Preplanned Studies

Age-Period-Cohort Analysis on Long-Term Mortality Trend of Genitourinary Diseases — China, 1987–2021

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Summary

What is already known about this topic?

There has been a lack of attention to genitourinary diseases for an extended period, resulting in limited research on the mortality trends of genitourinary diseases in China.

What is added by this report?

This study examines the long-term trend of genitourinary diseases' mortality across Chinese individuals of all genders and in various urban and rural regions. Additionally, it investigates the impact of age-period-cohort effects on this trend.

What are the implications for public health practice?

It is imperative to address genitourinary diseases, particularly among vulnerable populations such as rural older men. Policymakers should prioritize these individuals by providing necessary policy interventions and healthcare support.

Genitourinary diseases have been understudied despite being a significant public health issue (*1*). Epidemiological research indicates that these diseases are associated with aging and metabolic conditions like hypertension, diabetes, and metabolic syndrome (*2*). With China's transition to an aging society and the rise of non-communicable diseases due to industrialization and changing dietary habits and lifestyles (*3*–*4*), it becomes crucial to assess the mortality trends of genitourinary diseases in the country. Thus, this study analyzed genitourinary disease mortality data from 1987 to 2021, obtained from the National Health Commission's (NHC) death registration system. Joinpoint regression analysis and age-period-cohort models were employed to identify the long-term trends in genitourinary disease mortality rates among the Chinese population and explore age-period-cohort effects. The findings from this study indicate a downward trend in age-standardized mortality rate (ASMR) for genitourinary diseases, although the crude mortality rates showed a slight decline. It is evident that proactive measures need to be taken to address genitourinary diseases, with a specific focus on the burden in men and the elderly, thus providing policymakers with valuable insights while formulating appropriate strategies.

The age-specific mortality data for genitourinary diseases from 1987 to 2021 were obtained from China's NHC death registration system. The data were collected from various administrative organizations (*5*). Deaths were classified according to the 9th revision of the International Classification of Disease (ICD-9) before 2002 and ICD-10 thereafter. ASMRs were calculated using the World Standard Population (*6*). A joinpoint regression model with natural log-transformed rates was used to analyze the mortality trends of genitourinary diseases between 1987 and 2021. The Joinpoint Regression Program (version 4.9.10, Statistical Research and Applications Branch National Cancer Institute, Washington, USA) was employed for this analysis. Annual percentage changes (APCs) and average annual percentage changes (AAPCs) were calculated, along with 95% confidence intervals (*CI*s) for the entire study period. To address the exact collinearity among the effects of age, period, and cohort, the age-period-cohort model was utilized. This model employed a web tool developed by the U.S. National Cancer Institute. The net drifts were estimated to determine the annual percentage change for the entire population, while the local drifts represented the annual percentage change for each age group. Statistical significance was defined as a two-tailed P-value <0.05.

Table 1 displays the results of the joinpoint regression, showing the long-term trends of crude mortality rates and ASMRs for genitourinary diseases among Chinese individuals by sex and area. From 1987 to 2021, the crude mortality of genitourinary diseases declined slightly, whereas the ASMRs decreased substantially by sex and both urban and rural areas. The ASMR of genitourinary diseases decreased at a rate of −2.9% annually in urban areas and −2.2% annually in rural areas. However, the

TABLE 1. Joinpoint analysis of crude and age-standardized mortality rates of genitourinary diseases in urban and rural areas.

Categories	Mortality rate (per 100,000)		Total study period		Period 1		Period 2		Period 3	
	1987	2021	AAPC (%)	95% *CI*	Years	APC (%)	Years	APC (%)	Years	APC (%)
Crude mortality										
Genitourinary diseases in urban areas										
Total	10.05	6.75	−0.9*	(−1.4, −0.5)	1987–2004	−0.4	2004–2012	−3.8*	2012–2021	0.7
Male	10.29	7.94	−0.5	(−1.1, 0.0)	1987–2004	−0.1	2004–2011	−3.7*	2011–2021	1.1*
Female	9.80	5.56	−1.4*	(−1.9, −1.0)	1987–2004	−0.7*	2004–2012	−4.4*	2012–2021	−0.3
Genitourinary diseases in rural areas										
Total	8.08	7.86	−0.2	(−0.8, 0.4)	1987–1999	0.8	1999–2008	−4.1*	2008–2021	1.6*
Male	8.99	9.34	−0.1	(−0.9, 0.7)	1987–2000	0.9*	2000–2005	−6.7*	2005–2021	1.2*
Female	7.14	6.32	−0.4	(−1.2, 0.4)	1987–2000	0.5	2000–2008	−5.0*	2008–2021	1.6*
Age-standardized mortality										
Genitourinary diseases in urban areas										
Total	13.48	4.04	−2.9*	(−4.5, −1.3)	1987–2005	−1.9*	2005–2008	−14.1	2008–2021	−1.6*
Male	14.86	5.19	−2.8*	(−4.4, −1.2)	1987–2005	−2.2*	2005–2008	−13.9	2008–2021	−1.0*
Female	11.50	3.02	−3.2*	(−4.7, −1.7)	1987–2005	−1.8*	2005–2008	−14.4	2008–2021	−2.5*
Genitourinary diseases in rural areas										
Total	10.33	4.91	−2.2*	(−2.9, −1.5)	1987–2000	−0.4	2000–2008	−6.4*	2008–2021	−1.4*
Male	12.56	6.34	−2.3*	(−3.4, −1.2)	1987–2001	−0.8	2001–2005	−9.7*	2005–2021	−1.8*
Female	8.84	3.65	−2.4*	(−3.2, −1.5)	1987–2000	−0.3	2000–2008	−6.8*	2008–2021	−1.6*

Abbreviation: APC=annual percent change; AAPC=average annual percent change; *CI*=confidence interval.
* $P<0.05$.

decline in crude mortality among urban males and rural residents of both sexes was not statistically significant.

Figure 1 shows the age, period, and cohort effects on mortality from genitourinary diseases. After adjusting for period effects, the age effects demonstrate that the mortality of genitourinary diseases increases with age group and grows more rapidly in older age groups, with males having a higher rate than females. The period effects reveal a declining pattern for both males and females in urban and rural areas. In each subgroup, the period 1987–1992 has the highest risk, and taking the period 2002–2007 as the reference, the relative risk (RR) is 1.32 (95% *CI*: 1.24, 1.40) in urban males, 1.61 (95% *CI*: 1.52, 1.72) in urban females, 1.61 (95% *CI*: 1.49, 1.73) in rural males, and 1.73 (95% *CI*: 1.61, 1.87) in rural females. The cohort effects indicate that the older birth cohort has a greater risk across subgroups, with the 1902 cohort (born between 1900 and 1904) having the highest risk, with a risk ratio of 7.71 (95% *CI*: 6.79, 8.76) for urban males, 9.00 (95% *CI*: 7.76, 10.43) for urban females, 5.84 (95% *CI*: 4.92, 6.94) for rural males, and 6.32 (95% *CI*: 5.30, 7.53) for rural females, taking the 1962 cohort (born between 1960 and 1964) as the reference. The lowest risk is found in the 2017 cohort (born between 2015 and 2019).

Figure 2 presents the net drift and local drift for genitourinary diseases. The net drift was –4.16% (95% *CI*: –4.38, –3.94) in urban areas, with –3.59% (95% *CI*: –3.85, –3.34) for males and -4.82% (95% *CI*: –5.11, –4.52) for females. In rural areas, it was –3.66% (95% *CI*: –3.94, –3.38), with –3.34% (95% *CI*: –3.64, –3.05) for males and -4.05% (95% *CI*: –4.37, –3.73) for females. The local drifts were below 0 in all age groups.

DISCUSSION

The study findings showed a modest decrease in crude mortality rates and a significant decline in ASMR for genitourinary diseases over the study period. These results demonstrate the improvement in healthcare conditions in China, leading to a decrease in mortality rates for genitourinary diseases across different age groups, genders, and urban-rural areas. However, as the population in China continues to age, it highlights the need for increased attention to

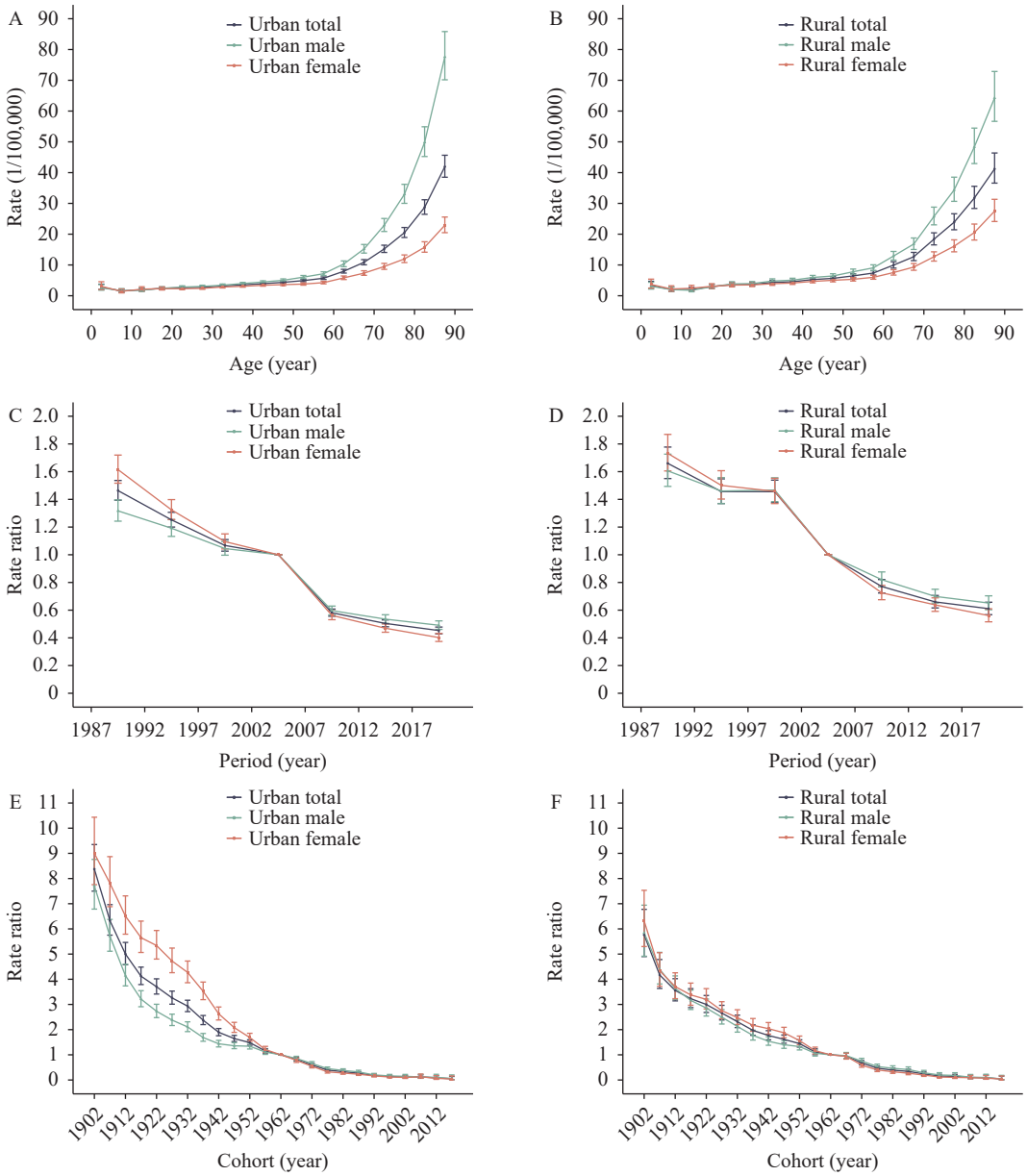

FIGURE 1. Age, period, and cohort effects on genitourinary diseases' mortality rate in rural-urban China from 1987 to 2021. (A) Age effects on mortality rates in urban China; (B) Age effects on mortality rates in rural China; (C) Period effects on mortality rates in urban China (D) Period effects on mortality rates in rural China; (E) Cohort effects on mortality rates in urban China; (F) Cohort effects on mortality rates in rural China.

genitourinary diseases.

Mortality rates for genitourinary diseases were higher in males than females in both urban and rural areas. However, there were notable period and cohort effects indicating that women experienced a greater reduction in genitourinary disease mortality from 1987 to 2021. These findings underscore the need to prioritize genitourinary diseases in males. Notably, older males derived greater benefits compared to older women, which could be attributed to a more pronounced mortality gap in elderly adults. Regarding urban and rural areas, we observed a crossover pattern where crude mortality and ASMR for genitourinary diseases were initially lower in rural China in 1987 but higher in 2021 compared to urban China. Notably, the crude mortality rate from genitourinary diseases in rural males increased between 1987 and 2021. This highlights that improved medical care has not offset the increased risk of death from aging and lifestyle changes in Chinese rural men. Consequently, policymakers should prioritize genitourinary diseases in vulnerable populations, particularly rural older men.

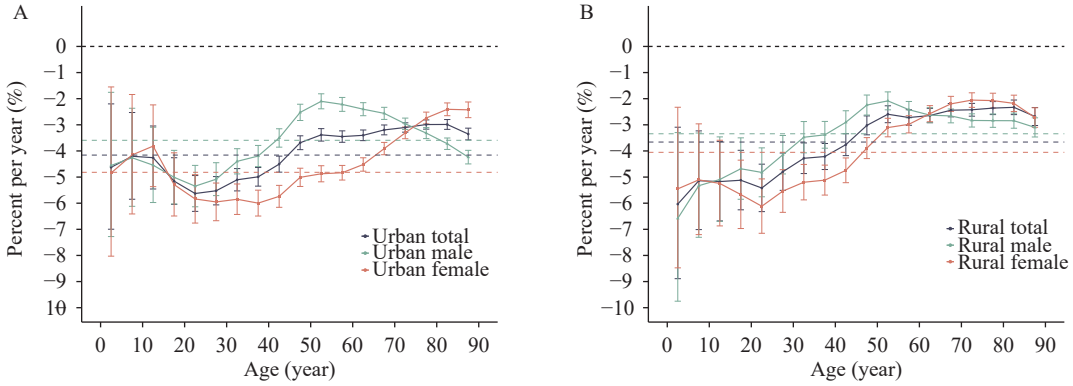

FIGURE 2. Local drift and net drift for genitourinary diseases' mortality and rural-urban difference by sex in China from 1987 to 2021. (A) In urban China; (B) In rural China.

In the context of aging and lifestyle changes, cardiovascular and cerebrovascular diseases, as well as cancers, have traditionally been the focus of researchers. However, our analysis also revealed a decline in ASMRs of genitourinary diseases. Nonetheless, it is important not to underestimate the impact of genitourinary diseases. First, it should be noted that the mortality rate of genitourinary diseases is higher in the elderly. Given the current trend of population aging in China, the risk of mortality from genitourinary diseases is expected to increase. Second, the global rise in heat waves presents a potential concern for an associated increase in mortality rates related to genitourinary illnesses (*7*). This can be attributed to the heightened risk of renal dysfunction resulting from hyperthermia and dehydration due to prolonged exposure to high temperatures (*8*). Furthermore, previous research has shown a significant increase in various mortality patterns in countries with low death rates over the past two decades. The percentage of deaths attributed to circulatory diseases has decreased, while the proportion of deaths attributable to other causes, including genitourinary diseases, has increased (*9*). As China moves towards being a low-mortality country, it is imperative and urgent to address genitourinary diseases at an earlier stage.

Several limitations exist in this study. First, the results were obtained from surveillance data rather than cohort data, which restricts our analysis to population-level trends rather than individual-level analysis. Second, the death categories were coded using ICD-9 prior to 2002, but ICD-10 coding was used thereafter. This may have introduced challenges in aligning the data with genitourinary disease trends, although previous research has indicated minimal impact from the transition from ICD-9 to ICD-10 (*10*).

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