Analysis and Prediction of Disease Burden Attributable to High BMI in China from 1990 to 2019: A Postprint Study

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Abstract

Background: Obesity is currently a prevalent metabolic disease and has become a serious public health problem of global concern. In recent decades, with China's rapid economic development and accelerated globalization and urbanization, the prevalence of overweight and obesity in China has shown a rapid upward trend, making population-wide obesity prevention and control extremely urgent.

Objective: To analyze the status and temporal trends of disease burden attributable to high BMI in China from 1990 to 2019, and to predict the standardized disability-adjusted life years (DALY) rate for high BMI in the next decade, providing evidence for developing obesity prevention and control strategies in China.

Methods: Data on DALYs and standardized DALY rates attributable to high BMI in China from 1990 to 2019 were extracted from the Global Burden of Disease database. The disease burden of high BMI in China was analyzed by sex, age group, and attributable disease burden. Trends were quantified using estimated annual percentage change (EAPC), and a grey prediction model GM(1,1) was established to forecast standardized DALY rates attributable to high BMI in China from 2020 to 2030.

Results: From 1990 to 2019, deaths and DALYs attributable to high BMI in China increased by 225% and 215%, respectively. Both standardized mortality (EAPC=1.21%, P<0.001) and standardized DALY rates showed upward trends (EAPC=1.41%, P<0.001). The DALY burden attributable to high BMI and its growth rate were significantly higher in males than in females during the same period. The DALY burden increased with age, with rapid growth in the <5 to $ $19 age group. Males of all ages showed increasing trends, while females

aged 20-54 exhibited unstable growth patterns, and those aged 55 and above showed accelerated growth. The four leading diseases in terms of attributable DALY burden in both 1990 and 2019 were stroke, ischemic heart disease, diabetes, and hypertensive heart disease. Diseases with more rapid increases in standardized DALY rates were primarily tumors and musculoskeletal diseases. In 2019, DALYs attributable to high BMI accounted for 6.50% of total DALYs, ranking fifth among 69 risk factors. GM(1,1) predictions indicate that standardized DALY rates for high BMI in China will continue to rise from 2020 to 2030, reaching 1,452.52 per 100,000 in 2030 (1,845.81 per 100,000 for males and 1,106.74 per 100,000 for females).

Conclusion: The disease burden attributable to high BMI in China increased significantly from 1990 to 2019. Targeted interventions should be implemented for different sexes and age groups, with emphasis on preventing and controlling related diseases and cancer types associated with high BMI. The disease burden of high BMI will further increase in the next decade, making nationwide community-based obesity prevention and control efforts extremely urgent.

Full Text

Analysis and Prediction of Disease Burden Due to High BMI in China from 1990 to 2019

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Abstract

Background: Obesity is a common metabolic disease that has become a serious public health problem worldwide. In recent decades, with China's rapid economic development and accelerated globalization and urbanization, the prevalence of overweight and obesity in China has risen sharply. In 2018, China had approximately 85 million obese adults aged 18–69 years. Obesity is a major risk factor for numerous chronic diseases, including hypertension, diabetes, hyperlipidemia, and gout, imposing a heavy burden on residents' health, families, society, and the healthcare system. Studies have projected that by 2030, the overweight/obesity rate among Chinese adults will reach 65.3% and 31.8% among school-age children, resulting in medical expenditures of $61 billion—approximately 22% of total national medical costs. The current obesity epidemic in China is concerning, and national documents such as the "Healthy

China 2030" Planning Outline and Healthy China Action (2019–2030) have proposed relevant requirements and strategic goals for obesity control, making population-wide obesity prevention and control efforts urgently needed.

Objective: To analyze the status and changing trends of disease burden attributable to high BMI in China from 1990 to 2019, and to predict the standardized Disability-Adjusted Life Years (DALY) rate for high BMI from 2020 to 2030, providing evidence for formulating obesity prevention and control strategies in China.

Methods: Data on deaths, standardized mortality rates, DALY numbers, and standardized DALY rates attributable to high BMI in China from 1990 to 2019 were extracted from the Global Burden of Disease Study 2019 (GBD 2019). The disease burden was analyzed by gender, age, and attributable diseases. Trends were quantified using the Estimated Annual Percentage Change (EAPC), and a grey prediction model GM(1,1) was established to forecast standardized DALY rates for high BMI in China from 2020 to 2030.

Results: From 1990 to 2019, deaths attributable to high BMI in China increased by 225% and DALY numbers increased by 215%. The standardized mortality rate showed an upward trend (EAPC=1.21%, 95%UI: 1.11–1.31), as did the standardized DALY rate (EAPC=1.41%, 95%UI: 1.31–1.51). The DALY burden and its growth rate were significantly higher in men than in women. The DALY burden increased with age, with rapid growth in the <5 to 19 age group. All male age groups showed increasing trends, while women aged 20–54 showed unstable trends, accelerating after age 55. The top four diseases with the greatest attributable DALY burden in both 1990 and 2019 were stroke, ischemic heart disease, diabetes, and hypertensive heart disease. Diseases with rapidly increasing standardized DALY rates were primarily tumors and musculoskeletal diseases. In 2019, DALYs attributable to high BMI accounted for 6.50% of total DALYs, ranking fifth among 69 risk factors. GM(1,1) predictions indicated that standardized DALY rates for high BMI in China will continue rising from 2020 to 2030, reaching 1,452.52 per 100,000 in 2030 (1,845.81 for males and 1,106.74 for females).

Conclusion: The disease burden attributable to high BMI increased significantly in China from 1990 to 2019. Targeted interventions should be implemented for different genders and age groups, focusing on preventing high BMI-related diseases and cancers. The burden will further worsen over the next decade, making nationwide community-based obesity prevention and control efforts urgently needed.

Keywords: BMI; Disease burden; Estimated annual percentage change; GM(1,1)

Introduction

Obesity is a common metabolic disease that has become a serious public health problem worldwide. In recent decades, with China's rapid economic development and accelerated globalization and urbanization, the prevalence of overweight and obesity in China has shown a rapid upward trend. In 2018, China had approximately 85 million obese adults aged 18–69 years. Obesity is a major risk factor for numerous chronic diseases, including hypertension, diabetes, hyperlipidemia, and gout, which not only affects residents' health but also imposes a heavy burden on families, society, and the healthcare system. Studies have projected that by 2030, the overweight/obesity rate among Chinese adults will reach 65.3% and 31.8% among school-age children, resulting in medical expenditures of $61 billion—approximately 22% of total national medical costs. The current obesity epidemic in China is concerning, and national documents such as the "Healthy China 2030" Planning Outline and Healthy China Action (2019–2030) have proposed relevant requirements and strategic goals for obesity control, making population-wide obesity prevention and control efforts urgently needed.

This study analyzes the disease burden attributable to high BMI in China from 1990 to 2019 based on the latest data from the Global Burden of Disease Study 2019 (GBD 2019), predicts standardized DALY rates for high BMI from 2020 to 2030, and provides scientific evidence for formulating policies to prevent and control overweight and obesity in China.

Methods

Data Sources

This study utilized data from GBD 2019, which assesses the attributable disease burden for 369 diseases (injuries) and 87 risk factors across 204 countries and territories. GBD employs comparative risk assessment theory, comparing the exposure distribution of a specific risk factor in a population with the theoretical minimum risk exposure level (TMREL) while holding other independent risk factor exposures constant. In GBD 2019, the TMREL for high BMI was 20–25 kg/m^2, and this study defined high BMI as BMI > 25 kg/m^2.

Indicators

Death numbers, standardized mortality rates, DALY numbers, and standardized DALY rates were used as indicators to evaluate the burden of high BMI. DALY is a comprehensive indicator that quantitatively assesses both mortality and disability time in survivors, consisting of years lived with disability (YLD) and years of life lost (YLL)—that is, DALY = YLD + YLL. Standardized mortality and DALY rates were calculated using the GBD world standard population. GBD 2019 estimates age-sex-region-year exposure levels for each risk factor based on all available data sources using spatiotemporal Gaussian pro-

cess regression, DisMod-MR 2.1, and Bayesian meta-regression methods, and calculates the latest estimates of attributable DALYs for each risk factor.

Statistical Methods

Estimated Annual Percentage Change (EAPC): EAPC quantifies the trend in rates over a specific interval and is calculated based on a regression model fitting the natural logarithm of rates. Using year as the independent variable (x) and the natural logarithm of the rate as the dependent variable (y), the model is expressed as $y = b + mx$, where $EAPC = 100 \times (\exp(m) - 1)$. Hypothesis testing for EAPC was performed using t-tests, with statistically significant EAPC indicating a stable rate of change. The 95% uncertainty interval (UI) for EAPC was obtained from the regression model. When both EAPC and its lower 95%UI limit are >0, the trend is increasing; when both EAPC and its upper 95%UI limit are <0, the trend is decreasing; and when the 95%UI includes 0, the trend is stable.

GM(1,1) Model: Grey system theory was proposed by Professor Deng Julong in 1982, and the grey prediction model GM(1,1) is a widely used forecasting model within this theory. It offers advantages including minimal sample data requirements, high fitting accuracy, and computational simplicity, and has been successfully applied in small-sample, poor-information, and uncertain systems. Detailed modeling procedures for GM(1,1) can be found in reference [13]. Model performance is evaluated using the posterior variance ratio C and small error probability P. Smaller C values indicate better concentration of differences between predicted and actual values, while larger P values indicate higher model fitting accuracy. The judgment criteria for model fitting are shown in Table 1 .

Statistical Analysis: Data were imported into Excel for statistical analysis and chart production of deaths, mortality rates, DALY numbers, and DALY rates attributable to high BMI in China from 1990 to 2019. SPSS 26.0 was used to establish regression models for EAPC calculation and t-tests. Matlab R2021b was used to establish prediction models for DALY burden attributable to high BMI in China from 2020 to 2030 and to evaluate model fitting grade. Two-sided tests were used with a significance level of $\alpha = 0.05$, where $P < 0.05$ indicated statistical significance.

Results

Overall Mortality and DALY Burden Attributable to High BMI in China, 1990–2019

Compared with 1990, deaths attributable to high BMI in China in 2019 increased by 225%, with standardized mortality rates showing an upward trend (EAPC = 1.21%, 95%UI: 1.11–1.31). DALY numbers increased by 215%, and standardized DALY rates showed a stable increase (EAPC = 1.41%, 95%UI: 1.31–1.51). The burden and growth rate were significantly higher in men than in women. Detailed data are presented in Table 2 .

Age- and Gender-Specific DALY Burden, 1990–2019

According to the age grouping method in GBD 2019, this study divided ages into 17 groups. The DALY rate attributable to high BMI in China increased with age, peaking at ages 75–79 for both men and women. All male age groups showed clear upward trends, while EAPC differences were not statistically significant for women aged 20–34 and 40–54, indicating unstable trends, with acceleration after age 55. From a developmental perspective, DALY rates for both sexes increased rapidly in the <5 to $ $19 age group, with overall growth rates higher than other age groups. The fastest growth occurred at ages 5–9, with EAPC = 4.92% (95%UI: 3.87%–5.87%) for boys and EAPC = 3.56% (95%UI: 2.33%–4.71%) for girls. Detailed data are shown in Table 3 .

Disease-Specific Attributable DALY Burden and Trends

GBD 2019 categorizes attributable DALY burden into four levels; this study selected level 4 disease categories. Diseases with etiological links to high BMI include eight major categories: neoplasms, cardiovascular diseases, chronic respiratory diseases, digestive diseases, neurological diseases, diabetes and kidney diseases, sensory organ diseases, and musculoskeletal diseases, which are further subdivided into 26 specific diseases (see Table 4 for details). The top four diseases with the greatest attributable DALY burden in both 1990 and 2019 were stroke, ischemic heart disease, diabetes, and hypertensive heart disease. The fifth-ranked disease was liver cancer in 1990 and chronic kidney disease in 2019. After standardization, the top five diseases remained unchanged between 1990 and 2019, with only slight ranking differences. From 1990 to 2019, standardized DALY rates for all high BMI-attributable diseases increased except for hypertensive heart disease, asthma, and liver cancer. The five diseases with the fastest increasing rates were non-Hodgkin lymphoma, kidney cancer, pancreatic cancer, colorectal cancer, and gout. No statistically significant differences were found in EAPC for esophageal cancer, uterine cancer, or hypertensive heart disease between 1990 and 2019 ($P > 0.05$).

Proportion and Ranking Among Risk Factors, 1990–2019

Based on GBD 2019's classification of 87 risk factors, this study analyzed 69 risk factors at the most detailed level 4 classification. In 1990, DALYs attributable to high BMI totaled 7.8763 million, accounting for 1.91% of China's total DALY burden and ranking 15th among 69 risk factors. Over time, the proportion and ranking of high BMI-attributable DALY burden increased annually. High BMI entered the top 10 risk factors in 2001 and remained in the top 5 from 2013 to 2019. In 2019, high BMI caused 24.83 million DALYs, accounting for 6.50% of total DALYs. Detailed data are presented in Table 5 .

Predictions for 2020–2030

The GM(1,1) model for standardized DALY rates attributable to high BMI in the total Chinese population from 2020 to 2030 yielded a posterior variance ratio C = 0.1658 and small error probability P = 1.00, indicating excellent model fit. For Chinese men, C = 0.1394 and P = 1.00 (excellent fit); for Chinese women, C = 0.4365 and P = 0.90 (good fit). The fitting effect between actual and predicted values is shown in Figure 2 [Figure 2: see original paper], with specific predicted values in Table 6 .

Discussion

From 1990 to 2019, deaths, standardized mortality rates, DALY numbers, and standardized DALY rates attributable to high BMI in China increased by 225%, 36%, 215%, and 44%, respectively. These growth rates far exceed global averages of 128%, 5%, 138%, and 18%, consistent with previous research findings. Although studies show that the average BMI increase among Chinese adults has slowed in recent years, it continues to rise, indicating that the overweight and obese population will continue to grow and the burden will become increasingly heavy.

This study found gender differences in DALY burden attributable to high BMI, with higher burden and growth rates in men than women. These disparities likely result from comprehensive factors including socioeconomic conditions, genetics, physiological factors, and lifestyle differences. The DALY burden increases with age, with varying growth rates across age groups and gender differences. Since 1990, the burden has grown rapidly in the <5 to $ $19 age group, with the fastest growth among children aged 5–9, where boys' growth rate was approximately double that of girls—consistent with trends in childhood and adolescent overweight/obesity in China over the past three decades. This suggests that China should strengthen obesity prevention and control efforts for children and adolescents, with targeted interventions for children aged 5–9 and boys as a high-risk group. Adult men in all age groups maintained increasing DALY burdens, with faster growth among those aged 20–49. Women aged 20–54 showed unstable trends, with acceleration after age 55, possibly due to hormonal changes after menopause, lower societal body-shape expectations for middle-aged and older women, and increased social status making weight gain easier. Currently, over 50% of Chinese adults are overweight or obese, nearly 20% of children and adolescents aged 6–17 are overweight or obese, and 10% of children under 6 are affected. With population aging and increased life expectancy, the DALY burden attributable to high BMI will continue to increase, requiring targeted, life-course interventions tailored to different genders and age groups.

Multiple studies have shown that increased BMI is an independent risk factor for cardiovascular disease and diabetes. This study found that stroke, ischemic heart disease, diabetes, and hypertensive heart disease were consistently the top

four diseases with highest attributable DALY burden from 1990 to 2019, consistent with previous research. Except for hypertensive heart disease, asthma, and liver cancer, standardized DALY rates for all other high BMI-attributable diseases increased. The declining rates for asthma and liver cancer likely reflect improved socioeconomic conditions, healthcare quality, living conditions, environmental improvements, and hepatitis B vaccination. However, the DALY burden for asthma and liver cancer remained high in 2019, indicating that prevention and treatment efforts remain challenging. The fastest-growing attributable DALY rates were for neoplasms and musculoskeletal diseases, aligning with China's overall cancer burden distribution. Among neoplasms, the five fastest-increasing standardized DALY rates were kidney cancer, pancreatic cancer, colorectal cancer, non-Hodgkin lymphoma, and ovarian cancer. Research indicates that men and older adults are key populations for cancer prevention and control, with middle-aged and older women being the focus for ovarian cancer. As China's aging process accelerates, early screening, diagnosis, and treatment of cancers can improve prognosis and survival. Studies have noted that moderate obesity benefits bone health, while excessive obesity disrupts bone homeostasis, leading to osteoarthritis, osteoporosis, and intervertebral disc degeneration. Gout-related arthritis has become the most common inflammatory joint disease. High BMI is a major risk factor for multiple chronic diseases, and maintaining normal weight could reduce major chronic disease incidence by approximately 12%. The increasing proportion and ranking of high BMI-attributable DALYs in China's total disease burden indicate that high BMI has become a major threat to residents' health and chronic disease development, urgently requiring effective obesity prevention policies.

GM(1,1) model predictions show that DALY burden attributable to high BMI will continue rising from 2020 to 2030, reaching a standardized rate of 1,452.52 per 100,000 in 2030 (1,845.81 for men and 1,106.74 for women). High BMI not only endangers health but also creates enormous economic burden. In 2010, direct economic costs of overweight and obesity in China reached 90.768 billion yuan, accounting for 42.9% of direct costs for five major chronic diseases (hypertension, coronary heart disease, diabetes, cerebrovascular disease, and cancer) and 4.5% of total health expenditures. Maintaining normal BMI can reduce both chronic disease risk and associated economic burden. Current obesity interventions primarily focus on individual levels, lacking population- and region-level measures. In national basic public health service programs, BMI is only controlled as one risk factor among chronic disease patients, ignoring the obese population alone. With China's growing obese population, nationwide obesity prevention and control should become an essential public health program. The study calls for early implementation of proactive, preventive community-based interventions combining macro-level approaches (government, health systems, social norms) with individual interventions to achieve optimal effectiveness.

Limitations

This study has several limitations. First, it lacks provincial-level burden data, preventing reflection of regional differences and characteristics. Second, diseases attributable to high BMI in GBD 2019 may not be comprehensive. Third, GBD 2019 defines high BMI as BMI > 25 kg/m^2, which may not meet thresholds for all at-risk populations and groups.

Conclusion

From 1990 to 2019, disease burden attributable to high BMI in China increased significantly, with gender and age differences. Over the past 30 years, stroke, ischemic heart disease, diabetes, and hypertensive heart disease have been the four leading diseases in terms of attributable DALY burden. Targeted interventions should be implemented for different genders and age groups, focusing on preventing high BMI-related diseases and cancers. Model predictions indicate that DALY burden attributable to high BMI will further worsen over the next decade, making nationwide community-based obesity prevention and control efforts urgently needed.

Author Contributions: YAN Danhong conceptualized and designed the study, drafted the manuscript, and performed statistical analysis. GAN Tongzhou conducted literature review, data collection and organization, and created figures and tables. YUAN Kongjun revised the manuscript. ZHOU Guangqing provided quality control and oversight for the entire article.

Conflict of Interest: The authors declare no conflict of interest.

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