Postprint: Trends and Forecast Analysis of Premature Death Probability for Four Categories of Chronic Diseases in Baise City, 2015-2021

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Abstract

Background The disease burden of chronic non-communicable diseases (chronic diseases) among Chinese residents is relatively severe and has become an important factor restricting the improvement of population health expectancy.

Objective To investigate the premature mortality from four major categories of chronic diseases (malignant tumors, cardiovascular and cerebrovascular diseases, diabetes, and chronic respiratory diseases) in Baise City from 2015 to 2021 and the achievement of the "Healthy China 2030"targets, thereby providing reference for formulating chronic disease prevention and control strategies in impoverished western regions.

Methods Mortality data registered in the cause-of-death surveillance system of Baise City Center for Disease Control and Prevention from 2015 to 2021 were collected to calculate mortality rates, probability of premature mortality, and other indicators. Joinpoint 24.0 software was used to describe trends in rate changes using average annual percent change (AAPC).

Results From 2015 to 2021, the crude mortality rate of the four chronic diseases in Baise City was 549.06/100,000 (AAPC=0.13%), and the standardized mortality rate was 302.92/100,000 (AAPC=-5.66%), with neither trend being statistically significant (P>0.05). The standardized mortality rate of the four chronic diseases among females showed a decreasing trend (AAPC=-1.66%, P=0.046). The crude mortality rates of cardiovascular and cerebrovascular diseases in the total population, males, and females showed increasing trends (AAPC=2.74%, P=0.004; AAPC=2.43%, P=0.013; AAPC=3.17%, P=0.011). The standardized mortality rates of chronic respiratory diseases among males and females showed decreasing trends (AAPC=-8.66%, P=0.023; AAPC=-8.17%, P=0.027). The probabilities of premature mortality from the four chronic diseases in the total

population, males, and females were 15.77%, 26.03%, and 10.42%, respectively, with the probability of premature mortality from chronic respiratory diseases showing decreasing trends in all groups (AAPC=-6.89%, P=0.012; AAPC=-7.18%, P=0.007; AAPC=-6.94%, P=0.020). The probability of premature mortality from the four chronic diseases among males was approximately 2.5 times that of females. Based on the average growth rate of premature mortality probability for the four chronic diseases in Baise City from 2015 to 2021, the projected probability of premature mortality from the four chronic diseases in Baise City in 2030 is 14.62%, while the target value for 2030 is 13.69%. Only the target values for females, malignant tumors, and chronic respiratory diseases are higher than the projected values. To achieve the 2030 premature mortality target, the average rate of decline in premature mortality probability for the four chronic diseases from 2021 to 2030 must be increased to 2.63%, with the rate for males needing to increase to 2.70%. The probability of premature mortality from diabetes requires special attention, as its projected value is lower than the target value with a substantial gap, and its rate of decline must be increased to 6.76%.

Conclusion From 2015 to 2021, the crude mortality rates of cardiovascular and cerebrovascular diseases in the total population, males, and females in Baise City showed increasing trends, while the mortality rates and probability of premature mortality from chronic respiratory diseases showed decreasing trends. Based on current average growth rates, Baise City still falls short of achieving the "Healthy China 2030" target values. Males should be the key focus population, with diabetes and cardiovascular and cerebrovascular diseases as priority intervention diseases, requiring an average growth rate of -2.63% from 2021 to 2030 to achieve the "Healthy China 2030" targets.

Full Text

Trend and Forecast Analysis of Premature Mortality Probability from Four Major Chronic Diseases in Baise, 2015–2021

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Abstract

Background The disease burden of non-communicable diseases (NCDs) among residents in China is relatively severe and has become a critical factor limiting improvements in healthy life expectancy. **Objective** To examine prema-

ture mortality from four major NCDs (malignant tumors, cardiovascular and cerebrovascular diseases, diabetes, and chronic respiratory diseases) and assess progress toward the "Healthy China 2030" targets in Baise from 2015 to 2021, providing evidence for chronic disease prevention and control strategies in impoverished western border regions. **Methods** Mortality data registered in the cause-of-death surveillance system of the Baise Center for Disease Prevention and Control from 2015 to 2021 were collected. Mortality rates and premature mortality probabilities were calculated, and Joinpoint 24.0 software was used to analyze trends using the average annual percentage change (AAPC). **Results** From 2015 to 2021, the crude mortality rate for the four major NCDs was 549.06 per 100,000 (AAPC=0.13%) and the age-standardized mortality rate was 302.92 per 100,000 (AAPC=-5.66%), with neither showing statistically significant trends (P>0.05). The age-standardized mortality rate for women decreased significantly (AAPC=-1.66%, P=0.046). Crude mortality from cardiovascular and cerebrovascular diseases showed an upward trend in the total population, men, and women (AAPC=2.74%, P=0.004; AAPC=2.43%, P=0.013; AAPC=3.17%, P=0.011), while standardized mortality from chronic respiratory diseases decreased in both men and women (AAPC=-8.66%, P=0.023; AAPC=-8.17%, P=0.027). The probability of premature mortality from the four major NCDs was 15.77%, 26.03%, and 10.42% for the total population, men, and women, respectively, with chronic respiratory diseases showing a decreasing trend (AAPC=-6.89%, P=0.012; AAPC=-7.18%, P=0.007; AAPC=-6.94%, P=0.020). The premature mortality probability for men was approximately 2.5 times that of women. Based on the average growth rate of premature mortality probability from 2015 to 2021, the projected probability for 2030 is 14.62%, while the "Healthy China 2030" target is 13.69%. Only women, malignant tumors, and chronic respiratory diseases have target values above projected values. To achieve the 2030 target, the average annual rate of decline in premature mortality probability must increase to 2.63% from 2021 to 2030, with the rate for men needing to reach 2.70%. Diabetes requires particular attention, as its predicted value falls substantially short of the target, necessitating an increased decline rate of 6.76%. **Conclusion** Cardiovascular and cerebrovascular disease crude mortality increased during 2015–2021, while chronic respiratory disease mortality and premature mortality probability decreased. Current trends suggest Baise will not achieve "Healthy China 2030"targets. Men should be prioritized as the key population, with diabetes and cardiovascular/cerebrovascular diseases as the primary intervention targets. Achieving an average annual decline rate of -2.63% from 2021 to 2030 is necessary to meet the "Healthy China 2030" goals.

Key words: Neoplasms; Diabetes mellitus; Cardiovascular and cerebrovascular diseases; Chronic respiratory disease; Probability of premature mortality; Joinpoint regression analysis; Trend analysis; Baise

Introduction

As mortality from infectious diseases declines, the risk of death from chronic non-communicable diseases (NCDs) continues to rise. According to 2022 WHO data, NCDs account for 73.6% of global deaths, with 70% of all-cause mortality attributed to four major NCDs [**?**]. In China, 82.98% of deaths are attributed to these four disease categories, with cardiovascular/cerebrovascular diseases and malignant tumors ranking as the top two causes of death [**?**]. China' s NCD mortality risk is thus significantly higher than the global average. WHO uses premature mortality probability from four major NCDs as a key indicator to evaluate chronic disease prevention and control effectiveness across regions [**?**]. Both the "Healthy China 2030" Planning Outline [**?**] and China' s Medium- and Long-term Plan for NCD Prevention and Control (2017—2025) [**?**] have established specific targets for reducing premature mortality. However, Zeng et al. [**?**] predicted that at previous rates of decline, nearly two-thirds of provinces —particularly economically disadvantaged ones—would fail to meet the Healthy China 2030 targets, highlighting the formidable challenges remaining in NCD control.

Baise, located in western Guangxi along the border, faces slow economic development and limited medical resources. Since establishing a comprehensive NCD prevention and control demonstration zone in 2019, no studies have examined premature mortality levels from the four major NCDs in this region. Understanding premature mortality patterns in Baise can provide valuable insights for policy development in impoverished border areas. Therefore, this study employs Joinpoint regression analysis to investigate trends in premature mortality probability from 2015 to 2021, assess NCD control effectiveness, and inform targeted intervention strategies.

Methods

Data Sources

Mortality data were obtained from the cause-of-death surveillance system at the Baise Center for Disease Prevention and Control, covering four surveillance points (Youjiang District, Tianyang District, Tiandong County, and Lingyun County) from 2015 to 2021. Population data comprised permanent residents of all age groups from the Baise Center for Disease Prevention and Control information system. The four major NCDs were classified according to the International Classification of Diseases, 10th Revision (ICD-10): malignant tumors (C00-C97), cardiovascular and cerebrovascular diseases (I00-I99), diabetes (E10-E14), and chronic respiratory diseases (J30-J98).

Indicators and Calculations

(1) Premature mortality probability is a statistical indicator calculating the probability of dying from the four major NCDs among individuals aged 30-

69 years. The calculation steps are as follows: age-group mortality rate ${}_{5M}x$ = (deaths from the four NCDs between ages x and $x+5$) / (population between ages x and $x+5$); mortality probability ${}_{5q}x = ({}_{5M}x \times 5)/(1 + {}_{5M}x \times 2.5)$; premature mortality probability ${}_{40}q_{30} = [1 - \prod_{x=30}^{65}(1 - {}_{5q}x)] \times 100\%$ [**?**].

(2) Average Annual Percentage Change (AAPC) is the primary indicator of Joinpoint regression models, used to assess the overall average trend across multiple segments. With P<0.05, AAPC>0 indicates an increasing trend, while AAPC<0 indicates a decreasing trend [**?**]. The formula is: AAPC = $(e^{\sum w_i \beta_i / \sum w_i} - 1) \times 100\%$, with parameter details described by Li et al. [**?**].

(3) Average growth rate = $(a_n/a_0)^{1/n} - 1$, where a_0 represents the 2015 premature mortality probability for the four NCDs in Baise, and a_n represents the target or predicted value.

(4) Target values: The 2020 target for premature mortality probability = 2015 probability × 90%; the 2030 target = 2015 probability × 70%.

(5) Predicted values: The predicted premature mortality probability in year n = 2015 probability × (1 + average growth rate from 2015-2021)$^{(n-2015)}$.

Statistical Methods

Cause-of-death surveillance data were compiled and summarized using Excel 2019 to establish a database. Joinpoint 24.0 software analyzed trends in chronic disease composition ratios, crude mortality rates, standardized mortality rates, and premature mortality probabilities, with age standardization based on the 2010 Sixth National Census data. This study used AAPC to describe trends in all indicators, with P<0.05 considered statistically significant.

Results

Chronic Disease Mortality Proportion and Trends

From 2015 to 2021, chronic diseases accounted for 56,849 deaths in Baise, representing 91.16% of total deaths, with an increasing trend (AAPC=0.53%, P=0.013). The four major NCDs caused 49,852 deaths (79.94% of total deaths), with 18,889 deaths (30.29% of total deaths) occurring among individuals aged 30-69 years. Neither trend was statistically significant (AAPC=0.31%, P=0.279; AAPC=-0.89%, P=0.370) .

Mortality Rates and Trends of Four Major Chronic Diseases

From 2015 to 2021, the crude mortality rate for the four major NCDs was 549.06 per 100,000, and the standardized mortality rate was 302.92 per 100,000, with neither showing statistically significant trends (both P>0.05). Cardiovascular and cerebrovascular diseases had the highest crude mortality at 319.42

per 100,000, with an increasing trend (AAPC=2.74%, P=0.004). Chronic respiratory diseases showed a decreasing crude mortality trend (94.31 per 100,000; AAPC=-6.73%, P=0.019) .

Among men, crude and standardized mortality rates were 613.99 and 657.63 per 100,000, respectively; among women, these rates were 474.14 and 385.62 per 100,000. Women's standardized mortality showed a significant decline (AAPC=-1.66%, P=0.046). Both men and women experienced increasing trends in cardiovascular/cerebrovascular disease crude mortality (AAPC=2.43%, P=0.013; AAPC=3.17%, P=0.011) and decreasing trends in chronic respiratory disease standardized mortality (AAPC=-8.66%, P=0.023; AAPC=-8.17%, P=0.027). Men' s crude mortality was 1.3 times that of women (613.99 vs. 474.14), and men' s standardized mortality was 1.7 times that of women (657.63 vs. 385.62) .

Mortality Rates and Trends Among Elderly Aged $ $60 Years

From 2015 to 2021, the proportion of elderly residents aged $ $60 years in Baise ranged from 11.68% to 16.18%. This group experienced 39,588 deaths from the four major NCDs, accounting for 79.41% of all NCD deaths. The crude mortality rate was 3,001.2 per 100,000, and the standardized rate was 3,011.13 per 100,000, with neither showing significant trends (both P>0.05). Both crude and standardized mortality rates for malignant tumors and chronic respiratory diseases decreased significantly (AAPC=-3.42%, P=0.023; AAPC=-3.08%, P=0.030; AAPC=-8.65%, P=0.012; AAPC=-8.34%, P=0.035) .

Premature Mortality Probability and Trends

From 2015 to 2021, the premature mortality probability for the four major NCDs was 15.77% for the total population, 26.03% for men, and 10.42% for women, with stable trends (all P>0.05). Premature mortality from chronic respiratory diseases decreased across all groups (AAPC=-6.89%, P=0.012; AAPC=-7.18%, P=0.007; AAPC=-6.94%, P=0.020), while premature mortality from malignant tumors decreased among men (AAPC=-4.79%, P=0.017). Men' s overall premature mortality probability was approximately 2.5 times that of women (26.03% vs. 10.42%) .

Achievement of Premature Mortality Probability Targets

Baise' s 2020 premature mortality probability of 16.03% met the 10% reduction target from 2015 levels specified in both the "Healthy China 2030" Planning Outline and China' s Medium- and Long-term Plan for NCD Prevention and Control (2017–2025). However, based on the current average annual decline of 1.92%, the projected 2030 probability is 14.62%, above the 13.69% target. Only women, malignant tumors, and chronic respiratory diseases have target values exceeding projections. To achieve the 2030 target, the average annual decline rate must accelerate to 2.63% from 2021 to 2030, with men' s rate needing to

reach 2.70%. Diabetes demands particular attention, as its predicted value falls substantially below the target, requiring an accelerated decline rate of 6.76% .

Discussion

From 2015 to 2021, deaths from the four major NCDs accounted for 79.94% of total deaths in Baise, similar to the 2015 national average (79.40%) [**?**] but higher than Guangxi' s rate (77.80%) [**?**]. The crude mortality rate of 549.06 per 100,000 was lower than the 2021 national average (588.97 per 100,000) [**?**] but higher than economically developed regions such as Beijing' s Daxing District (502.44 per 100,000) [**?**]. The absence of statistically significant trends in overall NCD mortality (both P>0.05) indicates a high but stable mortality burden. China faces severe population aging, with individuals aged $ $60 years comprising 18.70% of the population in 2020—the highest in the world—and two-thirds of elderly experiencing multimorbidity [**?**, **?**]. In Baise, the proportion of residents aged $ $60 years rose from 11.68% in 2015 to 16.18% in 2021, with this group accounting for 79.41% of NCD deaths. The crude mortality rate among elderly (3,001.20 per 100,000) and standardized rate (3,011.13 per 100,000) substantially exceeded those of the general population. Limited medical resources and poor transportation often delay or prevent care, increasing mortality. Economic disadvantage and poor educational resources contributed to an outflow rate of 7.09% between 2010 and 2020 [**?**], ranking second among 24 provinces and reducing the population base. Meanwhile, the permanent population grew slowly at 0.86%, and Baise' s reputation as a "longevity city" means many elderly die from chronic diseases, contributing to stable mortality levels. Although high, the stable mortality trend suggests recent NCD control efforts have achieved some success, though continued strengthening is needed as absolute deaths continue rising.

Cardiovascular and cerebrovascular diseases had the highest mortality (319.42 per 100,000), increasing at 2.74% annually, while chronic respiratory diseases were the only category showing a decline (6.73% annually). Men' s crude and standardized mortality rates exceeded women' s, consistent with Qingdao findings [**?**], and women' s standardized mortality declined at 1.66% annually, indicating higher NCD mortality risk among Baise men.

Guangxi ranks among the top five provinces with the highest premature mortality probability and slowest decline [**?**]. Baise' s 15.77% premature mortality probability from 2015 to 2021—while lower than the 2019 national average (16.50%) [**?**]—exceeded Guangzhou' s rate (10.50%) [**?**]. Compared with other regions, Baise faces high premature mortality risk with minimal change, except for chronic respiratory diseases declining at 6.89% annually, suggesting gaps compared with more developed regions. Comprehensive NCD prevention and control demonstration zones effectively reduce premature mortality [**?**], yet Baise's zone, established in 2019, has progressed slowly since 2020. The city will adopt a "5+2" model to engage government departments and healthcare workers in building a comprehensive NCD control system with specialized poverty

alleviation health promotion initiatives.

Men' s premature mortality probability was 2.5 times higher than women' s, though women' s probability declined faster at 4.55% annually, consistent with national studies [**?**, **?**]. Behavioral risk factors (smoking, alcohol abuse, unhealthy diet, physical inactivity) and metabolic risk factors (hypertension, hyperglycemia, overweight/obesity) drive these gender differences [**?**]. Men exhibit higher rates of smoking, drinking, unhealthy eating, obesity, hypertension, and diabetes [**?**], while pre-menopausal estrogen protects women from cardiovascular disease. Therefore, Baise should prioritize men in NCD interventions, intensifying health education to improve lifestyle behaviors and reduce the substantial gender gap.

The premature mortality probability from cardiovascular and cerebrovascular diseases was 9.73% (range: 8.13%-11.00%), higher than the national average (8.74%-14.54%) [**?**] but lower than Shenzhen (3.12%-4.29%) [**?**]. As the highest among the four NCD categories—mirroring national patterns [**?**]—this reflects regional variations in NCD control progress. Hypertension is the primary risk factor, yet awareness and control rates remain low in Baise [**?**]. The city must strengthen health education, promote early risk factor detection and control, integrate blood pressure, glucose, and lipid screening into public health examinations, improve stroke and chest pain center systems, and disseminate scientific treatment technologies to integrate prevention and care.

Malignant tumor premature mortality probability was 7.16% (5.78%-8.31%), below the national average (8.85%-12.57%) [**?**] but above Guangzhou (6.38%-7.40%) [**?**]. This high level, second only to cardiovascular disease, aligns with Beijing' s Daxing District [**?**]. Liver, lung, gastric, and nasopharyngeal cancers are most common in Baise, with breast and cervical cancers also contributing substantially to female mortality. Authorities should collaborate to improve environmental sanitation, conduct population-wide education, and control risk factors including smoking, air pollution, and unhealthy diets. Establishing screening systems for respiratory and digestive cancers, promoting CT and Helicobacter pylori screening, and standardizing treatment and rehabilitation can improve five-year survival rates.

Chronic respiratory disease premature mortality probability was 1.56% (1.27%-1.89%), below the national range (1.63%-6.72%) [**?**] and the only category showing a decline (-6.89%), though slower than Guangxi' s rate (-7.23%) [**?**]. This indicates effective screening and pulmonary function testing, yet risk remains high nationally. Continued efforts should emphasize smoking cessation, air pollution control, integrate pulmonary function testing into health examinations, expand high-risk population screening, improve influenza vaccine access, and enhance chronic obstructive pulmonary disease management and rehabilitation to improve quality of life.

Diabetes premature mortality probability was 0.74% (0.57%-0.92%), exceeding national (0.45%-0.66%) [**?**] and Shanghai Pudong New Area (0.47%-0.61%) [**?**]

levels. Despite being the lowest among the four categories, diabetes showed a non-significant upward trend (AAPC=1.19%, P>0.05), likely reflecting low awareness and control rates [?]. Notably, diabetes comorbidity with cardiovascular disease increases premature mortality risk [?]. Enhanced diabetes education, screening for diabetes and complications, and improved risk factor control and self-management capabilities are essential to curb rising premature mortality.

Based on the current -1.92% annual decline rate, only women, malignant tumors, and chronic respiratory diseases are projected to meet Healthy China 2030 targets. Achieving gender- and disease-specific targets requires accelerating men' s decline rate from -1.83% to -2.70%, diabetes from 4.66% to -6.76%, and cardiovascular/cerebrovascular diseases from -1.75% to -2.75%.

This study lacked detailed case information for multivariate regression analysis of mortality and risk factors. Few Joinpoint inflection points were observed, requiring additional years of surveillance data to improve precision. As Guangxi is an economically disadvantaged western region with numerous ethnic minorities, the inability to stratify by urban/rural residence or ethnicity in this study limits targeted policy recommendations.

In conclusion, cardiovascular and cerebrovascular disease crude mortality increased in Baise from 2015 to 2021, while chronic respiratory disease mortality and premature mortality probability decreased. Men' s mortality and premature mortality rates exceeded women' s, though their decline rate was slower. At the current -1.92% annual decline, only women, malignant tumors, and chronic respiratory diseases will achieve Healthy China 2030 targets. Following demonstration zone establishment, chronic respiratory disease control has proven effective, yet substantial NCD mortality and premature mortality risks persist. Government-led, multi-sectoral efforts must prioritize men, strengthen tertiary prevention and treatment of cardiovascular/cerebrovascular diseases and malignant tumors, adopt integrated prevention-care approaches, and maintain vigilance against diabetes and chronic respiratory diseases. Under the guidance of Healthy China 2030 and Baise' s 14th Five-Year Plan, achieving a 2.63% annual decline rate from 2021 to 2030 is necessary to reach the 2030 premature mortality target.

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Tables

Author Contributions: ZHANG Shengnan conceptualized and drafted the manuscript; XU Shihua supervised quality control; HUANG Rongchao, CHEN Jian, and ZHAO Chunru collected, compiled, and analyzed data; MENG Minglyu calculated and verified indicators; MA Yingjiao revised the final manuscript and takes responsibility for the work.

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