Preplanned Studies

Changing Patterns of Mortality in Diabetes Mellitus Among Older Adults — China, 1987–2021

Chen Chen[1,&]; Yihao Zhao[2,&]; Shangjun Liu[3,&]; Yu Wu[1]; Shan Yang[1]; Binbin Su[4,#]; Xiaoying Zheng[1,5,#]

Summary

What is already known about this topic?

Diabetes mellitus poses a significant public health concern for older adults in China, resulting in increased mortality rates.

What is added by this report?

This study investigates the evolving pattern of mortality associated with diabetes mellitus and analyzes the contributions of age, period, and cohort effects from 1987 to 2021. The results demonstrate a consistent rise in diabetes mellitus mortality over the last 30 years, notably in rural regions.

What are the implications for public health practice?

This research offers valuable insights to aid policymakers in developing targeted intervention strategies that address the specific needs of higher-risk populations, such as women, older adults, and individuals in rural areas.

Diabetes mellitus (DM) is a significant contributor to reduced global health-adjusted life expectancy, particularly among older adults (*1*). In China, the prevalence of DM has notably increased from 10.9% to 12.8% between 2013 and 2017, with a particularly high prevalence of 31.8% among older adults (*2*). China is currently undergoing a substantial demographic shift due to aging and has experienced significant transformations over the past three decades (*3*–*4*). However, research on the changing trend of DM, specifically in older adults and with a focus on urban-rural disparities, is scarce. Therefore, this study aimed to comprehensively examine the evolving trajectory of DM mortality from 1987 to 2021, with a specific focus on the influence of age, period, and cohort on shifting patterns. Our findings reveal distinct evolving patterns between urban and rural areas, with a significant increase in DM mortality among the oldest-old population. Addressing this trend should be a priority, and the government should implement measures to mitigate it.

Mortality data for Chinese older adults (age ≥60) with DM were collected from 1987 to 2021. The data were categorized by age, gender, and urban-rural areas, sourced from China's National Health Commission (1954–2013, Ministry of Health; 2013–2018, National Health and Family Planning Commission) death registration system. The age-standardized mortality rate per 100,000 was calculated using the direct standardization method with the World Standard Population as the reference (*5*). Significant fluctuations were identified using joinpoint regression analysis conducted with the Joinpoint Regression Software (v4.9.10, Statistical Research and Applications Branch, National Cancer Institute, Washington, USA). The independent effects of age, period, and cohort were determined using the age-period-cohort (APC) model, implemented with the Web Tool developed by the US National Cancer Institute (*6*). Statistical significance was determined with a two-tailed P-value <0.05.

Figure 1 delineates the trajectory of DM mortality from 1987 to 2021, showing an overall upward trend in the elderly populations of both urban and rural areas. However, distinct patterns emerge in the changing trajectories of urban and rural regions. The rural areas experienced a consistent rise, while urban areas initially increased and then gradually declined, resulting in a narrowed urban-rural discrepancy. Specifically, DM mortality in rural regions increased from 1.96 per 100,000 in 1987 to 8.52 per 100,000 in 2021. In contrast, urban areas saw an increase from 7.52 per 100,000 in 1987 to 14.28 per 100,000 in 2000, eventually decreasing to 10.49 per 100,000 in 2021. Regarding gender differences, higher DM mortality rates were consistently observed in men compared to women, regardless of whether they resided in urban or rural areas.

Table 1 shows periods of significant fluctuation identified through joinpoint regression analysis, revealing distinct evolving patterns in DM mortality. The results showcase a continuous increase [average annual percent change (AAPC)=4.8%, 95% confidence

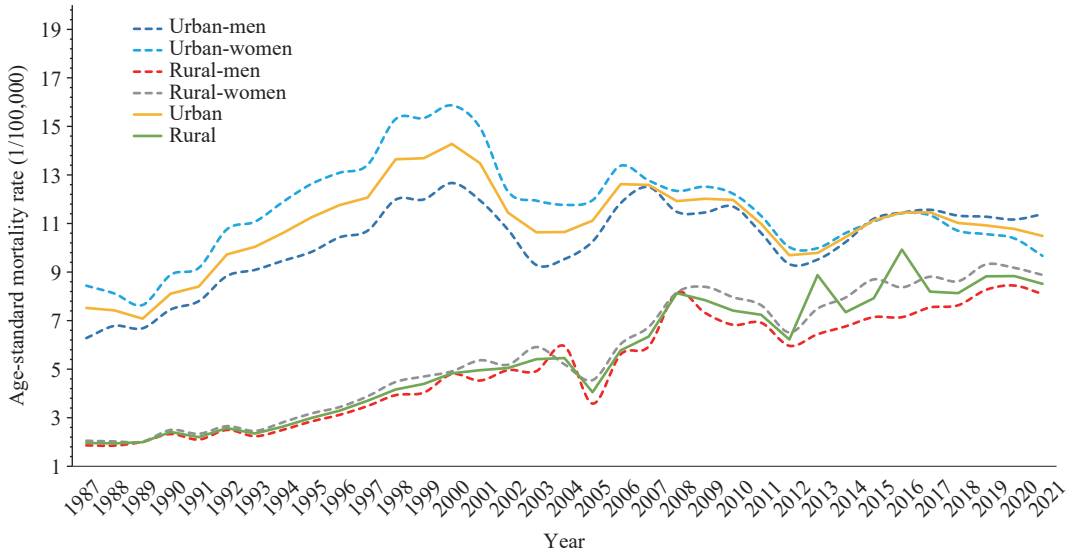

FIGURE 1. Trend of age-standardized mortality rate from diabetes mellitus in Chinese older adults from 1987 to 2021.

TABLE 1. Joinpoint analysis of age-standardized mortality rate of diabetes mellitus in Chinese older adults.

Diabetes mellitus	Total study period (1987–2021)		Period 1		Period 2	
	AAPC (%)	95% *CI*	Years	APC (%)	Years	APC (%)
Urban						
Total	1.1*	(0.6, 1.7)	1987–1998	5.7*	1998–2021	−1.0*
Men	1.6*	(1.0, 2.3)	1987–1997	6.0*	1997–2021	−0.1
Women	0.7*	(0.2, 1.3)	1987–1998	6.0*	1998–2021	−1.7*
Rural						
Total	4.8*	(4.0, 5.6)	1987–2008	6.6*	2008–2021	1.8*
Men	4.5*	(3.7, 5.3)	1987–2008	6.4*	2008–2021	1.4
Women	4.7*	(4.0, 5.4)	1987–2008	6.6*	2008–2021	1.6*

Abbreviation: AAPC=average annual percent change; APC=annual percent change; *CI*=confidence interval.
* Significant difference from zero (P<0.05).

interval (*CI*): 4.0%–5.6%] in rural areas. Conversely, urban areas display an upward trend from 1987 to 1998 (AAPC=5.7%), followed by a slow decline from 1998 to 2021 (AAPC=−1.0%). The table also provides a comprehensive overview of these trends across different periods.

Figure 2 shows the effects of age, period, and cohort on DM mortality. For the age effect, both urban and rural areas exhibited a J-shaped distribution, with DM mortality escalating more rapidly in later years. Notably, women displayed a steeper upward trend compared to men, regardless of whether they resided in urban or rural areas. Regarding the period effect, a flat variation was observed throughout the study period in urban regions. Conversely, in rural regions, the period effect on DM mortality displayed a continuous upward trend, with the risk approximately twice as high as in urban regions. Concerning the cohort effect, significant disparities were also observed between urban and rural areas. In urban areas, the risk of DM mortality remained relatively stable across different cohorts, regardless of gender. Conversely, in rural areas, the cohort effect indicated that the risk of DM mortality was notably higher among more recently born cohorts, reaching its peak in the cohort born in 1957 [risk ratio (RR)=1.83, 95% *CI*: 1.54–2.16].

DISCUSSION

This study identified an increase in DM mortality among older adults in China from 1987 to 2021, with rural areas experiencing a particularly notable rise. Notably, there were distinct patterns observed between urban and rural areas. In rural areas, there was a

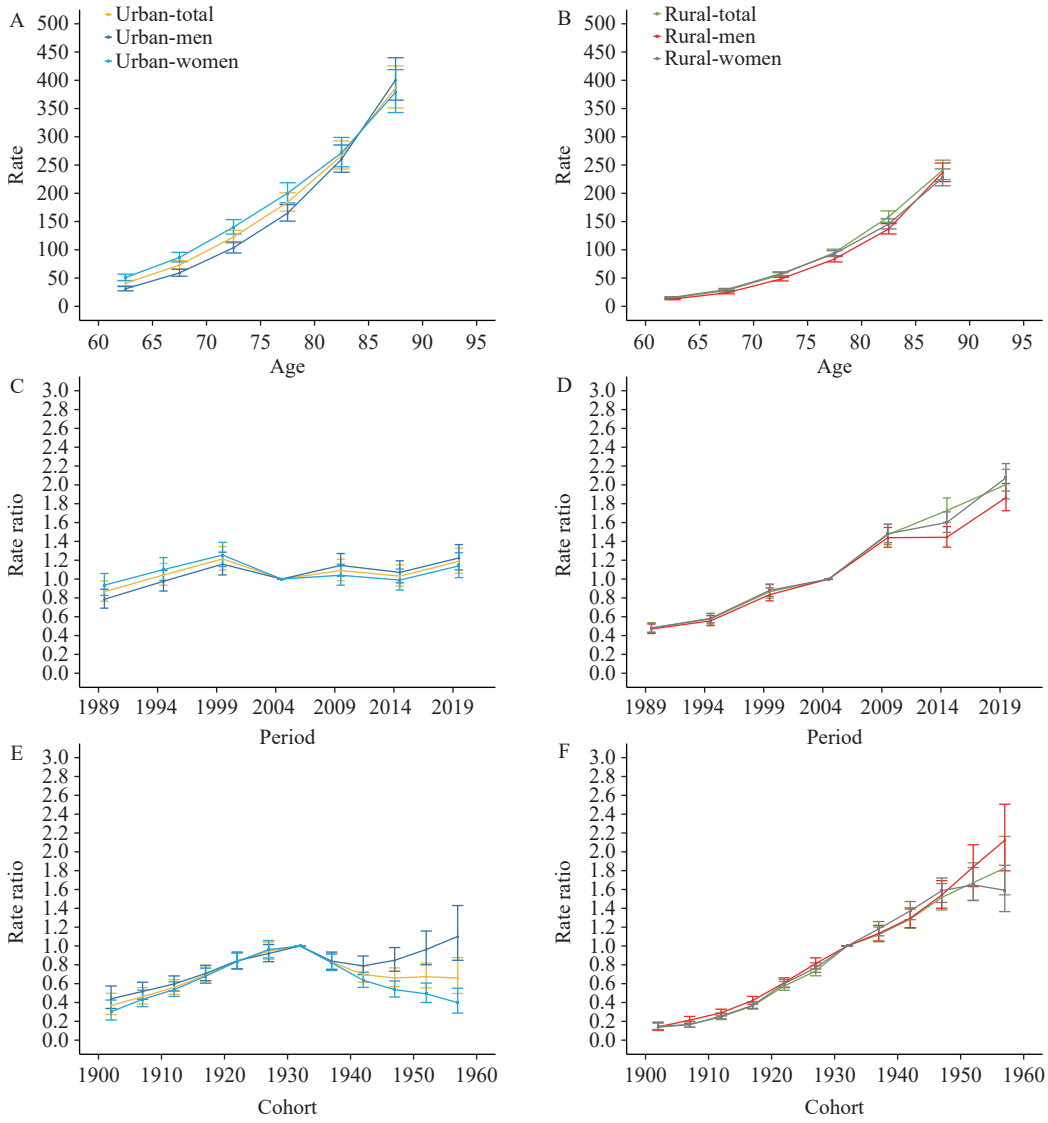

FIGURE 2. The effects of age, period, and cohort on age-standardized mortality rate of diabetes mellitus in Chinese older adults from 1987 to 2021. (A) Age effect in urban area; (B) Age effect in rural area; (C) Period effect in urban area; (D) Period effect in rural area; (E) Cohort effect in urban area; (F) Cohort effect in rural area.

consistent upward trend across all periods, while urban areas exhibited an increase in period 1 followed by a decrease in period 2, gradually narrowing the gap between them. DM mortality increased with age in both urban and rural areas across different age groups. In terms of period and cohort effects, urban areas showed relatively stable patterns, whereas rural areas exhibited J-shaped changing trends.

In the past three decades, China has experienced significant economic and societal changes, coinciding with an upward trend in mortality related to DM. This trend is consistent with global studies comparing DM mortality rates (*7*). Notably, developed countries like the United Kingdom and Germany have demonstrated a decline in DM mortality, whereas many developing nations undergoing an economic transition from low-income to middle-income status have observed a gradual increase in DM mortality. The difference in trends may be attributed, in part, to decreased exposure to risk factors and advances in medical management in developed countries.

The onset and progression of DM are closely associated with socioeconomic factors and lifestyle choices, including smoking, alcohol consumption, and unhealthy dietary habits. In the past three decades, the Chinese population has undergone significant changes in lifestyle and diet. According to the China Health and Nutrition Survey, the prevalence of obesity has increased from 4.0% to 16.4% between 1993 and 2019 (*8*). These changes have contributed to the rise in

DM mortality, as evidenced by the increase in DM-related deaths in both urban and rural areas from 1987 to 2021, as reported in this study. Notably, the Chinese government and researchers have recognized the health risks and burdens associated with non-communicable diseases, including DM, and have implemented preventive measures such as health education and non-communicable disease prevention and control programs.

Our analysis of urban-rural comparisons shows distinct trends in DM mortality. Before 2000, urban areas had a higher growth rate in DM mortality compared to rural areas. This could be due to factors such as higher economic status, a diet high in fat content, and better diagnosis rates in urban areas. However, after 2000, particularly in recent years, rural areas have experienced a significantly higher growth rate in DM mortality, with a stable or slightly declining trend. This aligns with a previous study that found a narrowing gap in DM mortality between urban and rural areas (*9*). The shift in this trend may be due to accelerated economic development, unfavorable lifestyle transitions, low health awareness, and lower standards of medical care in rural areas. The widening urban-rural disparity highlights the urgent need for increased attention and investment in strategies to prevent DM in rural areas.

In our analysis, we found that DM mortality rates were higher among women compared to men in both urban and rural areas. This gender disparity was more pronounced with increasing age. Potential factors contributing to this trend include the influence of sex hormones and possible physiological or biochemical effects on molecular pathways (*10*). It is also worth noting that women tend to live longer but may experience worse health outcomes. Additionally, DM affects a larger number of women than men (*11*). Examining the trend over time, we observed a greater decline in DM mortality among women in urban areas compared to men, while there was no significant gender difference in rural areas. This difference may be explained by economic factors, such as higher DM control rates, greater health awareness, and lower exposure to risk factors among women in urban areas. To mitigate this upward trend, targeted interventions for women, especially those in rural areas, are crucial. Furthermore, our study revealed that regardless of urban or rural areas, DM mortality increased at a higher rate among the oldest-old compared to the young-old. This highlights the heightened risk of DM mortality among the oldest-old population. These findings emphasize the need for increased attention to the risk of death from DM, particularly among the oldest-old population, especially in rural areas.

This study has some limitations. First, our dataset does not include information on different types of DM and province-level administrative divisions, which restricts our ability to analyze the specific types of DM and geographical variations in more detail. Second, our data rely on reported statistics rather than individual-level data, which may underestimate the mortality associated with DM since there may be undiagnosed cases in China. Third, as the APC model used in this study is an ecological research method, it does not allow us to establish causal relationships. However, our main research objective is to examine changes in DM mortality among older adults in China over the past three decades and provide scientifically supported explanations based on relevant literature.

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[#] Corresponding authors: Binbin Su, subinbin@sph.pumc.edu.cn; Xiaoying Zheng, zhengxiaoying@sph.pumc.edu.cn.

[1] Department of Population health and Aging science, School of Population Medicine and Public Health, Chinese Academy of Medical Sciences & Peking Union Medical College, Beijing, China; [2] Department of Chronic Diseases and Multimorbidity, School of Population Medicine and Public Health, Chinese Academy of Medical Sciences & Peking Union Medical College, Beijing, China; [3] Institute of Population Research, Peking University, Beijing, China; [4] Department of Health Economics, School of Population Medicine and Public Health, Chinese Academy of Medical Science & Peking Union Medical College, Beijing, China; [5] HeSAY/ Institute of Population Research, Peking University, Beijing, China.
[&] Joint first authors.

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REFERENCES

1. Martinez R, Lloyd-Sherlock P, Soliz P, Ebrahim S, Vega E, Ordunez P, et al. Trends in premature avertable mortality from non-communicable diseases for 195 countries and territories, 1990-2017: a population-based study. Lancet Glob Health 2020;8(4):e511 – 23. http://dx.doi.org/10.1016/s2214-109x(20)30035-8.
2. Li YZ, Teng D, Shi XG, Qin GJ, Qin YF, Quan HB, et al. Prevalence of diabetes recorded in mainland China using 2018 diagnostic criteria from the American Diabetes Association: national cross sectional study. BMJ 2020;369:m997. http://dx.doi.org/10.1136/bmj.m997.
3. Zheng XY, Luo YN, Su BB, He P, Guo C, Tian YH, et al. Developmental gerontology and active population aging in China. China CDC Wkly 2023;5(8):184 – 7. http://dx.doi.org/10.46234/ccdcw2023.033.
4. Zheng XY, Guo C. Strengthening systematic research on aging:

reflections from an omics perspective. China CDC Wkly 2022;4(39):875 – 8. http://dx.doi.org/10.46234/ccdcw2022.181.
5. Ahmad OB, Boschi-Pinto C, Lopez AD, Murray CJL, Lozano R, Inoue M. Age standardization of rates: a new WHO standard. World Health Organization. 2001;9(10):1 – 14. https://www.researchgate.net/publication/284696312_Age_Standardization_of_Rates_A_New_WHO_Standard.
6. Zou ZY, Cini K, Dong B, Ma YH, Ma J, Burgner DP, et al. Time trends in cardiovascular disease mortality across the BRICS: an age-period-cohort analysis of key nations with emerging economies using the global burden of disease study 2017. Circulation 2020;141(10):790 – 9. http://dx.doi.org/10.1161/circulationaha.119.042864.
7. The Emerging Risk Factors Collaboration. Diabetes mellitus, fasting blood glucose concentration, and risk of vascular disease: a collaborative meta-analysis of 102 prospective studies. Lancet 2010;375(9733):2215 – 22. http://dx.doi.org/10.1016/s0140-6736(10)60484-9.
8. Wang LM, Peng W, Zhao ZP, Zhang M, Shi ZM, Song ZW, et al. Prevalence and treatment of diabetes in China, 2013-2018. JAMA 2021;326(24):2498 – 506. http://dx.doi.org/10.1001/jama.2021.22208.
9. Li YY, Kou CG, Bai W, Hua WQ, Yu WY, Song Y, et al. Trends in diabetes mortality by gender in urban and rural areas in China from 2003 to 2012: an age-period-cohort analysis. Asia Pac J Public Health 2019;31(3):238 – 45. http://dx.doi.org/10.1177/1010539519841288.
10. Muka T, Nano J, Jaspers L, Meun C, Bramer WM, Hofman A, et al. Associations of steroid sex hormones and sex hormone-binding globulin with the risk of type 2 diabetes in women: a population-based cohort study and meta-analysis. Diabetes 2017;66(3):577 – 86. http://dx.doi.org/10.2337/db16-0473.
11. Saeedi P, Petersohn I, Salpea P, Malanda B, Karuranga S, Unwin N, et al. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: results from the International Diabetes Federation Diabetes Atlas, 9th edition. Diabetes Res Clin Pract 2019;157:107843. http://dx.doi.org/10.1016/j.diabres.2019.107843.