing medium and high SDI categories, respectively, are the world's most populous nations.[15] By the end of 2012, China's population aged 60 and above reached 194 million (14.3% of the total), with 123 million aged 65 and above, accounting for one-fifth of the global elderly population.[16] In the US, the prevalence of edentulism among those aged 65 and over was 12.9% in a 2015–2018 survey, and among those 75 and older, the rate of missing teeth reached 17.8%.[17] Therefore, it is of great significance to compare the epidemiologic trends of edentulism in China, the United States, and globally, with a particular focus on women.

Over the past 30 years, edentulism has been more common among women compared to men, underscoring the need for increased health awareness among women.[18] Women are more prone to edentulism due to factors such as hormonal fluctuations, postmenopausal osteoporosis, longer life expectancy, and socioeconomic inequalities limiting access to dental care. Results of a comprehensive 20-year study in Lithuania show that missing teeth are more prevalent in women.[19] Although numerous studies have examined the overall burden of edentulism, few have compared sex-specific patterns between China and the United States. Therefore, the purpose of this study was to compare the epidemiologic trends of female edentulism in China and the United States, as well as globally, in order to provide a scientific basis for the development of national public health policies for women in both countries.

Methods

Data Source

This retrospective, population-based comparative study used publicly available data from the Global Burden of Disease (GBD) 2021 database (https://ghdx.healthdata.org/gbd-results-tool, accessed on November 1, 2024). The GBD study is a comprehensive global initiative that provides standardized, population-level estimates of incidence, prevalence, mortality, and disability-adjusted metrics across 204 countries and territories. As the GBD dataset includes modeled estimates for entire national populations, no additional inclusion or exclusion criteria were required. China and the United States were selected for comparison because they represent countries with markedly different socioeconomic conditions, healthcare systems, and population structures, while both contribute substantially to the global burden of oral diseases.

Since mortality directly resulting from periodontitis and edentulism is unlikely, no deaths were attributed to these conditions. Consequently, Disability-Adjusted Life Year (DALY) estimates, which integrate years of life lost (YLL) and years lived with disability (YLD), were based exclusively on YLDs. In this study, therefore, YLD is equivalent to DALY, and only the term YLD is used to avoid confusion.

The primary outcome was the age-standardized incidence rate (ASIR) of edentulism among women in China, the United States, and globally from 2002 to 2021. Secondary outcomes included the YLD, and projected trends to 2046. Data on the incidence and YLDs related to missing teeth, as well as age-standardized rates in China and the United States from 2002 to 2021 were sourced from GBD 2021 database. This database is managed by the World Health Organization (WHO), coordinated by the Institute for Health Metrics and Evaluation, and funded by the Bill and Melinda Gates Foundation. For this study, data specific to China and the United States were selected, focusing on "Edentulism" as the cause, with "incidence" and "YLDs" as key measures. All estimates were provided with a 95% uncertainty interval (95% UI). To examine age-related patterns in incidence and YLDs, the population was categorized into 16 age groups: 20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74, 75–79, 80–84, 85–89, 90–94, and 95+ years. Detailed descriptions of the general methodologies employed in GBD 2021 are available on their official website (https://ghdx.healthdata.org/gbd-2021).

Statistical Analysis

Using the GBD 2021 dataset, we obtained annual counts and rates for the incidence and YLDs associated with edentulism, disaggregated by sex, age, and country for the period from 2010 to 2021. The age-standardized rate (ASR) and estimated average percentage change (EAPC) were calculated to assess the burden and trends of edentulism over time.

$$ASR = \frac{\sum_{i=1}^{A} a_i w_i}{\sum_{i=1}^{A} w_i} \times 100,000$$

In this study, a_i represents the age-specific rate for the ith age group, w denotes the population size (or weight) of that ith age group based on the reference standard population, and A indicates the total number of age groups. The EAPC calculation follows the methodology from Liu et al, using the equation y = a + bx + e, where y is the natural logarithm of the age-standardized rate ln (ASR) and x represents the calendar year. The EAPC is calculated as 100 × (exp(b) – 1), with its 95% confidence interval (CI) derived from the linear regression model. An EAPC greater than zero indicates an upward trend in the age-standardized indicator, while an EAPC less than zero shows a downward trend. An EAPC of zero signifies stability in the indicator.

Subsequently, an age-period-cohort (APC) analysis was conducted to evaluate the effects of age, period, and cohort on the previously mentioned disease metrics. This analysis employed a log-linear model incorporating additive effects of the three components—age, period, and birth cohort—equally at a given calendar time. Age effects represent the biological and social processes of aging that are specific to individuals.[20] Age effects represent the biological and social processes of aging that are specific to individuals.[21] Period effects are external factors that affect all age groups.[22] Cohort effects capture the varying formative life experiences of different generations, providing a crucial perspective for understanding how population health status evolves over time.[23]

This is represented by the following equation:

$$\log \lambda = \alpha_a + \beta_p + \gamma_c$$

In this context, the age effect is represented by α the period effect by β, and the cohort effect by γ.

In APC analyses, age, period, and cohort effects are linearly dependent, as cohort equals period minus age (Cohort = Period − Age). This exact linear dependency creates an "identification problem", making it statistically impossible to uniquely estimate all three effects using traditional regression models due to perfect multicollinearity. To address this issue and further assess temporal trends in edentulism, a Bayesian Age-Period-Cohort (BAPC) model coupled with Integrated Nested Laplace Approximation (INLA) was employed to project ASIR and ASYR trends for edentulism from 2022 to 2046. The Bayesian framework applies penalized complexity priors and smoothness constraints on the age, period, and cohort dimensions, effectively mitigating collinearity and enabling stable, interpretable posterior estimates of the independent temporal effects. The APC model assumes that age, period, and cohort effects are independent and additive, allowing for the decomposition of temporal patterns. The Bayesian regularization incorporated in the BAPC model stabilizes estimation and smooths random effects, making it well-suited for long-term trend analysis using population-level data. However, since the models are based on GBD-estimated data rather than raw observations, some inherent uncertainty remains; thus, all estimates are presented with 95% uncertainty intervals to reflect statistical uncertainty. In this study, the EAPC values were calculated based on the GBD 2021 data to quantify temporal trends in age-standardized rates. All analyses were conducted using the gR R package, a specialized toolkit developed for GBD data analysis that integrates APC and BAPC models with INLA for efficient Bayesian inference.

Results

Burden and Trends of Edentulism in Women from 2002 to 2021

The ASIR trends for China, the United States, and the world from 2002 to 2021 are illustrated (Figure 1A). During this period, China's ASIR reached its lowest in 2015 and peaked in 2020, whereas the United States saw its minimum in 2010 and its maximum in 2021. China's ASIR remained consistently below the global level, with a brief period from 2006 to

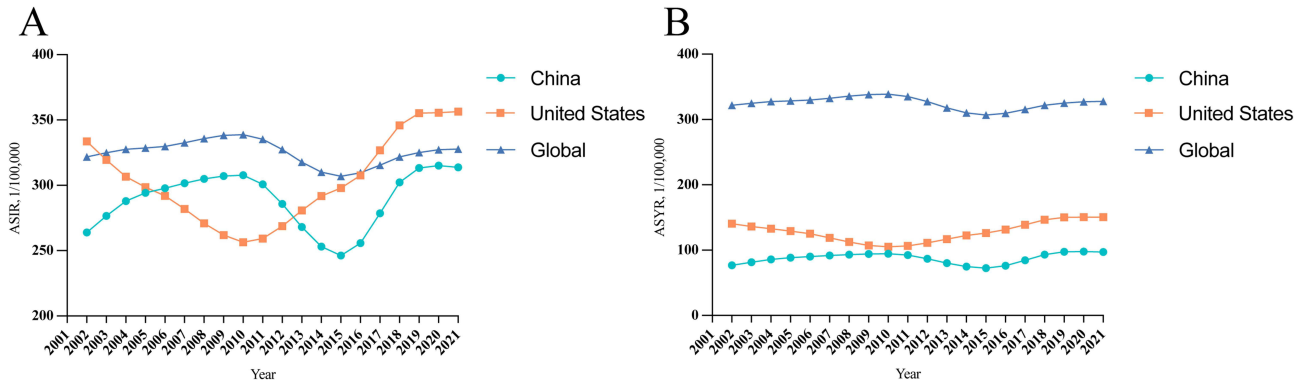

Figure 1 The edentulous ASIR and ASYR of females in China, the United States, and globally from 2002 to 2021. (**A**) Age-standardized incidence rate (ASIR). (**B**) Age-standardized years lived with disability rate (ASYR).

2012 when it was higher than that of the United States. Since 2015, ASIR has shown an overall upward tendency in China, the United States, and globally. The ASYR trends for the same regions and timeframe are shown (Figure 1B). Throughout the study period, ASYR levels in China, the United States, and globally remained relatively stable, with China's ASYR lower than that of the United States, and the United States' lower than the global average. Since 2015, ASYR in all three regions has been on the rise.

The change in the number of new cases in China and the United States from 2002 to 2021 is shown (Figure 2A). During this period, new cases in China consistently exceeded those in the United States by approximately two to four times. After 2015, new cases in China increased sharply, while the United States experienced a gradual rise beginning in 2010. The YLD trends for China and the United States from 2002 to 2021 are presented, showing that YLDs in China were consistently one to three times higher than in the United States over the study period (Figure 2B).

The Change of Edentulism Disease Burden of Women in Different Age Groups from 2002 to 2021

The changes in incidence rates across different age groups in China, the United States, and globally are shown (Table 1). In China, the age groups 20–24 and 25–29 experienced the most significant increases. The age groups 80–84, 85–89, and 90–94 showed the most marked declines. For the United States, the age groups 65–84 exhibited a significant upward trend. Globally, the 35–39 and 95+ age groups showed the most significant increases, while the 65–69 and 70–74 age groups had the most notable declines.

The changes in YLDs rates across different age groups in China, the United States, and globally (Supplementary Table S1). In China, the age groups 20–24, and 25–29 exhibited the most significant upward trends. In the United States,

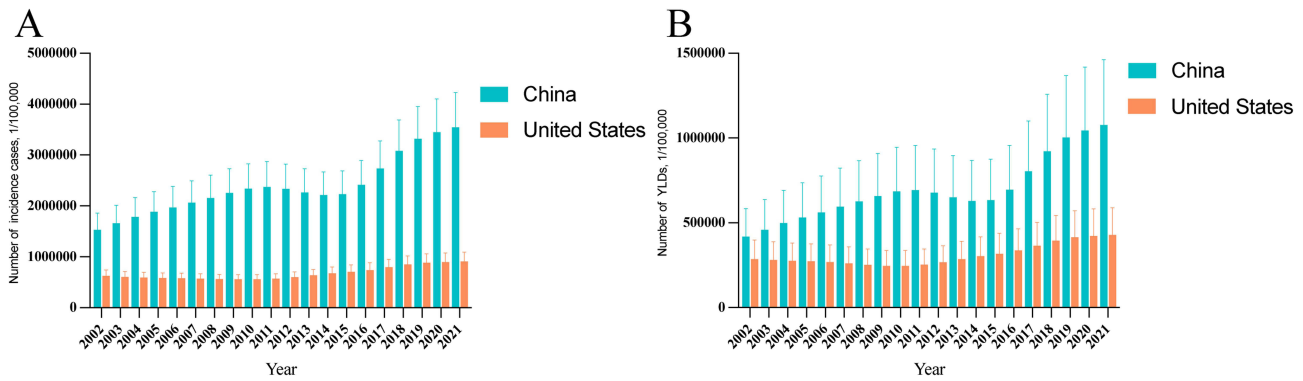

Figure 2 The edentulous number of incidence cases and YLDs of females in China and the United States, from 2002 to 2021. (**A**) Number of incidence cases. (**B**) Number of years lived with disability (YLDs).

Table 1 The EAPC of Edentulous Incidence in Women in Different Age Groups from 2002 to 2021

Age	EAPC (95% CI)		
	China	United States	Global
20-24 years	1.248 (0.308, 2.198)	1.265 (−0.269, 2.822)	0.217 (−1.373, 1.833)
25-29 years	1.328 (0.021, 2.652)	1.059 (−0.521, 2.664)	0.300 (−0.667, 1.276)
30-34 years	0.931 (−0.651, 2.538)	0.872 (−0.410, 2.170)	0.507 (0.024, 0.993)
35-39 years	0.651 (−0.866, 2.191)	0.755 (−0.428, 1.952)	0.616 (0.459, 0.774)
40-44 years	0.366 (−0.728, 1.472)	0.673 (−1.124, 2.503)	0.046 (−0.355, 0.448)
45-49 years	0.343 (−0.326, 1.017)	0.552 (−1.662, 2.815)	−0.398 (−0.863, 0.070)
50-54 years	0.460 (−0.319, 1.245)	0.521 (−1.382, 2.460)	−0.238 (−0.608, 0.133)
55-59 years	0.655 (−0.366, 1.686)	0.539 (−0.760, 1.856)	0.025 (−0.384, 0.435)
60-64 years	0.609 (−0.577, 1.809)	0.526 (−0.347, 1.407)	−0.138 (−0.660, 0.387)
65-69 years	0.357 (−0.691, 1.415)	0.706 (0.052, 1.364)	−0.497 (−0.911, −0.081)
70-74 years	0.016 (−0.567, 0.602)	1.080 (0.345, 1.819)	−0.687 (−0.973, −0.401)
75-79 years	−0.350 (−0.577, −0.122)	1.241 (0.320, 2.170)	−0.424 (−0.546, −0.301)
80-84 years	−0.589 (−0.888, −0.289)	0.943 (0.125, 1.768)	0.112 (−0.021, 0.244)
85-89 years	−0.643 (−1.043, −0.241)	0.372 (−0.161, 0.907)	0.297 (0.132, 0.463)
90-94 years	−0.521 (−0.912, −0.127)	−0.048 (−0.383, 0.288)	0.542 (0.356, 0.728)
95+ years	−0.302 (−0.610, 0.007)	−0.213 (−0.480, 0.054)	0.796 (0.530, 1.062)

Notes: In interpreting EAPC results, only values with 95% CI not crossing zero were considered statistically significant.
Abbreviation: EAPC, estimated average percentage change.

all age groups displayed an upward trend, with a particularly pronounced increase among those aged 75 years and older. Globally, the 75–79 age group showed most notable declines.

Age-Period-Cohort Analysis of the Incidence of Edentulism in Women from 2002 to 2021

The APC model was employed to evaluate the effects of age, period, and cohort on the incidence of edentulism in China and the United States (Figure 3). Regarding the age effect, the incidence begins to rise around age 40, peaking at approximately 75 years in China (Figure 3A) and 65 years in the United States (Figure 3D). For the period effect, the relative risks (RRs) (relative to 2007–2011) show an upward trend before 2010 and again after 2015 in China (Figure 3B), and a similar increase after 2010 in the United States (Figure 3E). The cohort RRs (relative to 1950–1954) remain relatively stable over the study period in China (Figure 3C) but show an upward trend, peaking in the cohorts after 1980 in the United States (Figure 3F).

Forecasts for the Incidence and YLDs Rates of Edentulism in Women from 2022 to 2046

The Bayesian APC model with INLA was applied to predict ASIR and ASMR trends for Edentulism of Women in China from 2022 to 2046 (Figure 4). Throughout the study period, ASIR in China shows an upward trend (Figure 4A), while ASYR shows a slight decrease (Figure 4D). In the United States, ASIR demonstrates an upward trend (Figure 4B), with a slight decline in ASYR (Figure 4E). Globally, both ASIR (Figure 4C) and ASYR (Figure 4F) show a downward trend.

Discussion

This study provides a comprehensive analysis of temporal trends and future projections of edentulism among women in China, the United States, and globally using GBD 2021 data. The burden of edentulism showed a gradual, though partly nonsignificant, increase among women in both countries, with notable differences in age-specific patterns—particularly the rising incidence among younger women in China and the differing peak onset ages between China and the United

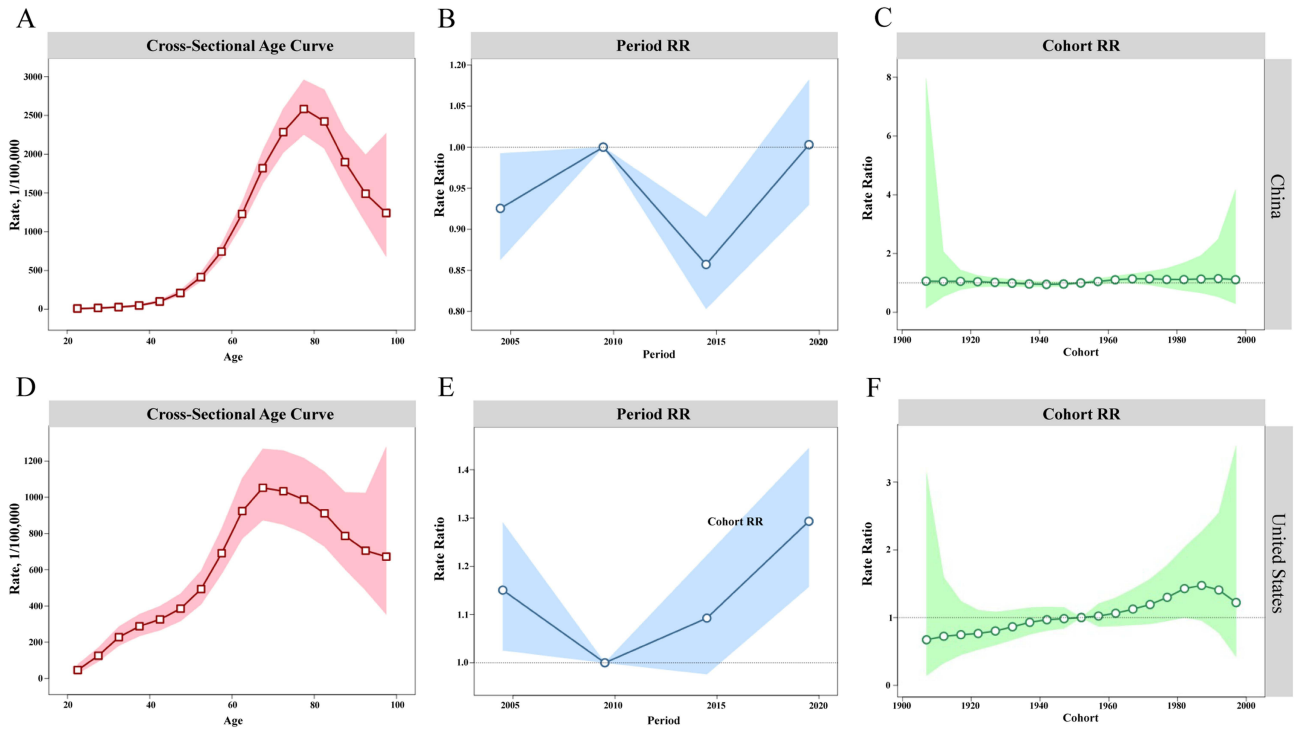

Figure 3 Age–period–cohort analysis of edentulous incidence in China and United States, 2002–2021. (**A**) Fitted cross-sectional age curves of incidence in China. (**B**) Relative risk for each time period in China, using 2007–2011 as a reference. (**C**) Relative risk for each cohort in China, with the 1950–1954 cohort as a reference. (**D**) Fitted cross-sectional age curves of incidence in United States. (**E**) Relative risk for each time period in United States, using 2007–2011 as a reference. (**F**) Relative risk for each cohort in United States, with the 1950–1954 cohort as a reference.
Abbreviation: RR: relative risk.

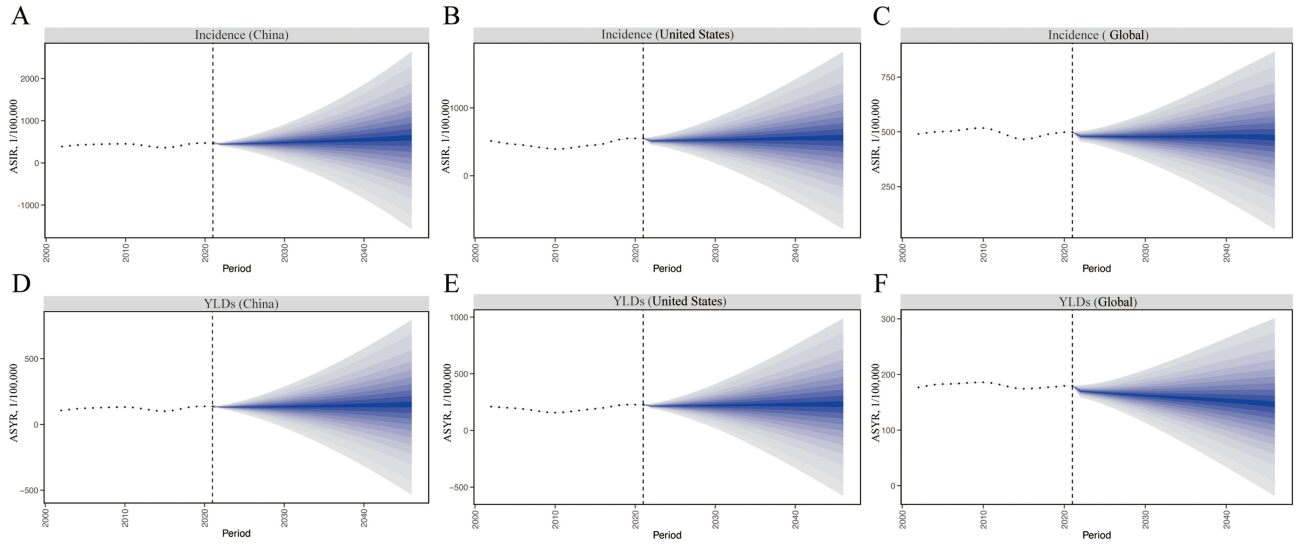

Figure 4 Projection of ASIR and ASYR for edentulism in China, the United States, and globally, 2022–2046. (**A**)Projected ASIR in China. (**B**) Projected ASIR in United States. (**C**) Projected ASIR globally. (**D**) Projected ASYR in China. (**E**) Projected ASYR in United States. (**F**) Projected ASYR globally.
Abbreviations: ASIR, age-standardized incidence rate; ASYR, age-standardized years lived with disability rate.

States. Although previous studies have examined overall or national trends of edentulism, few have focused on sex-specific, cross-national comparisons or employed predictive modeling to forecast future patterns. By addressing these gaps, our study provides new evidence on long-term trends and Bayesian projections of edentulism among women, offering valuable insights for developing gender-responsive oral health policies and targeted preventive interventions.

With the advancement of the social economy, significant changes have occurred in women's lifestyles, particularly in China. Women are now balancing professional responsibilities with family care, leading to increased mental stress. This shift may result in a diminished focus on oral hygiene. Additionally, factors such as hormonal fluctuations and osteoporosis can exacerbate periodontitis, ultimately contributing to tooth loss. In gender-specific studies on edentulism, the prevalence of edentulism is higher among women compared to men.[24] Pregnancy-related hormonal and immune (the antimicrobial peptide LL-37) changes can increase gingival inflammation and susceptibility to periodontal disease, which may progress to tooth loss if untreated.[25,26] During menopause, decreased estrogen levels accelerate alveolar bone resorption and reduce collagen turnover, contributing to greater periodontal attachment loss and edentulism risk.[27] Nutritional deficiencies—particularly inadequate calcium and vitamin D intake—can further exacerbate oral bone fragility.[28] In addition to biological factors such as hormonal fluctuations and osteoporosis, recent studies among Chinese women have identified reproductive history—including early childbearing and high parity—as significant predictors of edentulism later in life.[29] These findings suggest that women's reproductive health may represent a unique sociobiological determinant of oral health disparities, which warrants consideration in country-specific analyses.

From an overall trend perspective, our research indicates that in economically developed countries, the trend of tooth loss has been steadily decreasing.[30] Consequently, the incidence of edentulism in the United States is expected to be lower than in China. Our research contradicts this expectation, showing that after 2013, the ASIR of edentulism in the US surpassed that of China. Furthermore, the APC model analysis shows that the peak age effect of edentulism in China occurs approximately 10 years later than in the US This discrepancy may be primarily attributed to the significantly higher preference for sugary foods among American women. Sugary drinks (SSBs), which are the main source of added sugar in the American diet.[31,32] Approximately 50% of the US population consumes SSBs on any given day.[33] Besides, socioeconomic status and race also play critical roles in tooth loss in United States; many low-income, working-class individuals cannot afford dental insurance or costly treatments, and may choose to remain toothless rather than spending thousands of dollars to save their teeth.[34,35] In China, efforts to reduce oral treatment costs and implement centralized procurement of implant materials are crucial to ensuring equitable access to medical care for all. Additionally, the diminished regenerative capacity of dental tissue in older individuals further elevates the risk of tooth loss.[1,3]

We are used to paying attention to the toothless jaw of the elderly, but according to our research results, the growth rate of toothless jaw incidence rate of 20–29 years old is higher than that of other age groups in both China and the United States. For young people, in addition to congenital edentulism, trauma, and systemic diseases, the correction of periodontal disease and unhealthy lifestyle habits is more worthy of our attention.[36] The epidemiological studies have shown that the consumption of sugary drinks (SSB) by children in China has increased by 24.4% in the past 20 years.[37] Other risk factors, including smoking, alcohol consumption, and poor oral hygiene, may also lead to and exacerbate periodontitis.[38] In addition, studies have found that more severe periodontitis is associated with myopia in young adults.[39] And the incidence rate of myopia is also increasing.[40]

According to our research, from 2022 to 2046, the ASIR of edentulous women in China and the United States will be on the rise. Aging is one of the important reasons. In 2017, the global elderly population aged 60 and above reached 962 million, more than doubling from 382 million in 1980. By 2050, this number is projected to double again, reaching 2.1 billion.[41] As of December 2020, the elderly population aged 60 and above in China reached 264 million, making up approximately 18.7% of the total population. Of these, 190 million are aged 65 and above, accounting for about 13.5% of China's population.[42] In the United States, older adults (≥65 years old) are projected to represent 20% of the population by 2050, with around 10,000 people reaching age 65 each day.[43] Therefore, it is essential to focus on the prevention and treatment of oral diseases in the elderly, emphasizing the link between oral health and overall health.[44] This includes enhanced oral health management for elderly patients with chronic conditions like hypertension and diabetes, as well as providing services for periodontal disease, oral mucosal conditions, and denture restoration.

Based on our findings, a multi-sectoral approach is essential to reduce the disease burden of edentulism. Given that edentulism is a cumulative, long-term condition, policymakers should not only focus on the elderly but also prioritize the oral health of middle-aged and younger adults. Oral hygiene education programs should be implemented in schools and workplaces, complemented by policies that promote preventive oral health measures. Furthermore, managing and preventing complications from systemic diseases is crucial. High-risk groups should undergo early screening to ensure timely detection, diagnosis, and treatment. On an individual level, unhealthy lifestyle habits should be addressed, with regular dental checkups and early

treatment encouraged, alongside efforts to quit smoking, alcohol, and betel nut consumption. Collectively, these strategies can enhance global oral health.

This study also has certain limitations. Firstly, the data comes from GBD2021, and some of the data is estimated rather than directly measured. However, the literature and IHME annual reports have already proven the reliability of the data,[45] which can aid in assessing the long-term trends of edentulism.[46] Secondly, for the 0–20 age group, the disease burden from tooth loss is negligible, so we excluded this group. Although we retained the ≥95 age group, it does not fully align with the fixed format of the APC model, introducing certain limitations.

Conclusions

This study provides the first gender-specific, cross-national comparison and projection of edentulism among women in China and the United States using GBD 2021 data. By revealing the increasing incidence of edentulism among younger women and the differing peak ages between the two countries, our findings advance current knowledge on sex-related disparities in oral health. These results underscore the need for gender-sensitive public health policies and preventive strategies, including school- and workplace-based oral health promotion programs for younger women, as well as rehabilitation and management plans for elderly populations. Strengthening these measures could help reduce the long-term burden of edentulism and improve women's overall quality of life.

Abbreviations

GBD: Global Burden of Disease; EAPC: estimated average percentage change; YLDs: years lived with disability; ASIR: age-standardized incidence rate; ASYR: age-standardized years lived with disability rate.

Data Sharing Statement

The datasets generated during this study are available from the corresponding authors upon reasonable request.

Ethics Approval and Consent to Participate

The study got an exemption from the Ethical Review Committee of the Affiliated Huaian No.1 People's Hospital of Nanjing Medical University, because it used publicly available and deidentified data from GBD database.

Consent to Publication

All authors have read and approved the content of this manuscript and take responsibility for its accuracy and integrity, in accordance with the criteria set by the International Committee of Medical Journal Editors (ICMJE).

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare no competing interests in this work.

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