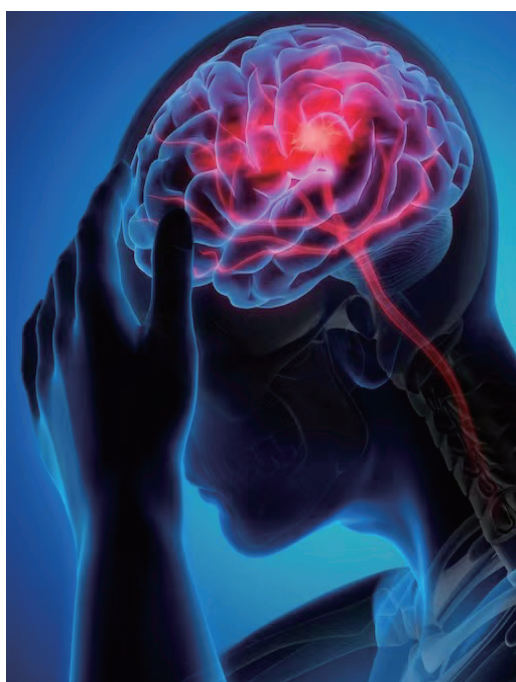


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Vital Surveillances

Trends in Stroke Mortality Rate — China, 2004–2019

Junxia Cheng¹; Wei Wang¹; Jianwei Xu¹; Ling Yin²; Yunning Liu¹; Jing Wu^{1,†}

ABSTRACT

Introduction: Stroke has been the leading cause of death in China for decades. This study described the trends in stroke mortality in China from 2004 to 2019.

Methods: Data was obtained from the National Disease Surveillance Point (DSP) system. A descriptive analysis was conducted. The adjusted mortality rate (AMR) and age-standardized mortality rate (ASMR) of stroke were calculated.

Results: From 2004 to 2019, the ASMR substantially decreased, with a reduction of 39.8%, but the AMR stayed relatively stable. The mortality rate of stroke in rural areas was consistently higher than in urban areas. A geographical gradient in mortality of stroke was also apparent, with an increased rate in the western part of China and a decreased rate in the eastern part of China. In central China, the rate remained relatively stable.

Conclusions: Although the ASMR of stroke continued to decline in China, the stagnant crude mortality rates suggested that China had not achieved sufficient decline to offset the demographic forces of population growth and ageing. More vigorous and effective prevention and treatment strategies are urgently needed to mitigate the disease burden of stroke in China, especially in areas with high stroke burden and limited resources.

Deaths from noncommunicable diseases are on the rise. According to a World Health Organization's (WHO) report, 7 out of the top 10 global leading causes of death in 2019 were noncommunicable diseases (1). Stroke, which is the second leading cause of death in the world, has been ranked as the first cause of death for decades in China. It is estimated that at least 1 out of every 5 deaths in China is resulted from stroke (2). The burden is expected to increase further as a result of population ageing, socioeconomic development, urbanization, and the resulting lifestyle

shifts and expanding prevalence of certain risk factors.

Strengthening prevention and control measures for stroke has risen as a national responsibility. The Chinese government has paid increasing attention to the prevention and treatment of strokes, including the establishment of the National Stroke Center, which launched the Stroke Screening and Intervention for High-Risk Population Program and several other important initiatives focused on reducing deaths associated with cardiovascular issues. One of the most important policies is “Healthy China 2030”, which summarizes stroke mortality in China and proposes initiatives to minimize its disease burden (3). This report described the trends in stroke mortality in China from 2004 to 2019 in order to evaluate the stroke prevention and control efforts taken by the Chinese government during this time. Finally, this report provided evidence-based stroke planning recommendations for the future.

METHODS

Data analyzed in this study was obtained from the National Disease Surveillance Point (DSP) system, forming a nationally-representative sample of mortality in China. Initially, data was gathered only from “unrepresentative surveillance points”, then the system gradually expanded to 161 points in 2004 and included 605 surveillance points by 2013, covering 24% of the population (over 300 million people). Considering the expanded quality and comprehensiveness of the data, the mortality data from 2004 to 2019 was analyzed.

Stroke deaths were identified by the International Classification of Diseases 10th Revision (ICD-10), including I60–I64 (codes I60–I62 for identifying hemorrhagic stroke, I63 for ischaemic stroke, and I64 for unspecified type of stroke) (4). For the significant differences in the mortality rate of stroke among different populations, to identify key populations for stroke prevention and control, we categorized the population by sex (male and female); age (<40, 40–49, 50–59, 60–69, 70–79, and ≥80); region {east [3

municipalities (Beijing, Tianjin, and Shanghai) and 8 provinces (Hebei, Liaoning, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan)]; central [8 provinces (Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, and Hunan)]; and west [1 municipality (Chongqing), 6 provinces (Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, and Qinghai), and 5 autonomous regions [Inner Mongolia, Guangxi, Xizang (Tibet), Ningxia, and Xinjiang]]]; and area type (urban and rural).

The crude mortality rate (CMR) of stroke was calculated by dividing the number of deaths by the associated population. The CMR was adjusted by the underreporting rate of data, with the equation:

$$\text{Adjusted mortality rate (AMR)} = \text{CMR} / (1 - \text{underreporting rate})$$

The overall underreporting rate of stroke (12.9%) was based on the propensity score weighting

established in a previous study (5). Age-standardized mortality rate (ASMR) was adjusted to the Seventh National Population Census in 2020 by the direct method. Analyses were conducted by pathological type and by region. R software (version 4.0.3, R Development Core Team, Vienna, Austria) was applied for statistical analysis.

RESULTS

The results regarding total deaths, AMR, and ASMR of stroke in 2004 and 2019 are shown in Table 1. From 2004 to 2019, the AMR decreased from 125.0/100,000 to 113.2/100,000, a decrease of 9.4%. The ASMR of stroke decreased from 195.0/100,000 to 117.4/100,000, a decrease of 39.8%. The ASMR of different subgroups all decreased. However, the AMR of stroke in the central and western regions increased

TABLE 1. Mortality rate and age-standardized mortality rate (ASMR) of stroke categorized by age group, sex, area type, region, and pathological types — China, 2004 and 2019.

Items	2004				2019				2004 vs. 2019	
	Deaths (n)	Proportion (%)	AMR (1/100,000)	ASMR (1/100,000)	Deaths (n)	Proportion (%)	AMR (1/100,000)	ASMR (1/100,000)	AMR (%)	ASMR (%)
Total	82,567	100.0	125.0	195.0	334,124	100.0	113.2	117.4	-9.4	-39.8
Age group (years)										
<40	1,227	1.5	3.0	-	3,527	1.1	2.4	-	-20.0	-
40–	3,506	4.2	35.8	-	10,955	3.3	23.0	-	-35.8	-
50–	8,380	10.1	109.2	-	27,330	8.2	59.1	-	-45.9	-
60–	16,852	20.4	386.7	-	57,932	17.3	182.0	-	-52.9	-
70–	29,133	35.3	1146.3	-	95,815	28.7	602.5	-	-47.4	-
≥80	23,469	28.4	3450.1	-	138,565	41.5	2076.2	-	-39.8	-
Sex										
Male	46,474	56.3	137.5	225.4	187,816	56.2	124.7	136.9	-9.3	-39.3
Female	36,093	43.7	111.8	166.4	146,308	43.8	101.1	98.9	-9.6	-40.6
Area type										
Urban	26,061	31.6	108.7	155.4	105,769	31.7	85.8	91.1	-21.1	-41.4
Rural	56,506	68.4	134.2	221.2	228,355	68.3	132.8	135.7	-1.0	-38.7
Region										
East	31,234	37.8	131.2	189.2	120,203	36.0	90.5	91.5	-31.0	-51.6
Central	31,606	38.3	135.2	215.8	119,331	35.7	136.8	141.2	1.2	-34.6
West	19,727	23.9	104.5	175.6	94,590	28.3	125.8	138.0	20.4	-21.4
Pathological type										
Ischemic stroke	23,430	28.4	35.5	57.3	147,161	44.0	49.8	52.1	40.3	-9.1
Hemorrhagic stroke	52,736	63.9	79.8	122.1	170,445	51.0	57.7	59.5	-27.7	-51.3
Stroke, not specified	6,401	7.8	9.7	15.6	16,518	4.9	5.6	5.8	-42.3	-62.8

Abbreviations: AMR=adjusted mortality rate; ASMR=age-standardized mortality rate.

–: Not applicable.

by 1.2% and 20.4%, respectively, reaching 136.8/100,000 and 125.8/100,000; the AMR of ischemic stroke increased by 40.3%, reaching 49.8/100,000 in 2019.

From 2004 to 2019, despite substantial reductions in ASMR, the decrease in mortality rate was less substantial and relatively stable (Figure 1). Overall, different trends were found in different pathological types. For example, the mortality rate decreased for hemorrhagic stroke but increased for ischemic stroke, which is the most common type of stroke.

Despite the observed improvements in stroke mortality at national level in China, the analysis revealed a large subgroup disparity. The patterns of trends in males and females are similar but the mortality rates were much higher among males than females in all regions (Figure 2). Notably, the stroke mortality rate in rural areas was consistently higher than in urban areas. Stroke-related mortality was undulatory in rural areas, whereas in urban areas, the trend was relatively stable and slightly decreased (Figure 2A–B). A geographical gradient in mortality of stroke was apparent with the rate increasing in the west, decreasing in the east, and remaining relatively stable in central China (Figure 2C–E).

DISCUSSION

This article demonstrated the sex and regional differences in mortality rate for ischemic strokes, hemorrhagic strokes, and strokes not specified as

hemorrhagic or ischemic in China. Long-term trends in stroke-related deaths in China from 2004 to 2019 indicated that the burden of stroke in China was still severe.

Our results on stroke mortality in men and women are comparable to previous studies (6). The mortality rate of stroke in China is significantly greater than in other low-middle sustainable development index (SDI) countries like Mexico (30.3/100,000), Brazil (60.5/100,000), and Thailand (72.8/100,000) (7). From 2004 to 2019, the ASMR of stroke was substantially decreased, which might be attributable to higher healthcare coverage, improved treatment, increased public knowledge of stroke, and support from the government (8). For example, in 2009, the government launched a stroke screening and prevention project, and in 2011, the Stroke Prevention and Control Engineering Committee was formally established. However, AMR, which represents the actual mortality level in China, remained relatively stable. The stagnant mortality rates suggest that China has not achieved a sufficient decline in stroke burden to offset the demographic forces of population growth and ageing. The ageing trend is also unlikely to be reversed in the near future and the burden of stroke is likely to remain high despite recent changes to the childbearing policy.

Next, the mortality rate of hemorrhagic stroke in China decreased from 2004 to 2019. However, the mortality rate of hemorrhagic stroke is still greater than that of ischemic stroke. This pattern is consistent with

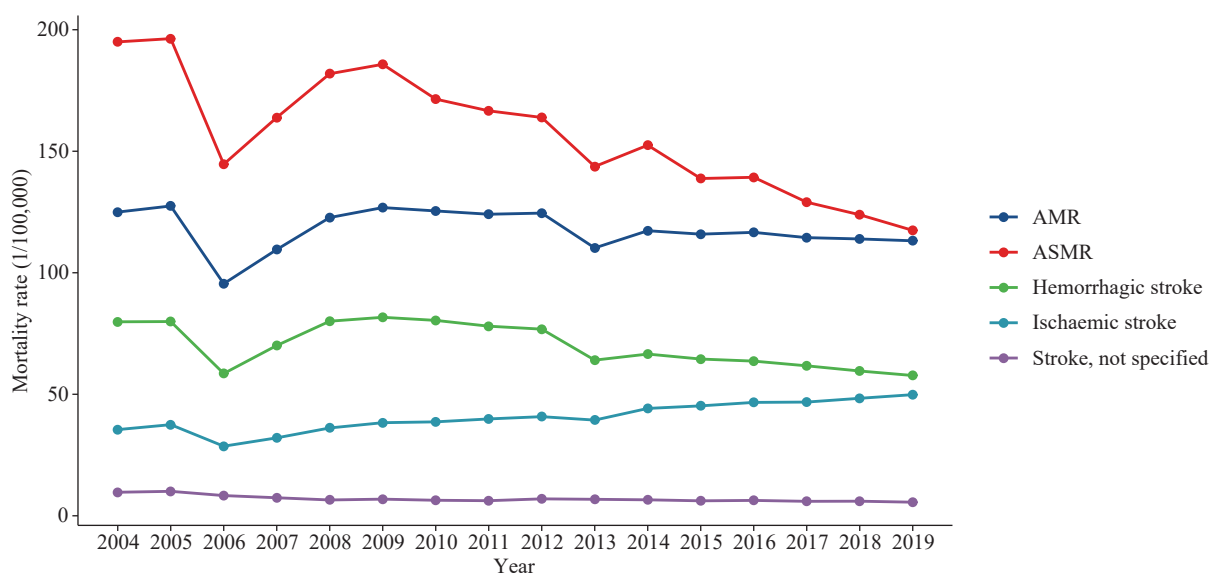


FIGURE 1. AMR, ASMR, and mortality rates of stroke categorized by pathology — China, 2004–2019. Abbreviations: AMR=adjusted mortality rate; ASMR=age-standardized mortality rate.

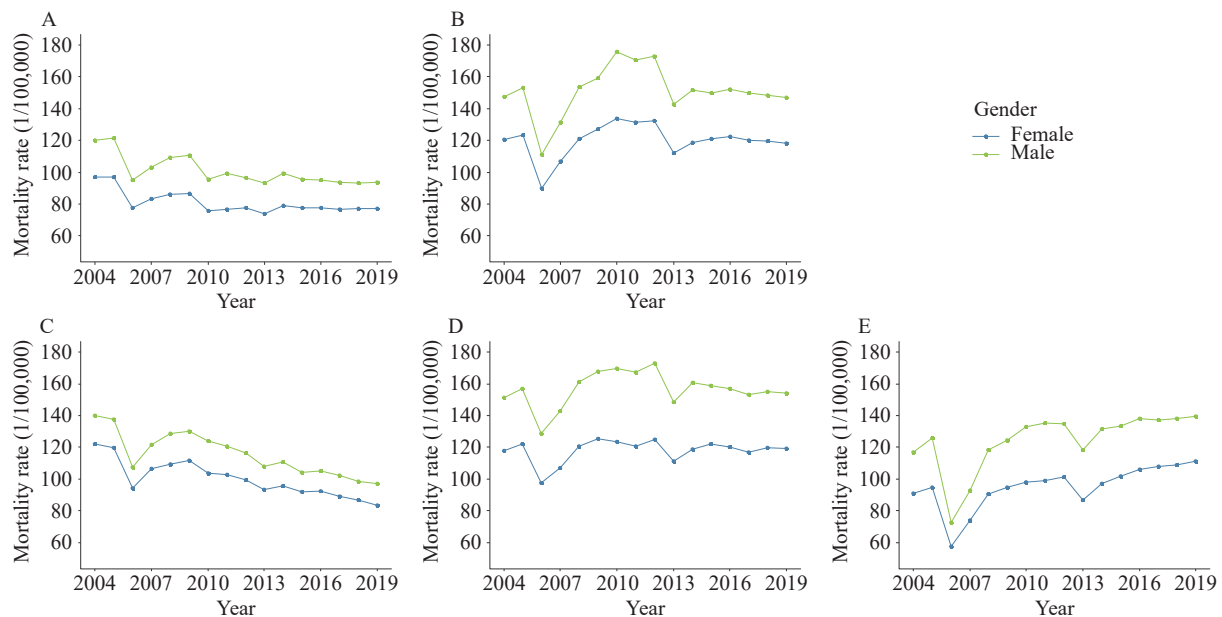


FIGURE 2. The mortality rate of stroke categorized by area type and region broken down by sex — China, 2004–2019. (A) The mortality rate of stroke in urban areas from 2004 to 2019 in China; (B) The mortality rate of stroke in rural areas from 2004 to 2019 in China; (C) The mortality rate of stroke in eastern China from 2004 to 2019; (D) The mortality rate of stroke in central China from 2004 to 2019; (E) The mortality rate of stroke in western China from 2004 to 2019.

previous studies in China (9) and what has been observed in other low- to middle-income countries (10). Hypertension is one of the most important modifiable risk factors for stroke, especially hemorrhagic stroke. The National Health Commission has included hypertension as one of the 20 national public health service equalization projects. Measures are needed to further increase awareness, treatment, and control of hypertension.

Lastly, the mortality rate of stroke was shown to be higher in central and western regions of China than in the eastern region, and higher in rural areas than in urban areas. These results are consistent with those of Wang et al. (11). In their study, they found a gradient scale of stroke mortality rates between the north and south of China and between rural and urban areas. An underlying cause of these regional disparities might be attributable to higher exposure to some modifiable risk factors and the limited availability and quality of stroke services in rural areas and in the western regions. It should be noted that the prevalence of hypertension is the highest in northeast, northern, and southwest China, which is consistent with these findings. The variation in doctor coverage, being the highest in northern and eastern China and the lowest in the southwest of China, might also be associated with the distribution of stroke mortality (9). China has actively explored and vigorously carried out the construction of stroke centers since 2012. As of 2022, thousands of

stroke centers have been built. Despite improved access to overall health services, the area and population they cover are far from meeting the needs of stroke patients across China (12). Furthermore, the availability of specialized stroke care is variable across the country, with the proportion of stroke centers being relatively higher in eastern and southern China, lower in the northeast and western China, and especially disparate in rural areas (12). The earlier decline in stroke mortality in urban and eastern China may be due to the control of risk factors and the development of medical and health services. Additionally, over half of the Chinese population lives in rural areas, where the mortality rate of stroke is higher. Therefore, rural areas and the central and western regions of China should be the focus of stroke prevention and control investment.

This study has some limitations. Due to the inevitable underreporting of data, the data in this study was adjusted using the underreporting rate. However, the underreporting rate was not estimated year by year. Thus, the reported results might be underestimated (13). Second, although the data has broad national representation, the distribution of monitoring points is not uniform. More data is required across time and regions, particularly for rural areas, to provide a more thorough overview of stroke outcomes in China. Third, this study analyzed long-term trends in stroke mortality using data from the DSP system. Unavoidably, the quality of surveillance has not been

completely consistent over the decades, which can cause abnormal fluctuations in the data. For example, in 2006–2007, data from the Third National Retrospective Sampling Survey of Death Causes was used instead of surveillance data, and in 2013, surveillance systems were integrated, which might have led to a decline in the quality of work.

CONCLUSION

In summary, the mortality rate of stroke in China from 2004 to 2019 decreased, however, the burden of stroke remained heavy. Overall, the decline in AMR was not significant compared with ASMR. In addition, the gradients of stroke mortality across China were clearly shown. To achieve the goals of “Healthy China 2030,” more extensive and effective prevention and treatment strategies are needed to mitigate the disease burden of stroke in China. Therefore, it is necessary to further underline the significance of stroke prevention, improve hypertension control, promote healthy lifestyles like reducing salt intake, and equip stroke health services, especially in some specific areas with high or increased burden of stroke and limited resources.

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Preplanned Studies

Case Fatality Rate of Patients with Acute Myocardial Infarction in 253 Chest Pain Centers — China, 2019–2020

Zheng Long¹; Wei Liu¹; Zhenping Zhao¹; Suijun Tong¹; Lijun Wang¹; Maigeng Zhou¹; Dingcheng Xiang²; Yundai Chen³; Jianan Wang⁴; Xiaoshu Cheng⁵; Bao Li⁶; Lang Li⁷; Wei Li⁸; Bei Shi⁹; Hong Shi¹⁰; Peng Yin^{1, #}; Kai Huang^{11, #}; Yong Huo^{12, #}

Summary

What is already known about this topic?

Acute myocardial infarction (AMI) is the most serious form of cardiovascular diseases. The case fatality rate (CFR) of AMI patients is an important index to reflect the prognosis of AMI.

What is added by this report?

During the study period, the overall 30-day, 60-day, and 90-day CFR of AMI was 5.9%, 6.9%, and 7.6%, respectively. The CFRs in grade III hospitals were lower than in grade II hospitals, and the in-hospital CFR was significantly lower than that in post-discharge out-of-hospital.

What are the implications for public health practice?

This study can provide evidence for targeted prevention and highlight the need to strengthen the level of treatment of patients with AMI in grade II hospitals.

Cardiovascular diseases (CVDs) are the leading cause of death worldwide (1) and account for more than 40% of deaths in China (2). Acute myocardial infarction (AMI) is a common and the most serious form of CVD with a high mortality rate (3). The World Health Organization (WHO) monitoring trends and determinants in CVDs MONICA project reported that AMI was the cause of approximately three-quarters of CVD deaths across 37 populations in 21 countries over the past few decades (4). The case fatality rate (CFR) of AMI patients is an important index to reflect the prognosis of AMI. It can provide information on severity of AMI and help determine the focus of secondary prevention (5). A few studies showed that in-hospital CFR of AMI patients in China had decreased in recent years, but most of them were single-city studies with limited geographical coverage or focusing on grade III hospitals (5). No studies were carried out to address the post-discharge out-of-hospital CFR. This study used data of AMI patients

from 253 chest pain centers (CPC) in China from 2019 to 2020 to estimate the CFR of AMI (6). The study found that the CFR of AMI in-hospital was significantly lower than that of post-discharge out-of-hospital, and the CFR in grade II hospitals was higher than that in grade III hospitals. In this study, the overall CFR of AMI post-discharge out-of-hospital was 6.0% and grade III hospitals was 5.2%. Much more efforts should be made to promote the level of treatment of patients with AMI in grade II hospitals.

The study linked patients' data to China National Death Registration System by unique national identification numbers to obtain the accurate vital status for all patients within CPC. The system collected all deaths outside of hospitals and in hospitals, covering nearly 99% of the counties and districts in China. CPC data was obtained from the CPC reporting system initiated since 2015 and the data quality was improved gradually. We used patients' data from CPC in 2019 and 2020 when China Chest Pain Center Quality Control Indicators and Assessment Measures (Second Edition) and the China Chest Pain Center Normalization Quality Control Plan were carried out to form a three-level external and internal quality control mechanism for hospitals (6). The study first selected 885 CPCs whose completeness of patients' ID was higher than 90%. In the next step, CPCs with AMI patients less than 50 in 2019 and 2020 were excluded as some CPCs did not report data from all of their patients. A total of 36,689 AMI patients from 253 CPCs from 23 provincial-level administrative divisions (PLADs) (10 from east, 6 from central, and 7 from west) were included in the analysis. These patients were identified as having ST-segment elevation myocardial infarction (STEMI) and non-ST-segment elevation myocardial infarction (NSTEMI) by discharge diagnosis. The study also considered both in-hospital and post-discharge out-of-hospital deaths and calculated the 30-day, 60-day, and 90-day CFR of AMI patients by the following formula to define the

proportion of patients who died within 30 days, 60 days, and 90 days in all AMI patients admitted to CPCs:

30-day/60-day/90-day CFR = the number of deaths occurring within 30/60/90 days from date of admission to date of death/the number of all AMI patients in CPC

In-hospital death and post-discharge out-of-hospital death were defined according to death's place in the death certificate. Categorical variables were presented as counts (%). The 30-day, 60-day, and 90-day CFRs of AMI were also calculated in different age groups, sex, AMI types, risk factors, comorbidities and hospital levels. SAS software package (version 9.4; SAS Institute, Inc. Cary, NC, USA) was used for all statistical analyses.

This study included 36,689 patients with AMI, 74.0% were males, 91.4% were older than 45 years, 64.5% were STEMI, and 35.5% were NSTEMI; many AMI patients presented comorbidities, including 2,354 (6.4%) with stroke, 847 (2.3%) with chronic obstructive pulmonary disease (COPD), 249 (0.7%) with cancer, and 6,785 (18.5%) with diabetes mellitus. Overall, 11,638 (31.7%) were from grade II hospitals and 25,051 (68.3%) were from grade III hospitals (Table 1).

AMI patients' overall 30-day, 60-day, and 90-day CFRs were 5.9%, 6.9%, and 7.6%, respectively. The CFR increased with age and was higher in females than in males. The 30-day CFR of STEMI was 6.6%, higher than NSTEMI (4.7%). Patients with cancer had the highest CFR on different days. Compared with the grade II hospitals, the CFR of AMI patients in grade III hospitals was much lower (Table 2).

For post-discharge out-of-hospital deaths, the overall CFR was 6.0%, higher in grade II hospitals (7.8%) than in grade III hospitals (5.2%), and the 30-day, 60-day, and 90-day CFRs of all AMI patients in grade III hospitals were 2.5%, 3.1%, and 3.6%, respectively, which were lower than grade II hospitals (3.7%, 4.7%, and 5.5%, respectively) (Figure 1A). For in-hospital deaths, the overall CFR was 4.0% higher in grade II hospitals (4.1%) than in grade III hospitals (3.9%), and the 7-day, 14-day, and 21-day CFRs were 2.3%, 2.6%, and 2.8%, respectively, which were also lower than grade II hospitals (2.7%, 3.1%, and 3.2%, respectively) (Figure 1B).

DISCUSSION

This study provided the most recent estimates of

TABLE 1. Baseline Characteristics of 36,689 acute myocardial infarction patients from 253 chest pain centers in China, 2019–2020.

Variable	N	Proportion (%)
Total	36,689	100.0
Year		
2019	10,272	28.0
2020	26,417	72.0
Age group (years)		
<45	3,164	8.6
45–65	16,794	45.8
>65	16,731	45.6
Sex		
Male	27,136	74.0
Female	9,553	26.0
Type of MI		
STEMI	23,672	64.5
NSTEMI	13,017	35.5
Risk factors		
Hypertension	17,737	48.3
Hyperlipidemia	8,258	22.5
Current smoking	13,285	36.2
Obesity	2,588	7.1
Family history of CVD	926	2.5
Comorbidity		
Stroke	2,354	6.4
COPD	847	2.3
Cancer	249	0.7
Diabetes mellitus	6,785	18.5
Hospital level		
Grade II	11,638	31.7
Grade III	25,051	68.3

Notes: Grade II hospitals are generally affiliated with medium size cities, counties, or districts and contain 100–500 beds. Grade III hospitals are generally located in major cities with more than 500 beds and offer the highest-quality care.

Abbreviations: MI=myocardial infarction; STEMI=ST-segment-elevation myocardial infarction; NSTEMI=non-ST-segment-elevation myocardial infarction; CVD=cardiovascular disease; COPD=chronic obstructive pulmonary disease.

CFR of AMI patients from CPCs in China from 2019 to 2020. First, the 30-day, 60-day, and 90-day CFR of all AMI patients were 5.9%, 6.9%, and 7.6%, respectively, 65% of the patients were STEMI patients and the CFR of STEMI patients were higher compared to that of NSTEMI patients. STEMI patients were more likely to have comorbidities (7) and NSTEMI patients lacked typical electrocardiogram changes, had

TABLE 2. Case fatality rate of patients with acute myocardial infarction in 253 chest pain centers in China, 2019–2020.

Variable	Case fatality rate (%)		
	30-day	60-day	90-day
Total	5.9	6.9	7.6
Year			
2019	4.6	5.8	6.7
2020	6.4	7.4	7.8
Age group (years)			
<45	1.9	2.1	2.2
45–65	3.1	3.5	3.9
>65	9.6	11.2	12.4
Sex			
Male	4.7	5.5	6.1
Female	9.4	10.9	12.0
Type of MI			
STEMI	6.6	7.6	8.2
NSTEMI	4.7	5.8	6.6
Risk factors			
Hypertension	5.8	6.9	7.6
Hyperlipidemia	3.5	4.3	4.8
Current smoking	3.5	4.1	4.6
Obesity	5.3	6.1	6.8
Family history of CVD	4.8	6.0	6.7
Comorbidity			
Stroke	8.4	10.2	11.6
COPD	8.1	10.4	12.5
Cancer	13.7	16.9	18.5
Diabetes mellitus	6.7	7.9	8.6
Hospital level			
Grade II	7.0	8.2	9.2
Grade III	5.4	6.3	6.9

Notes: Grade II hospitals are generally affiliated with medium size cities, counties, or districts and contain 100–500 beds. Grade III hospitals are generally located in major cities with more than 500 beds and offer the highest-quality care.

Abbreviations: MI=myocardial infarction; STEMI=ST-segment-elevation myocardial infarction; NSTEMI=non-ST-segment-elevation myocardial infarction; CVD=cardiovascular disease; COPD=chronic obstructive pulmonary disease.

a lower incidence of alarm symptoms of arrhythmia and resting chest pain, and had lower levels of blood myocardial necrosis markers, which may lead to clinical misdiagnosis and delayed treatment (8). Second, the CFR of AMI in grade II hospitals was higher than that in grade III hospitals, which may be related to better facilities and healthcare level of grade

III hospitals.

Compared with previous studies (5), the 30-day, 60-day, and 90-day CFRs of all AMI patients in this study were lower, which may be due to the continuous improvement of the treatment of AMI and the extensive national healthy lifestyle campaign. In addition, based on the primary purpose of “rapid diagnosis, timely treatment, reducing death, and avoiding waste,” CPCs have been gradually established in China since 2014, playing an essential first aid role. Our results also showed that three-quarters of all AMIs occurred in males. It can be explained by the fact that men are more likely to be exposed to various AMI risk factors such as smoking, alcohol abuse, unbalanced diet, and air pollution than women (9). Although there were more male patients, the CFR was much lower in men than in women. The reason may be that female patients were older than male patients, the risk of concomitant disease was higher, and the use of secondary prophylaxis drugs was significantly lower than that of males (10).

The findings of this study should be interpreted in view of several limitations. First, we only have two years of data and cannot analyze the trends of the CFR of AMI. Therefore, this study mainly describes the current situation. Second, we may underestimate the number of deaths of AMI patients due to the under-reporting in the national death registration system. The vast majority of CPCs in this study were from eastern and central PLADs, where the completeness of death registration is high and potential under-reporting from western PLADs may not have a major impact on the results. Third, we only included patients from CPC and those patients who died out-of-hospital prior to hospital admission were not covered in our study. More data from the emergency care system will be needed to address this issue. Finally, the generalization of the results is limited because the data were from hospitals with certified CPC.

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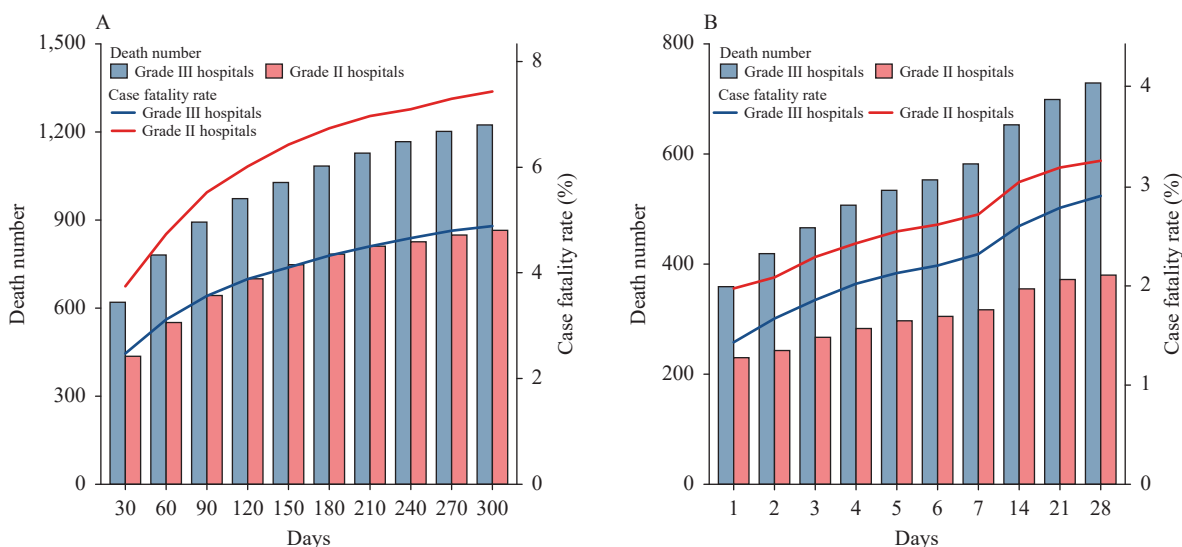


FIGURE 1. The number of death and case fatality rate (CFR) of acute myocardial infarction (AMI) in post-discharge out-of-hospital and in-hospital of Grade II and III hospitals in China, 2019–2020. (A) The number of post-discharge out-of-hospital death and CFR of AMI in Grade II and III hospitals, China, 2019–2020. (B) The number of in-hospital death and CFR of AMI in Grade II and III hospitals, China, 2019–2020.

Notes: Grade II hospitals are generally affiliated with medium size cities, counties, or districts and contain 100–500 beds. Grade III hospitals are generally located in major cities with more than 500 beds and offer the highest-quality care.

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Preplanned Studies

Association Between Urinary Sodium and Potassium Excretion and Blood Pressure Among Non-Hypertensive Adults — China, 2018–2019

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Summary

What is already known about this topic?

High sodium and low potassium in 24 h urinary excretion were associated with elevated blood pressure.

What is added by this report?

With increasing body mass index levels, decreasing unit urinary sodium excretion was more effective in reducing systolic and diastolic blood pressure, and increasing unit urinary potassium excretion was more effective in reducing diastolic blood pressure.

What are the implications for public health practice?

Reducing sodium and increasing potassium intake was more effective in reducing blood pressure in overweight and obese non-hypertensive adults compared to underweight and normal weight adults.

Elevated blood pressure is a major risk factor for the global burden of disease, and the resulting cardiovascular diseases are the leading causes of death and disability in China (1). High sodium and low potassium diets were associated with elevated blood pressure (2). Evidence has shown that the relationship between urinary sodium and potassium and their ratio to blood pressure was affected by body mass index (BMI) (3); at present, there is limited evidence of this in non-hypertensive adults in China.

We used data from the 2018 China Chronic Disease and Risk Factor Surveillance (CCDRFS) to study the relationship among non-hypertensive adults with different BMI levels. In this study, the urinary sodium-to-potassium ratio (UNa/K ratio) did not show a significantly better correlation than urinary sodium concentration (UNaC) or urinary potassium concentration (UKC) with blood pressure. With increasing BMI levels, decreasing unit urinary sodium excretion was more effective in reducing systolic blood pressure (SBP) and diastolic blood pressure (DBP), and

increasing unit urinary potassium excretion was more effective in reducing DBP. This finding suggested that the blood pressure in overweight and obese adults was more sensitive to changes in urinary sodium and potassium excretion.

Cross-sectional data were obtained from residents aged 18 years old and above in the 2018 CCDRFS, a nationally representative survey of the Chinese population (4). Every participant had a standard questionnaire and a physical examination of blood pressure, weight, and height, and collected a random urine sample. An ion-selective electrode method was used for sodium and potassium analysis, and the enzyme-coupled sarcosine oxidase method was used for creatinine analysis. Hypertension was defined as a self-reported previous diagnosis by health professionals along with the use of anti-hypertensive medications in the past 2 weeks. Underweight was defined as $BMI < 18.5 \text{ kg/m}^2$, normal weight was $18.5 \leq BMI < 24.0 \text{ kg/m}^2$, overweight was $24.0 \leq BMI < 28.0 \text{ kg/m}^2$, and obesity was $BMI \geq 28.0 \text{ kg/m}^2$. The 24h urinary creatinine excretion (24h UCrE), 24h urinary sodium excretion (24h UNaE), and 24h urinary potassium excretion (24h UKE) were estimated from Kawasaki's equation using a random urine sample (5). A total of 184,876 participants participated in the survey, this study excluded the hypertensive population, participants with missing data in UNaC, UKC, urinary creatinine concentration (UCrC), SBP, DBP, height, and weight. A total of 146,311 non-hypertensive participants were included in this analysis.

ANOVA and Kruskal-Wallis tests were conducted to test for differences in BMI groups in normally and non-normally distributed data. The correlation of UNaC, UKC, and UNa/K ratios to blood pressure was assessed by the Spearman correlation coefficient. Multivariable linear regression was used to assess the associations of blood pressure with 24h UNaE, and 24h UKE. $P < 0.05$ was deemed significant. All

statistical analyses were conducted using SAS software (version 9.4, SAS Institute Inc., Cary, USA).

In this study, the average participant age was 53.51 years, 55.16% were female, and over 1/2 were classified as overweight (35.87%) or obesity (14.14%). The average SBP increased with BMI levels from 122.35 mmHg for underweight participants to 137.79 mmHg in obese participants, and DBP showed a similar change. UNaC, 24h UNaE, and 24h UKE increased with BMI levels (Table 1).

In this analysis, the UNa/K ratio was more strongly correlated to SBP ($r_s=0.093$) and DBP ($r_s=0.067$) than to UKC, but not more than UNaC. In the obese group, the UNa/K ratio ($r_s=0.096$) was more strongly correlated to SBP than UNaC ($r_s=0.075$) or UKC ($r_s=-0.081$). In normal weight, overweight, and obese groups, the UNa/K ratio was higher than either UNaC

or UKC in relation to DBP (Tables 2–3).

24h UNaE was directly associated with SBP (1.964 mmHg) and DBP (0.924 mmHg) for each 1 g increase in urinary sodium excretion. The 24h UKE was inversely associated with SBP (-0.617 mmHg) and DBP (-0.126 mmHg) for each 1 g increase in urinary potassium excretion. As BMI levels increased, the standardized β regression coefficient between 24h UNaE and SBP increased from 0.116 in underweight group to 0.138 in obesity group. The standardized β regression coefficient between 24h UNaE and DBP increased from 0.084 in underweight group to 0.105 in obesity group. As BMI levels increased, the standardized β regression coefficient between 24h UKE and DBP increased from -0.020 in normal weight group to -0.041 in obesity group, while the relationship between 24h UKE and SBP showed no

TABLE 1. Participant characteristics by BMI groups in non-hypertensive adults — China, 2018.

Characteristics	Total	Underweight	Normal weight	Overweight	Obesity
N*	146,311	5,004 (3.42)	68,131 (46.57)	52,489 (35.87)	20,687 (14.14)
Age (year) [†]	53.51±13.80	54.84±18.17	53.70±14.54	53.86±12.57	51.65±12.90
Gender					
Male (%)*	65,604 (44.84)	2,194 (43.84)	30,608 (44.93)	23,735 (45.22)	9,067 (43.83)
Female (%)*	80,707 (55.16)	2,810 (56.16)	37,523 (55.07)	28,754 (54.78)	11,620 (56.17)
Ethnic group					
Han (%)*	126,896 (86.73)	4,141 (82.75)	58,503 (85.87)	46,214 (88.05)	18,038 (87.19)
Other (%)*	19,415 (13.27)	863 (17.25)	9,628 (14.13)	6,275 (11.95)	2,649 (12.81)
Current smoker (%)*	36,715 (25.09)	1,482 (29.62)	18,626 (27.34)	12,155 (23.16)	4,452 (21.52)
Drinker (%)*	51,872 (35.45)	1,451 (29.00)	23,665 (34.73)	19,217 (36.61)	7,539 (36.44)
Diabetes (%)*	19,709 (13.47)	449 (8.97)	6,776 (9.95)	8,084 (15.40)	4,400 (21.27)
Cancer (%)*	3,021 (2.06)	135 (2.70)	1,399 (2.05)	1,044 (1.99)	443 (2.14)
Kidney disease (%)*	7,557 (5.17)	262 (5.24)	3,497 (5.13)	2,794 (5.32)	1,004 (4.85)
SBP (mmHg) [†]	130.66±19.00	122.35±19.69	127.24±18.63	133.10±18.36	137.79±18.44
DBP (mmHg) [†]	77.10±10.93	71.42±10.72	74.68±10.31	78.79±10.57	82.16±11.07
UNaC (mmol/L) [§]	126.00 (87.00, 169.00)	119.00 (80.00, 162.00)	124.00 (85.00, 168.00)	126.00 (88.00, 169.00)	133.00 (93.00, 175.00)
UKC (mmol/L) [§]	32.15 (20.47, 50.15)	31.12 (19.49, 49.05)	32.21 (20.46, 50.30)	32.01 (20.52, 49.98)	32.45 (20.65, 50.33)
UCrC (mmol/L) [§]	9.09 (5.70, 13.59)	8.70 (5.29, 13.49)	9.10 (5.70, 13.67)	9.06 (5.72, 13.47)	9.25 (5.73, 13.66)
UNa/K ratio [§]	3.85 (2.51, 5.69)	3.83 (2.38, 5.81)	3.79 (2.46, 5.62)	3.88 (2.55, 5.68)	4.01 (2.64, 5.90)
24h UNaE (g/d) [†]	4.64±1.46	4.16±1.47	4.44±1.39	4.76±1.47	5.11±1.53
24h UKE (g/d) [†]	1.79±0.51	1.61±0.52	1.72±0.49	1.83±0.52	1.93±0.52
24h UCrE (g/d) [†]	1.19±0.34	0.96±0.29	1.10±0.29	1.24±0.33	1.40±0.41

Abbreviations: SBP=systolic blood pressure; DBP=diastolic blood pressure; UNaC=urinary sodium concentration; UKC=urinary potassium concentration; UCrC=urinary creatinine concentration; UNa/K ratio=urinary sodium-to-potassium ratio; 24h UNaE=24h urinary sodium excretion; 24h UKE=24h urinary potassium excretion; 24h UCrE=24h urinary creatinine excretion; BMI=body mass index; SD=standard deviation; P₂₅=25th percentile; P₇₅=75th percentile.

* Data are expressed as numbers (percentages).

[†] Data are expressed as mean±SD.

[§] Data are expressed as median (P₂₅, P₇₅).

TABLE 2. Spearman correlation coefficients relating urinary sodium and potassium concentration and their ratio with SBP in non-hypertensive adults — China, 2018.

Characteristics	Total		Underweight		Normal weight		Overweight		Obesity	
	r_s (95% CI)	<i>P</i>	r_s (95% CI)	<i>P</i>	r_s (95% CI)	<i>P</i>	r_s (95% CI)	<i>P</i>	r_s (95% CI)	<i>P</i>
UNaC (mmol/L)*	0.094 (0.089, 0.100)	<0.05	0.065 (0.036, 0.093)	<0.05	0.077 (0.069, 0.084)	<0.05	0.093 (0.085, 0.102)	<0.05	0.075 (0.061, 0.089)	<0.05
UKC (mmol/L)†	−0.069 (−0.075, −0.064)	<0.05	−0.040 (−0.068, −0.012)	<0.05	−0.059 (−0.066, −0.051)	<0.05	−0.072 (−0.080, −0.063)	<0.05	−0.081 (−0.095, −0.068)	<0.05
UNa/K ratio§	0.093 (0.087, 0.098)	<0.05	0.061 (0.033, 0.089)	<0.05	0.077 (0.070, 0.085)	<0.05	0.093 (0.085, 0.102)	<0.05	0.096 (0.082, 0.109)	<0.05

Abbreviations: UNaC=urinary sodium concentration; UKC=urinary potassium concentration; UNa/K ratio=urinary sodium-to-potassium ratio; CI=confidence interval; r_s =spearman correlation coefficient; SBP=systolic blood pressure.

* Adjusted by age, sex, race, current smoker, drinker, diabetes, cancer, kidney disease, and urinary potassium concentration.

† Adjusted by age, sex, race, current smoker, drinker, diabetes, cancer, kidney disease, and urinary sodium concentration.

§ Adjusted by age, sex, race, current smoker, drinker, diabetes, cancer, and kidney disease.

TABLE 3. Spearman correlation coefficients relating urinary sodium and potassium concentration and their ratio with DBP in non-hypertensive adults — China, 2018.

Characteristics	Total		Underweight		Normal weight		Overweight		Obesity	
	r_s (95% CI)	<i>P</i>	r_s (95% CI)	<i>P</i>	r_s (95% CI)	<i>P</i>	r_s (95% CI)	<i>P</i>	r_s (95% CI)	<i>P</i>
UNaC (mmol/L)*	0.060 (0.054, 0.065)	<0.05	0.032 (0.004, 0.060)	<0.05	0.039 (0.031, 0.046)	<0.05	0.059 (0.050, 0.067)	<0.05	0.053 (0.039, 0.067)	<0.05
UKC (mmol/L)†	−0.052 (−0.058, −0.047)	<0.05	−0.011 (−0.039, 0.018)	0.47	−0.045 (−0.053, −0.038)	<0.05	−0.053 (−0.062, −0.045)	<0.05	−0.062 (−0.076, −0.048)	<0.05
UNa/K ratio§	0.067 (0.062, 0.072)	<0.05	0.018 (0.010, 0.047)	0.20	0.051 (0.044, 0.059)	<0.05	0.069 (0.060, 0.077)	<0.05	0.077 (0.064, 0.091)	<0.05

Abbreviations: UNaC=urinary sodium concentration; UKC=urinary potassium concentration; UNa/K ratio=urinary sodium-to-potassium ratio; CI=confidence interval; r_s =spearman correlation coefficient; DBP=diastolic blood pressure.

* Adjusted by age, sex, race, current smoker, drinker, diabetes, cancer, kidney disease, and urinary potassium concentration.

† Adjusted by age, sex, race, current smoker, drinker, diabetes, cancer, kidney disease, and urinary sodium concentration.

§ Adjusted by age, sex, race, current smoker, drinker, diabetes, cancer, and kidney disease.

TABLE 4. β -coefficients relating 24h urinary sodium and potassium excretion with SBP in non-hypertensive adults — China, 2018.

Groups	24h UNaE (g/d)*			24h UKE (g/d)†		
	β	Standardized β	<i>P</i>	β	Standardized β	<i>P</i>
Underweight	1.545	0.116	<0.05	−0.855	−0.023	0.13
Normal weight	1.582	0.118	<0.05	−1.128	−0.030	<0.05
Overweight	1.639	0.131	<0.05	−1.566	−0.044	<0.05
Obesity	1.657	0.138	<0.05	−1.197	−0.034	<0.05
Total	1.964	0.151	<0.05	−0.617	−0.016	<0.05

Abbreviations: 24h UNaE=24h urinary sodium excretion; 24h UKE=24h urinary potassium excretion; SBP=systolic blood pressure.

* Adjusted by age, sex, race, current smoker, drinker, diabetes, cancer, kidney disease, and 24h urinary potassium excretion.

† Adjusted by age, sex, race, current smoker, drinker, diabetes, cancer, kidney disease, and 24h urinary sodium excretion.

trend (Tables 4–5).

DISCUSSION

This study found that BMI affected the relationship

between urinary sodium and potassium on blood pressure. The UNa/K ratio was more strongly than UKC in relation to SBP and DBP, but not than UNaC. With increasing BMI levels, decreasing unit urinary sodium excretion was more effective in

TABLE 5. β -coefficients relating 24h urinary sodium and potassium excretion with DBP in non-hypertensive adults — China, 2018.

Groups	24h UNaE (g/d)*			24h UKE (g/d) [†]		
	β	Standardized β	P	β	Standardized β	P
Underweight	0.612	0.084	<0.05	0.441	0.021	0.19
Normal weight	0.636	0.086	<0.05	-0.416	-0.020	<0.05
Overweight	0.702	0.098	<0.05	-0.797	-0.039	<0.05
Obesity	0.760	0.105	<0.05	-0.862	-0.041	<0.05
Total	0.924	0.124	<0.05	-0.126	-0.006	<0.05

Abbreviations: 24h UNaE=24h urinary sodium excretion; 24h UKE=24h urinary potassium excretion; CI=confidence interval; DBP=diastolic blood pressure.

* Adjusted by age, sex, race, current smoker, drinker, diabetes, cancer, kidney disease, and 24h urinary potassium excretion.

[†] Adjusted by age, sex, race, current smoker, drinker, diabetes, cancer, kidney disease, and 24h urinary sodium excretion.

reducing SBP and DBP, and increasing unit urinary potassium excretion was more effective in reducing DBP. These findings suggested that reducing sodium and increasing potassium intake could better lower blood pressure. This was especially true in overweight and obese non-hypertensive adults, whose blood pressures were more sensitive to changes in urinary sodium and potassium.

Some studies have shown that the UNa/K ratio was cross-sectionally associated with blood pressure, and suggested to use it for practical sodium reduction and potassium increase instead of either urinary sodium or potassium alone (6). In the correlation studies with blood pressure, the UNa/K ratio did not show a significant predominance over UNaC and UKC.

In this study, decreasing UNaE or increasing UKE had a significantly greater effect on reducing SBP than DBP. It was consistent with prior findings (7–8). Also, UNaE had a greater effect on blood pressure than UKE. Some studies of gene polymorphisms have shown that Asians might be more sensitive to salt (9). In another study among Chinese adults, SBP changes was more sensitive to UKE than UNaE (10). They speculated that it might have been due to the relatively lower potassium intake, making the participants sensitive to increased potassium intake.

Most studies used BMI as an adjusted factor in analytical models analyzing the relationship between urinary sodium and potassium and blood pressure (10–11), but this study grouped BMI into separate models. The INTERMAP study found that controlling for BMI resulted in attenuation of the relationship between 24h UNaE and blood pressure in a multivariate regression analysis, and normal weight and obese participants manifested significant positive relations between blood pressure and urinary sodium,

but relations were weaker for overweight people (3). In this study, the regression of unit urinary sodium or potassium excretion on blood pressure changes was stronger in overweight and obese participants, relative to underweight and normal weight participants.

The gold standard for estimating individual daily sodium and potassium intake was 24h urine collection. We did not collect 24h urine and used the Kawasaki method to estimate 24h UNaE and 24h UKE by random urine, which may result in overestimation or underestimation (11).

In conclusion, the higher the BMI, the more likely the blood pressure is to be high, and the stronger the effect will be of reducing sodium and increasing potassium intake to lower blood pressure instead. The government departments should formulate policies related to sodium reduction and potassium increase, and implement salt reduction and healthy weight projects of “China Healthy Lifestyle for All.” The public is advised to reduce sodium and increase potassium intake to lower blood pressure and prevent cardiovascular disease.

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Preplanned Studies

Disease Burden of Pancreatic Cancer — China, 1990–2019

Yuan He^{1,2}; Xiaolong Zhou²; Xueqi Fan²; Bin Zhang^{2,3}; Li Ma⁴; Jing Wu^{2,5}; Xudong Li^{4,6}**Summary****What is already known about this topic?**

Pancreatic cancer is one of the most malignant tumors of the digestive tract, and the etiology is not clear. Pancreatic cancer has a poor prognosis and high mortality.

What is added by this report?

Compared with 1990, the burden of pancreatic cancer in China increased significantly in 2019. In 1990 and 2019, the disease burden indicator of male pancreatic cancer was higher than that of females, and pancreatic cancer became more common as age increased, especially above 50 years old.

What are the implications for public health practices?

This study mainly provided scientific data and references for the prevention and control of pancreatic cancer in people aged 50 and above.

Pancreatic cancer is prone to distant metastasis, has a high degree of malignancy, and an extremely poor prognosis, and statistics from the National Cancer Centre of China showed that its 5-year survival rate was only 7.2% (1). However, in recent years, the total number of pancreatic cancer cases in the world has been increasing, and in China, the disease burden caused by pancreatic cancer was also relatively high. Based on the Global Burden of Disease Study (GBD 2019) database in China, this research analyzed the burden of pancreatic cancer in China and its changes from 1990 to 2019. This study found that the burden of pancreatic cancer had increased in recent years and was mainly concentrated in the male population of the older age group. Therefore, it is recommended that attention should be paid to the prevention, control, and health management of pancreatic cancer in high-risk groups, and relevant health policies should be formulated as soon as possible.

All data in this study came from the Global Health Data Exchange database (<http://ghdx.healthdata.org/gbd-resultstool>). GBD 2019 estimated the burden of disease in China and utilized data from multiple

sources, primarily using data from the national census, population surveys, disease surveillance systems, and cause of death registration reporting information systems, and systematically reviewed studies on the incidence and prevalence of various diseases. Years of life lost (YLLs) were obtained by multiplying the number of age-specific deaths by the life expectancy corresponding to that age, years living with disability (YLDs) were obtained by multiplying the number of illnesses by the corresponding disability weights, and disability-adjusted life years (DALYs) were calculated as the sum of YLLs and YLDs (2). Table 1 shows the incidence, prevalence, mortality, and disease burden indicators of pancreatic cancer by gender in 1990, 2000, and 2019 from GBD 2019, and obtains their standardized rates, expressed as numbers and rates (1/100,000), respectively.

Compared with 1990, the incidence and mortality of pancreatic cancer in China increased in 2019 (Figure 1A, B). In 2019, pancreatic cancer was estimated to cause 117,374 deaths and 2,805,178 disability-adjusted life years. From 1990 to 2019, DALYs, YLLs, and YLDs in all age groups caused by pancreatic cancer showed an overall increasing trend, with the most significant increase in the age group of 70 years and older (Figure 1C, D, E).

In 2019, the number of pancreatic cancer cases in China was estimated to be 114,964, and the incidence was estimated to be 5.78/100,000, an increase of 329.40% and 82.11% compared with 1990, respectively. Among them, 69,635 were males and 45,329 were females. The incidence for males is greater than that for females. The prevalence of pancreatic cancer was estimated to be 4.46/100,000, an increase of 85.41% over 1990 (2.40/100,000). The number of deaths in 2019 was estimated to be 117,374, and the mortality was estimated to be 5.99/100,000, an increase of 333.05% and 79.46% compared with 1990, respectively. Among them, 70,218 were male deaths and 47,156 were female deaths. The mortality for males is greater than that for females, as shown in Table 1. The DALYs caused by pancreatic cancer in China were estimated to have increased from 749,415

TABLE 1. Overall incidence, prevalence, deaths, and burden indicators of pancreatic cancer for the years 1990, 2000, and 2019 in China.

Gender	Year	Incidence		Prevalence		Deaths		DALYs		YLLs		YLDs	
		Number	P'	Number	P'	Number	P'	Number	P'	Number	P'	Number	P'
Male	1990	15,832	3.89	12,817	2.94	15,869	4.12	455,549	99.25	452,149	98.43	3,400	0.82
	2000	24,905	4.67	19,773	3.51	25,212	4.94	688,378	115.71	683,105	114.74	5,274	0.97
	2019	69,635	7.43	55,700	5.75	70,218	7.69	1,760,522	176.41	1,746,099	174.91	14,423	1.51
	2019 vs. 2000 (%) [*]	179.60	59.06	181.70	63.66	178.52	55.70	155.75	52.46	155.61	52.44	173.48	55.28
	2019 vs. 1990 (%) [*]	339.84	90.87	334.57	95.57	342.49	86.79	286.46	77.74	286.18	77.69	324.21	84.05
Female	1990	10,941	2.55	8,520	1.92	11,235	2.70	293,866	64.48	291,532	63.94	2,334	0.54
	2000	17,557	3.14	13,473	2.34	18,195	3.33	453,981	76.45	450,256	75.79	3,725	0.66
	2019	45,329	4.36	34,678	3.31	47,156	4.58	1,044,656	98.93	1,035,187	98.03	9,470	0.91
	2019 vs. 2000 (%) [*]	158.18	38.97	157.39	41.18	159.17	37.44	130.11	29.41	129.91	29.35	154.22	37.15
	2019 vs. 1990 (%) [*]	314.30	70.79	307.01	72.46	319.71	69.54	255.49	53.43	255.09	53.31	305.66	67.61
Both	1990	26,773	3.17	21,337	2.40	27,104	3.34	749,415	81.48	743,680	80.81	5,734	0.67
	2000	42,462	3.86	33,246	2.91	43,406	4.07	1,142,359	95.80	1,133,360	94.99	8,999	0.81
	2019	114,964	5.78	90,378	4.46	117,374	5.99	2,805,178	136.57	2,781,285	135.38	23,892	1.19
	2019 vs. 2000 (%) [*]	170.74	49.69	171.85	53.41	170.41	47.09	145.56	42.57	145.40	42.53	165.51	47.03
	2019 vs. 1990 (%) [*]	329.40	82.11	323.57	85.41	333.05	79.46	274.32	67.61	273.99	67.53	316.66	77.11

Note: P' was standardized rate calculated using the 2010 National Census as the standard population, expressed as 1/100,000.

Abbreviations: DALYs=disability-adjusted life years; YLLs=years of life lost; YLDs=years lived with disability.

* Percentage change (%) was calculated as the difference between 2019 and 2000 divided by the amount in 2000 and the difference between 2019 and 1990 divided by the amount in 1990.

person-years in 1990 to 2,805,178 person-years in 2019, an increase of 274.32%, and the DALYs rate was estimated to have increased from 81.48/100,000 to 136.57/100,000, a growth rate of 67.61%. The standardized rates of DALYs, YLLs, and YLDs due to pancreatic cancer all increased in 2019 compared with 2000, with YLDs showing the largest increase, more in men than in women; regardless of 1990, 2000, and 2019, men's disease burden indicators were higher than women's (Table 1).

Whether in 1990 or 2019, the incidence of pancreatic cancer was low before the age of 50, and it substantially increased with age, starting from the 50–54 age group, and reaching its peak in the 85-and-over age group. The pattern of changes in mortality was broadly the same among all age groups (Figure 2).

Compared with 1990, DALYs, YLLs, and YLDs of all age groups were estimated to have increased significantly in 2019. YLLs accounted for a larger proportion of DALYs in all age groups, indicating that the disease burden caused by pancreatic cancer was mainly the loss of life due to premature death in 2019. In 2019, DALYs were estimated to have reached a maximum of 457,701 person-years in the 15–49 age group, of which YLLs were estimated to 455,259 person-years, an increase of 273,219 person-years and

271,707 person-years, respectively, compared with 1990, and YLDs were estimated to have reached a maximum of 3,984 person-years in the 65–69 age group. In 2019, the DALYs rate of pancreatic cancer increased with age up to 75–79 years old. The largest increase was in the 75–79 age group. The DALYs rate and YLLs rate gradually increased and reached their peak rate in 70–74 age group (Table 2).

DISCUSSION

In this paper, pancreatic cancer's estimated disease burden and its changes in China were analyzed in detail. The results of this study showed that the incidence and mortality of pancreatic cancer in China in 2019 increased significantly compared with 1990. In 1990, the death toll from pancreatic cancer in China only accounted for 1.88% of all malignant tumor deaths, but it rose to 4.33% in 2019, and it continuously increased. The incidence of pancreatic cancer in China in 2019 was 5.78/100,000, which is lower than the global level (6.57/100,000), but the incidence and mortality have increased significantly, increasing by 82.11% and 79.46% in recent 30 years, respectively. The speed was much higher than the global level (25.86% and 27.90%).

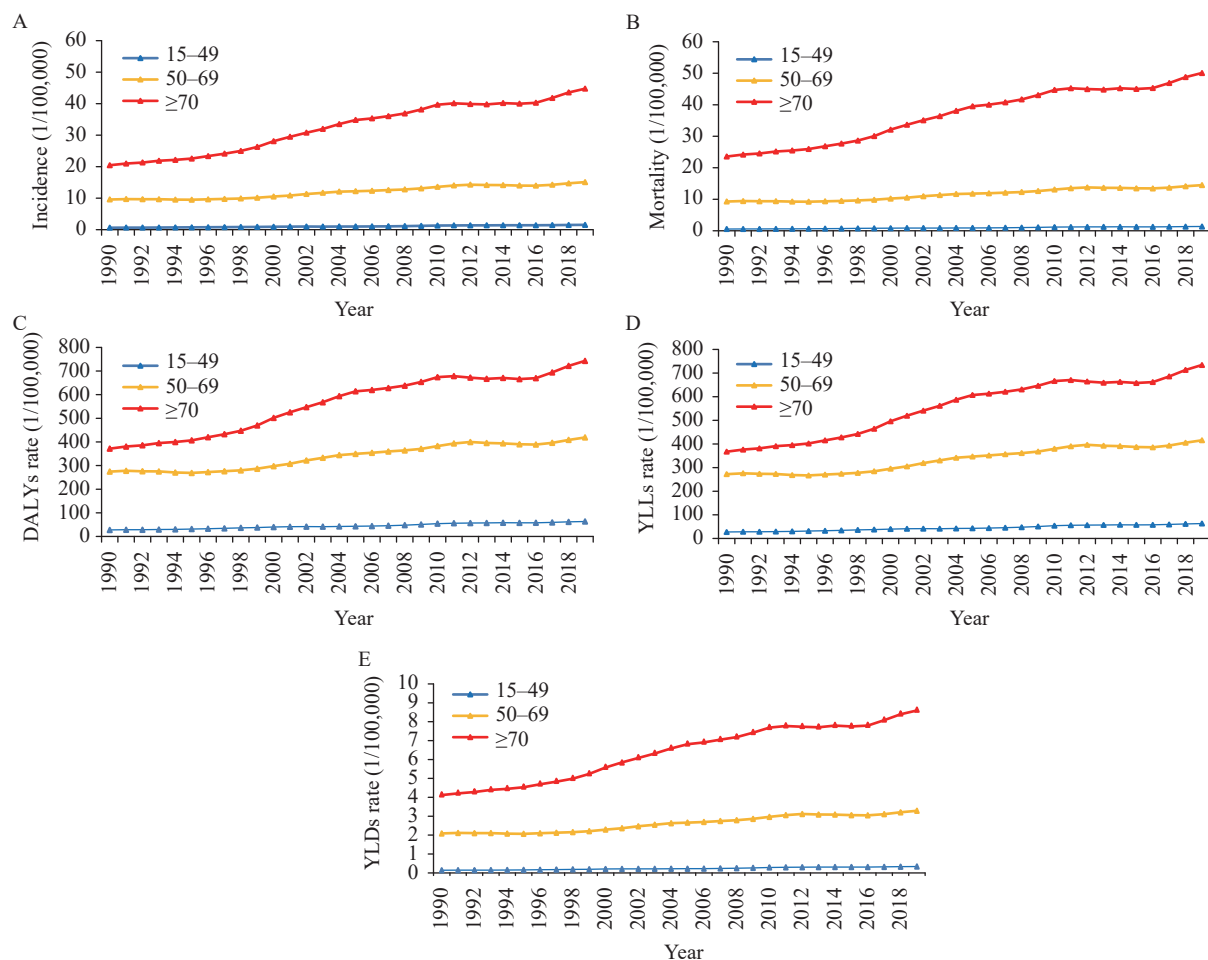


FIGURE 1. Trends of disease burden in pancreatic cancer in 3 age groups, China, 1990–2019. (A) Trends of incidence (1/100,000); (B) Trends of mortality (1/100,000); (C) Trends of DALYs rate (1/100,000); (D) Trends of YLLs rate (1/100,000); (E) Trends of YLDs rate (1/100,000).

Abbreviations: DALYs=disability-adjusted life years; YLLs=years of life lost; YLDs=years lived with disability.

The increased number of cases in China could possibly be associated with better diagnostic technology and the aging of the population, but also possibly associated with some risk factors for pancreatic cancer, such as unhealthy living habits, *Helicobacter pylori* infection, obesity, etc. (3). And a meta-analysis (4) confirmed that folic acid was a protective factor for pancreatic cancer, and people with higher levels of folic acid in the body have a lower risk of disease. Therefore, it is recommended to pay attention to the level of folic acid in the body and take folic acid supplements when levels are low. The YLLs and YLDs of elderly patients with pancreatic cancer increased. The latest census results show that the population aging degree in China is further deepened, and the proportion of the population aged 60 and above is more than 18.70% (5). As the population ages, the disease burden of pancreatic cancer will continue to

increase. The reasons for increased deaths could be limitations in diagnostic and treatment methods as the recurrence rate after surgical resection is high and the prognosis is poor. The 5-year survival rate of patients after surgery is only 7% to 25% (6).

In 2019, the incidence and mortality of pancreatic cancer in China for males (7.43/100,000 and 7.69/100,000) were higher than for females (4.36/100,000 and 4.58/100,000). This result may be due to differences in lifestyle behaviors between men and women. Among the differences in lifestyle, the effects of smoking and drinking were more obvious. According to the latest “Report on Nutrition and Chronic Disease Status of Chinese Residents (2020)” (7), the smoking and drinking rates of Chinese men were as high as 50.5% and 46.2%, which were much higher than women (2.1% and 10.2%). Smoking is the most common risk factor for pancreatic cancer. A

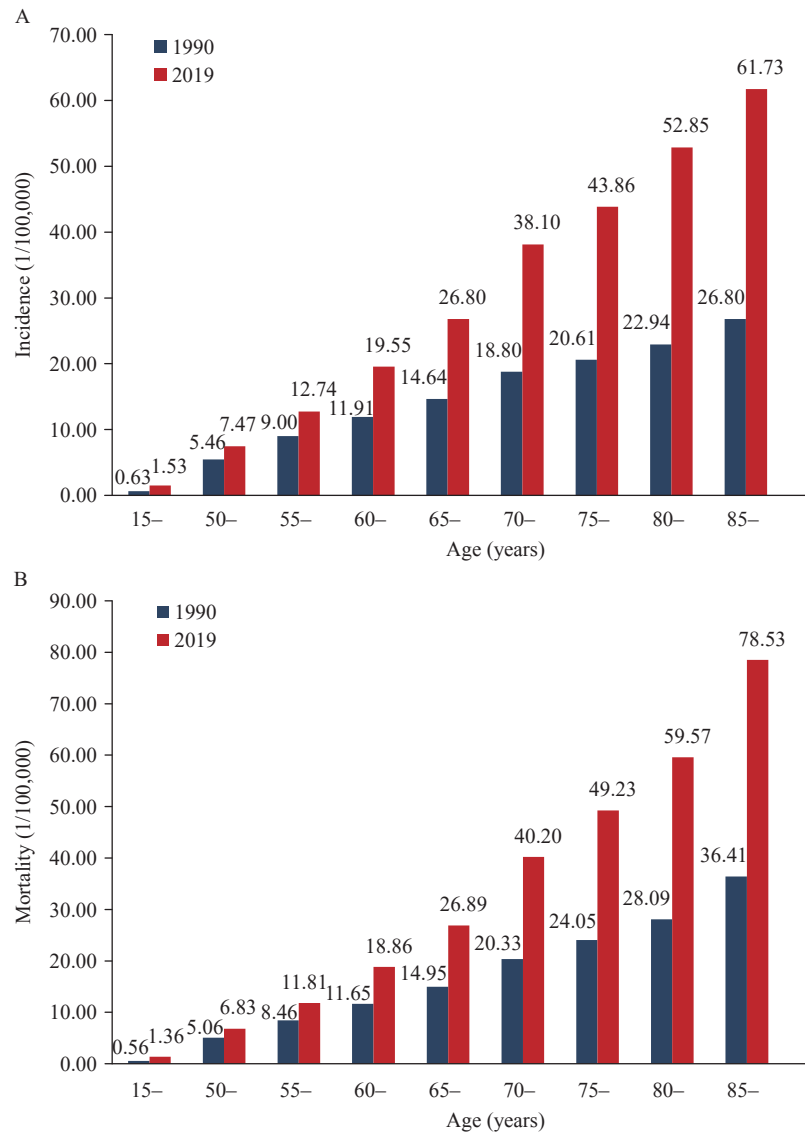


FIGURE 2. Incidence and mortality of pancreatic cancer by age group in China in 1990 and 2019. (A) Incidence of pancreatic cancer; (B) Mortality of pancreatic cancer.

TABLE 2. Disease burden of pancreatic cancer by age group in China, 1990 vs. 2019.

Age (years)	DALYs (person years)		DALYs rate (1/100,000)		YLLs (person years)		YLLs rate (1/100,000)		YLDs (person years)		YLDs rate (1/100,000)	
	1990	2019	1990	2019	1990	2019	1990	2019	1990	2019	1990	2019
15–	184,482	457,701	27.60	63.51	183,552	455,259	27.46	63.17	930	2,442	0.14	0.34
50–	90,383	319,059	189.08	255.04	89,808	316,981	187.87	253.38	576	2,079	1.20	1.66
55–	120,140	365,891	276.42	385.80	119,272	363,193	274.43	382.96	868	2,698	2.00	2.84
60–	115,848	415,592	327.06	529.04	114,931	412,229	324.47	524.76	918	3,363	2.59	4.28
65–	96,386	444,960	352.19	632.19	95,533	440,976	349.07	626.53	853	3,984	3.12	5.66
70–	74,005	370,395	392.47	773.98	73,269	366,724	388.56	766.31	736	3,671	3.90	7.67
75–	42,034	223,896	368.38	750.16	41,556	221,352	364.19	741.64	478	2,544	4.19	8.52
80–	26,136	207,684	327.06	686.28	25,760	204,572	322.35	675.99	376	3,112	4.71	10.28
Total	749,415	2,805,178	63.31	197.22	743,680	2,781,285	62.83	195.54	5,734	23,892	0.48	1.68

Abbreviations: DALYs=disability-adjusted life years; YLLs=years of life lost; YLDs=years lived with disability.

meta-analysis study (8) on pancreatic cancer risk factors showed that the risk of pancreatic cancer in smokers was as high as 1.74 times (95% CI: 1.61–1.87) compared with non-smokers. Previous studies have found that alcohol intake also had an impact on the incidence of pancreatic cancer. Long-term alcohol consumption may increase the risk of pancreatitis and diabetes, thereby increasing the risk of pancreatic cancer, and alcohol was associated with increased risk of pancreatic cancer in men, especially in heavy drinkers, but there was no significant correlation with the risk of pancreatic cancer in women (9).

The study was subject to at least two limitations. The first is that the GBD results are mainly estimates obtained through the calculation of a system dynamics model combined with a statistical model and are not real observations, so it is difficult to avoid the possibility of distortion of the estimates. Second, we did not have access to provincial data on the disease burden of pancreatic cancer in China, so we could only analyze at the national level and could not analyze the differences in the disease burden of pancreatic cancer between regions.

This research found that the disease burden of pancreatic cancer in China has increased in the past 30 years, and it was the most obvious in the population aged 70 and above. DALYs, YLLs, YLDs, and their standardized rates all increased. The disease burden of pancreatic cancer in men was higher than that in women, and the incidence of pancreatic cancer was more common in the older age group and lower in the 15–49 age group, which was consistent with findings of a study in China that analyzed trends in pancreatic cancer incidence and mortality from 2005–2015 (10). Therefore, strengthening the implementation of smoking and alcohol control policies and focusing on high-risk groups such as middle-aged and elderly men are important early preventive measures for the prevention and control of pancreatic cancer. In addition, we found that from the results obtained in this study, it appears that there may be an interactive effect of pancreatic cancer incidence and mortality with the three factors of year, age, and sex, which is well worthy of continued in-depth study. So this study not only analyzes the development trends of pancreatic cancer in China from 1990–2019, but also provides us with ideas for the next step of research.

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Notifiable Infectious Diseases Reports

Reported Cases and Deaths of National Notifiable Infectious Diseases — China, March 2022

Diseases	Cases	Deaths
Plague	0	0
Cholera	1	0
SARS-CoV	0	0
Acquired immune deficiency syndrome*	5,020	1,655
Hepatitis	140,574	47
Hepatitis A	1,050	0
Hepatitis B	114,003	38
Hepatitis C	21,722	9
Hepatitis D	23	0
Hepatitis E	3,131	0
Other hepatitis	645	0
Poliomyelitis	0	0
Human infection with H5N1 virus	0	0
Measles	71	0
Epidemic hemorrhagic fever	344	2
Rabies	8	6
Japanese encephalitis	2	0
Dengue	2	0
Anthrax	15	0
Dysentery	2,836	0
Tuberculosis	73,110	312
Typhoid fever and paratyphoid fever	408	0
Meningococcal meningitis	10	2
Pertussis	3,747	1
Diphtheria	0	0
Neonatal tetanus	1	0
Scarlet fever	1,848	0
Brucellosis	6,656	1
Gonorrhea	8,886	0
Syphilis	46,978	6
Leptospirosis	5	0
Schistosomiasis	5	0
Malaria	31	0
Human infection with H7N9 virus	0	0
COVID-19†	41,577	2
Influenza	133,184	1
Mumps	10,001	0

Continued

Diseases	Cases	Deaths
Rubella	98	1
Acute hemorrhagic conjunctivitis	2,559	0
Leprosy	35	0
Typhus	36	0
Kala azar	30	0
Echinococcosis	338	0
Filariasis	0	0
Infectious diarrhea [§]	122,555	0
Hand, foot and mouth disease	33,287	0
Total	634,258	2,036

* The number of deaths of acquired immune deficiency syndrome (AIDS) is the number of all-cause deaths reported in the month by cumulative reported AIDS patients.

† The data were from the website of the National Health Commission of the People's Republic of China.

§ Infectious diarrhea excludes cholera, dysentery, typhoid fever and paratyphoid fever.

The number of cases and cause-specific deaths refer to data recorded in National Notifiable Disease Reporting System in China, which includes both clinically-diagnosed cases and laboratory-confirmed cases. Only reported cases of the 31 provincial-level administrative divisions in the mainland of China are included in the table, whereas data of Hong Kong Special Administrative Region, Macau Special Administrative Region, and Taiwan are not included. Monthly statistics are calculated without annual verification, which were usually conducted in February of the next year for de-duplication and verification of reported cases in annual statistics. Therefore, 12-month cases could not be added together directly to calculate the cumulative cases because the individual information might be verified via National Notifiable Disease Reporting System according to information verification or field investigations by local CDCs.

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