Disease Burden and Incidence Prediction of Diabetes in China, 1990-2019: Postprint

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Abstract

Background: Diabetes mellitus is a chronic metabolic disease and has become one of the major chronic diseases threatening the health of Chinese residents.

Objective: To understand the epidemic characteristics and disease burden of diabetes mellitus in China from 1990 to 2019, and to provide data reference for evaluating and formulating diabetes-related prevention and control policies and measures.

Methods: Utilizing the results of the 2019 Global Burden of Disease Study, we described the trends and age distribution characteristics of diabetes mellitus incidence, mortality, disability-adjusted life years (DALYs), years of life lost due to premature mortality (YLLs), and years lived with disability (YLDs) in China from 1990 to 2019, and predicted the incidence rate of diabetes mellitus in China from 2020 to 2030 using the Bayesian Age-Period-Cohort (BAPC) analysis method.

Results: In 2019, the crude incidence rate of diabetes mellitus in China was 265.45 per 100,000, and the age-standardized incidence rate was 204.31 per 100,000, representing increases of 63.12% and 15.93%, respectively, compared with 1990; the crude mortality rate was 12.16 per 100,000, and the age-standardized mortality rate was 9.44 per 100,000, with increases of 105.41% and 2.61%, respectively. The YLL rate exhibited a declining trend, while the YLD rate and DALY rate showed upward trends. The disease burden of diabetes mellitus in males was higher than that in females, with a faster growth rate; the disease burden of diabetes mellitus increased with age; between 2020 and 2030, the incidence rate of diabetes mellitus in the Chinese population is projected to show a declining trend.

Conclusion: The disease burden of diabetes mellitus in China remains substantial, with numerous incident cases and deaths; the disease burden is character-

ized by a high burden attributable to disability. Early prevention of diabetes mellitus should be emphasized to reduce the occurrence of complications; males and middle-aged and elderly populations bear a heavier disease burden and should receive adequate attention.

Full Text

Preamble

Analysis of Disease Burden of Diabetes and Incidence Prediction in China, 1990-2019

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Abstract

Background: Diabetes is a chronic metabolic disease that has become one of the major chronic diseases threatening the health of Chinese residents. **Objective:** To understand the epidemiological characteristics and disease burden of diabetes in China from 1990-2019, and to provide data for evaluating and formulating diabetes-related prevention and treatment policies and measures. **Methods:** Using the results of the Global Burden of Disease Study 2019, we described the changes and age distribution characteristics of diabetes incidence, mortality, disability-adjusted life years (DALY), years of life lost (YLL), and years lived

with disability (YLD) in China from 1990 to 2019, and projected the incidence of diabetes in China from 2020 to 2030 using Bayesian age-period-cohort analysis (BAPC) method. **Results:** In 2019, the crude incidence of diabetes in China was 265.45/100,000 and the standardized incidence was 204.31/100,000, representing increases of 63.12% and 15.93% respectively relative to 1990; the crude mortality rate was 12.16/100,000 and the standardized mortality rate was 9.44/100,000, representing increases of 105.41% and 2.61% respectively. The YLL rate showed a decreasing trend, while the YLD rate and DALY rate showed increasing trends. The disease burden of diabetes in men was higher than that in women, with a faster growth rate. The disease burden of diabetes increased with age. Between 2020-2030, the incidence of diabetes in our population shows a decreasing trend. **Conclusion:** The disease burden of diabetes in China remains heavy, with high numbers of morbidity and mortality. The disease burden is characterized by a high burden caused by disability. Attention should be paid to early prevention of diabetes to reduce the occurrence of complications. The disease burden is higher in males and middle-aged and elderly populations, and sufficient attention should be given to these groups.

Keywords: Diabetes; Burden of Disease; Prediction; China

Introduction

Diabetes is a chronic metabolic disease that causes serious damage to the heart, blood vessels, eyes, kidneys, and other organs over time. Both the number of people with diabetes and diabetes-related deaths are increasing globally, with particularly rapid growth in developing countries such as China and India. In addition to the significant increase in prevalence and mortality, diabetes control and treatment of its complications consume substantial medical resources [1]. A study investigating diabetes among Chinese adults from 2015-2017 found that the prevalence rate was 11.2%, and diabetes significantly increases the risk of ischemic heart disease and stroke, demonstrating that diabetes has become one of the chronic diseases threatening the health of Chinese residents [2]. Currently, some Chinese scholars have studied the disease burden of diabetes in certain regions, finding that although diabetes mortality is decreasing, the overall disease burden continues to rise [3–5]. Other studies have shown that the cancer disease burden attributable to type 2 diabetes in China is increasing, with diabetes exerting a growing influence on cancer [6]. Therefore, this study utilizes the Global Burden of Disease Study (GBD) database to comprehensively analyze the incidence, mortality, and disease burden of diabetes in China from 1990-2019 and their changes, and to predict the incidence trend from 2020-2030. This will help to comprehensively understand the prevention and control situation of diabetes in China, reduce residents' risk of other diseases caused by diabetes, and provide data for relevant departments to formulate diabetes prevention and treatment policies and measures.

Methods

1.1 Data Sources

This study utilized data from the Global Burden of Disease Study 2019 (GBD 2019) for statistical analysis. GBD 2019 employs unified and comparable methods to comprehensively analyze and estimate the disease burden of 369 diseases or injuries in 204 countries and territories globally, while systematically 梳理 ing the attributable disease burden of 87 risk factors [7]. We screened the GBD database, selecting "China" as the region, "Diabetes mellitus" as the cause of death, all years from 1990-2019, and age groups of 0-4, 5-9, 10-14···90-94, and 95+ years.

1.2 Measurement Indicators

This study used standardized incidence and mortality rates to describe morbidity and mortality, and employed disability-adjusted life years (DALY), years of life lost (YLL), and years lived with disability (YLD) to assess the disease burden of diabetes in China, where DALY = YLL + YLD. All these data can be obtained directly from the GBD data website.

1.3 Statistical Analysis Methods

We used Bayesian age-period-cohort analysis (BAPC) method to predict the incidence of diabetes in China from 2020-2030 based on GBD big data on diabetes incidence in China from 1990-2019 [8,9]. Future standardized population data adopted population forecasts from the 2017 GBD database [10]. The BAPC model is based on the age-period-cohort (APC) model, which is commonly used to analyze trends in chronic disease incidence and mortality. The classical APC model can describe disease trends based on the effects of age, period, and cohort on incidence or mortality, and make predictions according to these trends. However, there is a linear relationship among these three factors in the APC model, making parameter estimation difficult. Therefore, a Bayesian model is added to the APC model. The Bayesian model can integrate prior information about unknown parameters with sample information to estimate the posterior distribution, and infer unknown parameters based on the posterior distribution. This model estimation commonly uses the integrated nested Laplace approximation (INLA) algorithm to directly approximate the posterior marginal distribution. Since expected effects in adjacent time periods may be similar, a second-order random walk (RW2) model is used to study the effects of age, period, and cohort, estimating the number of incident cases, age-specific incidence rates, and standardized incidence rates. This prediction process is typically implemented through the BAPC package and INLA package in R [9,11,12]. Descriptive data were organized and analyzed using EXCEL software, while predictive data were calculated using R (version v4.1.2) and visualized using the ggplot2 package.

Results

2.1 Diabetes Incidence and Mortality

From 1990-2019, the crude incidence of diabetes in China increased from 162.73/100,000 to 265.45/100,000, a growth of 63.12%, while the standardized incidence increased from 176.23/100,000 to 204.31/100,000, a growth of 15.93%. The crude mortality rate increased from 5.92/100,000 to 12.16/100,000, a growth of 105.41%, while the standardized mortality rate increased from 9.2/100,000 to 9.44/100,000, a growth of 2.61%.

By gender, in 2019, the standardized incidence and mortality rates for Chinese men were 216.38/100,000 and 10.72/100,000 respectively, representing increases of 23.94% and 25.07% compared to 1990. For Chinese women in 2019, the standardized incidence and mortality rates were 191.96/100,000 and 8.76/100,000 respectively, representing increases of 7.03% and a decrease of 12.74% compared to 1990. As shown in [Figure 1: see original paper], the incidence of diabetes in both men and women showed a fluctuating, slow upward trend from 1990-2019, with higher incidence in men than in women. The standardized mortality rates for both men and women peaked around 2004, with women' s rates higher than men' s before 2004 and men' s rates higher than women' s after 2004.

By age group, in 2019, the total standardized incidence of diabetes in China rose linearly before the 50-54 age group, reaching its peak in the 50-54 age group, after which it gradually declined with age. The trend for women was similar to the overall trend. For men, the standardized incidence showed inflection points in the 40-44, 55-59, and 65-69 age groups, presenting an "M-shaped" pattern.

Table 1 Diabetes incidence and deaths in China, 1990-2019 (1/100,000)

2.2 Diabetes Disease Burden

From 1990-2019, the YLL rate due to diabetes in the Chinese population decreased from 204.71/100,000 to 178.45/100,000, the YLD rate increased from 260.74/100,000 to 316.30/100,000, and the DALY rate increased from 465.46/100,000 to 494.76/100,000.

By gender, in 2019, the YLL rate, YLD rate, and DALY rate for men increased by 8.09%, 30.04%, and 21.08% respectively compared to 1990. For women, the YLL rate and DALY rate decreased by 28.31% and 6.68% respectively, while the YLD rate increased by 12.65%. See .

By age group, in 2019, the YLL rate, YLD rate, and DALY rate generally showed a clear upward trend with age, but with inflection points in the 75-79 and 70-74 age groups respectively. Men' s YLL rate, YLD rate, and DALY rate were higher than women' s in all age groups, and substantially exceeded women'

s rates in the 75-79, 65-69, and 70-74 age groups respectively. See [Figure 3: see original paper].

Table 2 Disease burden of diabetes in China, 1990-2019 (1/100,000)

2.3 Disease Burden by Diabetes Type

Comparing the disease burden of type 1 and type 2 diabetes, type 2 diabetes had higher standardized incidence, standardized mortality, and DALY rates than type 1 diabetes. By type, the standardized incidence of type 1 diabetes showed a slow upward trend, increasing from 1.96/100,000 in 1990 to 3.26/100,000. Compared to 1990, both the standardized mortality and DALY rate of type 1 diabetes decreased, by 52.63% and 38.48% respectively. In 2019, the standardized incidence, standardized mortality, and DALY rate of type 2 diabetes in China all increased compared to 1990, rising by 15.37%, 6.26%, and 9.34% respectively. See .

Table 3 Disease burden of type 1 and type 2 diabetes in China, 1990-2019 (1/100,000)

2.4 Prediction of Diabetes Incidence in China from 2020-2030

During the projected period of 2020-2030, the standardized incidence of diabetes in the Chinese population shows a certain downward trend. Specifically, the standardized incidence for men will decrease from 212.14/100,000 in 2020 to 187.84/100,000 in 2030, a decline of 11.45%. For women, the standardized incidence will decrease from 185.25/100,000 in 2020 to 150.79/100,000 in 2030, a decline of 18.60%. According to these projections, the decline will be greater for women than for men.

Figure 4 Prediction results of diabetes in China, 2020-2030 [Figure 4: see original paper]

Discussion

3.1 Trends in Diabetes Incidence and Mortality in China from 1990-2019

This study used data from GBD 2019 for China to analyze the incidence, mortality, and disease burden of diabetes from 1990-2019. Over the 30-year period, the standardized incidence of diabetes in China showed a fluctuating upward trend. According to the latest estimates of diabetes prevalence and trends in various countries and regions by the International Diabetes Federation (IDF), the number of people with diabetes in China reached 140.9 million in 2021, ranking first globally. The number of patients in India, the second-ranked country, was 74.2 million—China' s patient count is nearly double that of India. China' s age-adjusted prevalence rate of diabetes among adults reached 10.6%,

higher than the global diabetes prevalence level of 9.8%. In 2019, China' s standardized mortality rate increased by 2.65% compared to 1990, a relatively small increase. However, according to IDF data, China is the country with the highest number of annual diabetes deaths in the Western Pacific region, with nearly 1.4 million deaths in 2021. Additionally, 72.8 million adults in China had undiagnosed diabetes. Furthermore, China is the country with the highest diabetes-related health expenditure after the United States, reaching $165.3 billion in 2021 [13]. The direct economic burden of diabetes is related to prevalence, national economic development level, and diabetes prevention and treatment efforts [1]. These data all indicate that diabetes imposes a heavy economic burden on both families and the nation. With a huge number of diabetes patients in China, the prevention and control situation is severe, and diabetes prevention and control work still faces enormous challenges.

3.2 Trends in Diabetes Disease Burden in China from 1990-2019

The results of this study show that in 2019, the YLD rate accounted for as high as 63.93% of the DALY rate, compared to 56.02% in 1990, while the YLL rate accounted for 36.07%, a decrease of 12.83% compared to 1990. The decline in the YLL rate is mainly related to the decrease in diabetes mortality, indicating that the risk of death from diabetes in China has decreased, which may be associated with increased accessibility of medical services and improved medical levels in recent years. However, the risk of disability from diabetes has increased, consistent with previous research results [4,14]. Diabetes has the characteristics of high prevalence and disability rates, leading to serious diseases of the heart and blood vessels, eyes, kidneys, and nerves. The treatment costs of complications are also much higher than those for patients without complications [15,16]. However, the awareness rate of diabetes in China is only 36.5%, the treatment rate is 32.2%, and the treatment control rate is 49.2% [2]. Therefore, it is necessary to actively popularize residents' awareness of self-blood glucose management, attach importance to early diagnosis of diabetes, further improve the quality of community diabetes management, and simultaneously reduce the incidence of diabetes complications to alleviate the disease burden caused by diabetes-related disability.

From the perspective of diabetes types, type 2 diabetes is the main type of diabetes disease burden in China. Type 2 diabetes mostly occurs in adulthood, and obesity and overweight are risk factors [17]. Studies have shown that regular moderate-intensity exercise can effectively prevent the occurrence of type 2 diabetes, and physical activity can affect blood glucose levels in the body and reduce the risk of developing diabetes [18].

3.3 Gender and Age Characteristics of Diabetes Disease Burden in China

By gender, from 1990-2019, the standardized incidence of diabetes among Chinese men was higher than that among women. Men' s standardized mortality

rate surpassed women' s around 2008, and the growth rates of standardized incidence, standardized mortality, and DALY rate were all faster than those for women. This may be related to higher exposure levels of risk factors such as obesity and overweight, smoking, excessive drinking, and sedentary lifestyle among men [19–22]. From the perspective of age distribution, the high-incidence period of standardized incidence in 2019 was between 35-79 years, and standardized mortality showed an upward trend with age, increasing rapidly starting from the 65-69 age group, which is consistent with most previous research results [3,4,23]. In 2019, the YLL rate, YLD rate, and DALY rate increased with age, peaking at 70-89 years. The YLL rate increased significantly after age 50, indicating that middle-aged and elderly people have a higher risk of death from diabetes. This suggests that health monitoring of middle-aged and elderly populations should be strengthened, particularly health promotion for middle-aged and elderly men, to improve health awareness of regular blood glucose checks in this group. For high-risk groups such as those who are overweight or obese or have elevated blood glucose, early detection, early management, and early treatment of diabetes should be achieved to reduce the disease burden.

3.4 Predicted Trends in Diabetes Incidence in China

This study predicts the incidence of diabetes in China from 2020-2030, and the results show a downward trend for both men and women during this decade, suggesting that China' s "Medium and Long-term Plan for the Prevention and Treatment of Chronic Diseases (2017-2025)" may be achieving results. However, IDF predicts that the number of people with diabetes in China will reach 164.1 million in 2030, and the number of patients is still increasing. In addition, studies have shown that the diabetes mortality rate and disease burden attributable to high BMI in China' s 15+ age group have increased significantly. Therefore, attention should be paid to potential disease risks among Chinese adolescents, health promotion should be carried out for this group, appropriate physical exercise should be encouraged, and awareness of disease risk prevention should be established [19,24].

This study collected nearly 30 years of data on diabetes incidence and mortality in China from the GBD 2019 database and analyzed the trends in diabetes incidence and mortality in China. From 1990-2019, the number of diabetes cases and deaths in China increased significantly. The disease burden of diabetes in men was higher than that in women, and the growth rate was faster than that in women. Type 2 diabetes and middle-aged and elderly populations had the heaviest diabetes disease burden. This suggests that health management and prevention awareness should be strengthened for type 2 diabetes patients and high-risk groups to reduce the disease burden of diabetes. Meanwhile, men and middle-aged and elderly populations should be the focus of diabetes attention, and appropriate allocation of health resources should be 倾斜 ed toward these groups. However, this study has limitations: it did not include risk factors for diabetes. If subsequent research can conduct in-depth analysis of risk factors

affecting diabetes, it will help provide references for China to adopt more precise intervention measures. In addition, predictions are simulated under limited conditions, and many uncontrollable factors affect disease occurrence, which may be influenced by various factors such as population, environment, health, and economy. Therefore, the prediction results of this paper will deviate from the actual situation, and the accuracy of the prediction results will decrease with increasing prediction time. The BAPC model needs to be further improved to enhance its prediction accuracy.

Author Contributions: Liang Shanshan conceived the article and wrote the initial draft; Zhou Zhihua was responsible for data collection, statistical analysis, and mapping; Li Chengcheng revised the paper; Chen Huijing organized the literature; Zhou Shangcheng was responsible for quality control and review of the article.

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Note: Figure translations are in progress. See original paper for figures.