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Premature death patterns and trends of stomach cancer in Pudong, Shanghai: a population based study

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Abstract

Background Estimating the disease burden of stomach cancer is essential to developing evidence-based prevention and treatment strategies.

Aims To analyze the number of deaths and the temporal trends in the mortality and years of life lost (YLL) in relation to gender, age, and the impact of aging and comorbidity via non-communicable diseases on stomach cancer burden in one of the most developed regions of a transitioning country.

Methods Mortality data of stomach cancer were collected from the Vital Statistics System of the Pudong New Area, Shanghai, China, from 2005 to 2019. The long-term trends in crude mortality rates (CMR), age-standardized mortality rates worldwide (ASMRW), and rate of YLL(YLLr) were analyzed using the Joinpoint regression program. The aging and non-aging factors affecting the mortality rate were evaluated by the decomposition method.

Results A total of 11,609 deaths from stomach cancer occurred from 2005 to 2019. The CMR and ASMRW of stomach cancer were 29.83/10^5 person-year and 12.20/10^5 person-year, respectively. The CMR, ASMRW, and YLLr in males were nearly twice as higher as those in females(CMR: 35.47/10^5 vs. 19.83/10^5, ASMRW: 15.64/10^5 vs. 7.74/10^5, YLLr: 378.63/10^5 vs. 229.13/10^5). The main co-morbidities involved the circulatory (24.64%) and respiratory system (20.62%). The main metastatic sites were liver (9.08%), lung (2.79%) and peritoneum (2.33%). The long-term trends in CMR and ASMRW were significantly decreasing in males, females, and the total population from 2005 to 2019. A total of 9,460 (81.48%) elderly people aged ≥ 60 years died of stomach cancer. The top three age groups with the highest CMR were ≥ 80 years, 70–79 years, and 60–69 years. The CMR and YLLr of people aged ≥ 80 years showed the largest significantly decreasing trends. The CMR caused by aging showed significantly upward trends [average annual percent changes (AAPC) 95%CI = 37.63(14.95,64.79)%, $P < 0.001$], which caused by non-aging factor showed significantly downward trends [AAPC 95%CI = -18.17(-22.83,-13.22)%, $P < 0.001$].

Conclusion Age is an important factor affecting the trend of disease burden of stomach cancer. Paying attention to high-risk people may help to reduce the YLL.

Keywords Stomach cancer, Trend analysis, Aging, Years of life lost, Decomposition method, Mortality, Transitioning countries

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Introduction

Stomach cancer remains a frequently diagnosed cancer globally, especially in eastern Asia, and there were over one million new occurs of stomach cancer in 2020 and an estimated 769,000 deaths, making it the fifth most common cancer and the third leading cause of cancer-related death worldwide [1]. In China, stomach cancer is the second most commonly diagnosed cancer (679,000 cases), and the second leading cause of cancer-related death (498,000 cases), meanwhile the mortality rate in males is twice that in females [2]. Because of the great demographic and socioeconomic changes, the life expectancy at birth increased from 74.1 to 83.2 years from 1973 to 2015 in Shanghai, but there has not been clearly stated the impact of those factors on the disease burden of stomach cancer [3, 4]. To our knowledge, the key demographic factor is aging and the non-demographic factors mainly involves the development of medical treatment modalities, changing living environments, and improvement in health consciousness, which prompts the development of comprehensive medical treatment strategies for cancer, including surgical treatment, radiotherapy, chemotherapy, immunotherapy, and targeted therapy [5, 6]. Under these circumstances, survival rates for localized stomach cancer have improved, for example, the overall 5-year observed survival rates increased from 46.0% in 2000 to 60.0% in 2010, and the survival rates for all stomach cancer patients increased from 18.8% in 2000 to 28.0% in 2010 [7]. However, we do not know the contribution of each factor to the increase of survival rate or the decrease of mortality rate of stomach cancer.

Due to the following reasons, Shanghai Pudong New Area (PNA) was chosen as a research area. First, PNA has 3.17 million permanent residents, accounting for over fifth part of the total resident population in Shanghai in 2020 [8]. Second, PNA is recognized as the epitome of China's reformation, and the demographic structure has changed with the immigration of foreign population and the aging of local residents. It is therefore regarded as a good representative of China's general population [9]. Third, compared with other transitioning countries or regions, better quality mortality data from PNA were derived from a reliable mortality registration system [10].

Previous studies on stomach cancer have focused on using incidence and mortality to express the epidemiological characteristics of stomach cancer, but they never quantify the impact of risk factors on the cause of death, the metastatic sites and the main co-morbidities involved in people died in stomach cancer. In this study, we analyzed the number of deaths and the temporal trends in the mortality and years of life lost (YLL) in relation to gender, age, and the impact of aging and comorbidity via non-communicable diseases on stomch cancer burden in one of the most developed regions of a transitioning country from 2005 to 2019.

Methods

Data source

Detailed data were collected from the mortality registration system of the Shanghai PNA of China, which included age, gender, date of birth or date of death and all causes of death. To explore long-term trends in mortality since 2005, the annual death data of permanent residents with stomach cancer were analyzed. In accordance with the standard guidelines, periodic assessments, data cleaning and compilation were carried out to ensure the integrity of the registration system, as described in a previous study [10]. The causes of death from stomach cancer were coded according to the international Classification of diseases 10 (ICD-10). According to the 2000 Declaration of Helsinki, the study was performed and approved by the ethics committee of the Shanghai PNA Center for Disease Control and Prevention (IRB#2016-04-0586).

Statistical analysis

The crude mortality rates (CMR) and ASMRW (using the Segi world standard population) for stomach cancer were calculated and represented as per 100,000 ($/10^5$) population. The CMR was analyzed for the different age groups of 0–14 years, 15–29 years, 30–44 years, 45–59 years, 60–69 years, 70–79 years, and ≥ 80 years.

A standard life expectancy was used to estimate YLLs [11]. The YLL was calculated using the World Health Organization template [12]. The Poisson approximation method and Mantel-Haenszel test were used to compare the CMR and ASMRW between genders. The Joinpoint Regression Program 4.3.1.0 (downloaded from the website of the National Cancer Institute, MD, USA) was used to calculated the temporal trends in ASMRW, CMR and the rate of YLL (YLLr). The annual percent change (APC) and average APC (AAPC) with a corresponding 95% confidence interval (CI) was used to express the long-term trends, as detailed in our previous study [13]. The decomposition method [14] was used to analyze the mortality rates for each year for deaths caused by aging and deaths caused by non-aging factors by based on the CMR of 2005, in which mortality rates were calculated and compared for each age group, from 0 to 14 to 80 + years. All statistical analyses were conducted using SPSS 21.0 (SPSS, Inc., Chicago, IL) and R (version 3.4.3). *P* value of < 0.05 was considered statistically significant.

Results

Baseline

A total of 11,609 stomach cancer specific deaths were considered, accounting for 4.01% of all 312,281 deaths from 2005 to 2019 in PNA. There were 7,437 male

(64.06%) and 4,172 female (35.64%). The median age and average age at death from stomach cancer was 73.79 years and 71.71 ± 12.76 years. The CMR and ASMRW of stomach cancer were 27.64/10^5 person-year and 11.44/10^5 person-year, respectively. The CMR and ASMRW were 35.47/10^5 and 15.64/10^5 person-years and 19.83/10^5 and 7.74/10^5 person-years in males and females, respectively. The CMR and ASMRW in males were almost twice as higher as those in females (all $P < 0.05$) (Table 1).

Premature death due to stomach cancer

From 2005 to 2019, the YLL due to stomach cancer was 127,592.83 years, and the YLLr was 303.76/10^5. YLL and YLLr in males (79,395.00 years, 378.63/10^5) were nearly twice than those in females (48,197.83 years, 229.13/10^5). The top three co-morbidities involved the circulatory system (I00-I99), respiratory system (J00-J99) and urinary system (K00-K99), accounting for 24.64%, 20.62% and 16.79%, respectively. Moreover, 3,347(28.83%) patients died due to stomach cancer-related metastases. The top three metastatic sites of gastric cancer were the liver (9.08%), lung (2.79%), and retroperioneum and peritoneum (2.33%). Furthermore, the other CMR, ASMRW in relation to different genders and causes of death are detailed in Table 1.

Age-specific disease burden

A total of 9,460(81.48%)elderly people aged ≥ 60 years died of stomach cancer. The top three age groups with the highest CMR were ≥ 80 years, 70–79 years, and 60–69 years, which were204.28/10^5 person-years, 115.35/10^5 person-years, 44.05/10^5 person-years, respectively. Among them, the age group of 60–69 years had the highest YLL, with a loss of 34,796.19 years. The top three age groups with the highest YLLrs were ≥ 80 years, 70–79 years, and 60–69 years, with rates of 1077.29/10^5, 1055.96/10^5, and 616.54/10^5, respectively (Table 2).

Trends of mortality and YLLr

The long-term trends in CMR, and ASMRW (Fig. 1A, Table S1, Table S2) were significantly decreasing in males, females, and the total population from 2005 to 2019 (all $P < 0.05$, except male CMR). The ≥ 80 years and 70–79 years age groups showed an obviously downward trend. The CMR and ASMRW in females decreased by -1.40% and − 3.83% (95% CI= -2.23% to -0.56%; -4.65% to -3.00%, $P < 0.001$) per year, while there was a significant downward trend of ASMRW in the males. Furthermore, the YLLr decreased significantly by -3.11% per year in the whole population (95% CI = -4.75% to -1.45%, $P = 0.001$), as detailed in Fig. 1B.

The CMR of the total population showed downward trends from 2005 to 2019 in terms of age-specific mortality and disease burden. The top three downward

Table 1 Baseline characteristics of deaths and burden in different genders and types of stomach cancer during 2005–2019

Characteristic	Deaths (*n*,%)	Age at years (Mean ± SD)	Age at years (Median)	Age at years (Range)	CMR (/10^5)	ASMRW (/10^5)	YLL (years)	YLL rate (/10^5)
Gender								
Male	7437(64.06)	71.47 ± 11.63	72.91	18.15-101.53	35.47	15.64	79,395	378.63
Female	4172(35.94)	72.13 ± 12.76	76.08	18.18-107.24	19.83	7.74	48197.83	229.13
Metastatic cancer								
Metastatic carcinoma(C00-C96)	3347(28.83)	68.93 ± 12.77	70.41	18.18–95.99	7.97	3.53	40565.26	96.57
Metastatic gastric cancer to the liver (C78.7)	1054(9.08)	70.90 ± 10.99	72.55	27.09–94.23	2.51	1.06	11805.27	28.1
Metastatic gastric cancer to the lung (C78.0)	324(2.79)	71.25 ± 11.67	73.36	24.38–94.71	0.77	0.32	3583.1	8.53
Metastatic gastric cancer to the Retroperitoneum and peritoneum(C78.6)	270(2.33)	62.63 ± 12.14	66.74	27.08–97.99	0.64	0.3	3575.71	8.51
The main co-morbidity in all causes of death								
Diseases of the circulatory system(I00-I99)	2860(24.64)	76.32 ± 10.76	78.37	25.70-102.48	6.81	2.48	25870.25	61.59
Diseases of the respiratory system(J00-J99)	2394(20.62)	74.15 ± 12.01	76.69	21.22–98.57	5.7	2.21	23699.14	56.42
Diseases of the urinary system(K00-K99)	1949(16.79)	71.41 ± 12.79	72.58	23.57–99.72	4.64	1.93	21727.85	51.73
Diseases of the metabolic system(E00-E99)	1526(13.14)	73.17 ± 11.40	74.85	28.87–96.81	3.63	1.44	15898.6	37.85
Total	11,609(100.00)	71.71 ± 12.76	73.79	18.15-107.24	27.64	11.44	127592.83	303.76

ASMRW, age-standardized mortality rate by Segi's world standard population; CMR, crude mortality rate; YLL years of life lost

Table 2 Age-specific mortality and burden of stomach cancer during 2005–2019

Age group (years)	Deaths (*N*)	Proportion (%)	CMR (/10^5)	YLL (years)	YLL rate (/10^5)
0–14	0	0	0	0	0
15–29	49	0.42	0.71	1331.5	19.38
30–44	313	2.7	3.32	7525.3	79.87
45–59	1787	15.39	16.12	33783.86	304.77
60–69	2486	21.41	44.05	34796.19	616.54
70–79	3447	29.69	115.35	31555.67	1055.96
≥ 80	3527	30.38	204.28	18600.3	1077.29
Total	11,609	100	27.64	127592.83	303.76

ASMRW, age-standardized mortality rate by Segi's world standard population; CMR, crude mortality rate; YLL, years of life lost

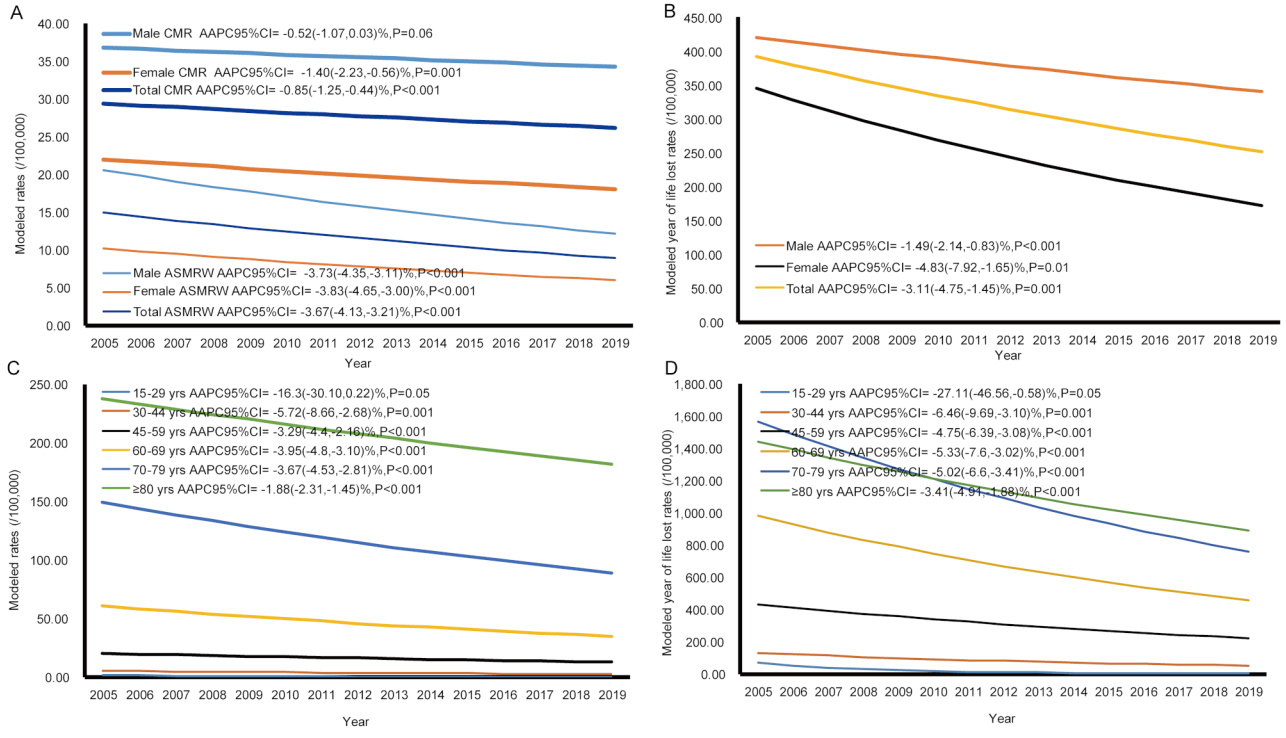

Fig. 1 The long-term trends in CMR, ASMRW, and YLL of patients with underlying cause of death from stomach cancer in genders and age groups in PNA, Shanghai, China, 2005–2019. (**A**) trends in CMR and ASMRW in genders; (**B**) trends YLL rate in genders; (**C**) trends in CMR among different age groups; (**D**) trends in YLL rate among different age groups

CMR, crude mortality rate (per 100,000); ASMRW, age-standardized mortality rate by Segi's world standard population (per 100,000); YLL, year of lost. AAPC, average annual percent change; CI, confidence interval

trends of CMR were also seen in the 60–69 years, 70–79 years, and ≥ 80 years age groups, accounting for – 3.95% (95% CI = -4.80% to -3.10%), -3.67% (95% CI = -4.53% to -2.81%), and – 1.88% (95% CI = -2.31% to -1.45%, all $P < 0.05$) per year, respectively (Fig. 1C and Table S3). The YLLr also decreased significantly in the different age groups (Fig. 1D and Table S4). The modeled proportions of death, as analyzed by the Joinpoint regression program, are detailed in Table S5. Furthermore, the AAPC of ASMRW was significantly increased in the age groups of 60–69 years and ≥ 80 years (Fig. 2).

There were a joinpoint in 2007 in the trends of female or total YLLr, and also in the YLLr of people above 45 years old, and the decline rates of them from 2007 to 2019 were slower than those from 2005 to 2007. The details of APC were shown in Table S6.

Impact of aging on mortality

The increasing trends of CMR caused by non-aging and aging from 2006 to 2019, as compared with the CMR in 2005 are shown in Fig. 3A and Table S7. A significant upward trend [AAPC (95% CI) = 37.63% (14.95–64.79%), $P < 0.001$] in the increase rate caused by aging was observed in the total population, whereas, a significant downward trend was observed in the increase rate affected by non-aging, with an AAPC of -18.17% [(95%

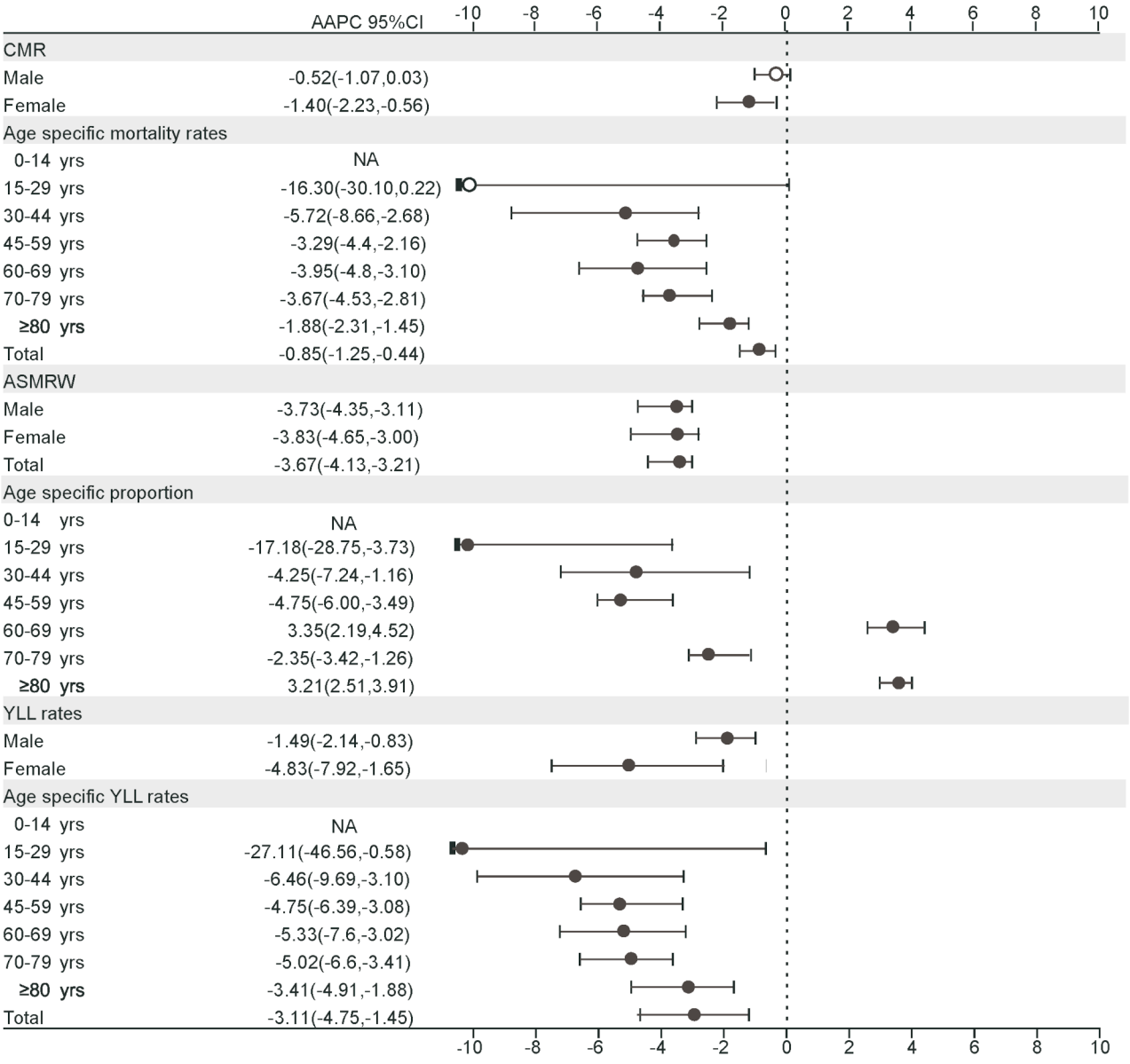

Fig. 2 The AAPC change in CMR, ASMRW, YLL rates of persons with underlying cause of death from stomach cancer in genders and age specific proportion in Pudong New Area (PNA), Shanghai, China, 2005–2019

CMR, crude mortality rate (per 100,000); ASMRW, age-standardized mortality rate by Segi's world standard population (per 100,000); YLL, year of lost; AAPC, average annual percent change; CI, confidence interval

CI) =-22.83% to -13.22%, $P<0.001$]. In males, the increase mortality rate affected by non-aging factors decreased by -18.52% (95% CI = -22.61% to -14.22%, $P<0.001$), and the rate due to aging increased by 39.62% (95% CI = 14.95–69.59%, $P<0.001$). In females, the increase mortality rate due to non-aging factors showed a downward trend [AAPC (95% CI) = -13.66% (-18.03% to -9.06%), $P<0.001$], contrary to the rate due to aging [AAPC (95% CI) = 34.41% (13.98–58.49%), $P<0.001$] (Fig. 3B).

Discussion

Stomach cancer is still a common disease burden in China, which accounts for approximately half of the global new occurs and deaths [15]. Therefore, it is essential to understand the mortality and disease burden due to stomach cancer. In this population-based study, the liver, lung, and peritoneum and retroperitoneum metastasis were concluded to be the top three leading causes of death from metastatic stomach cancer, which shows the importance of appropriate follow-up strategies after diagnosis. For patients with metastatic cancer, supportive

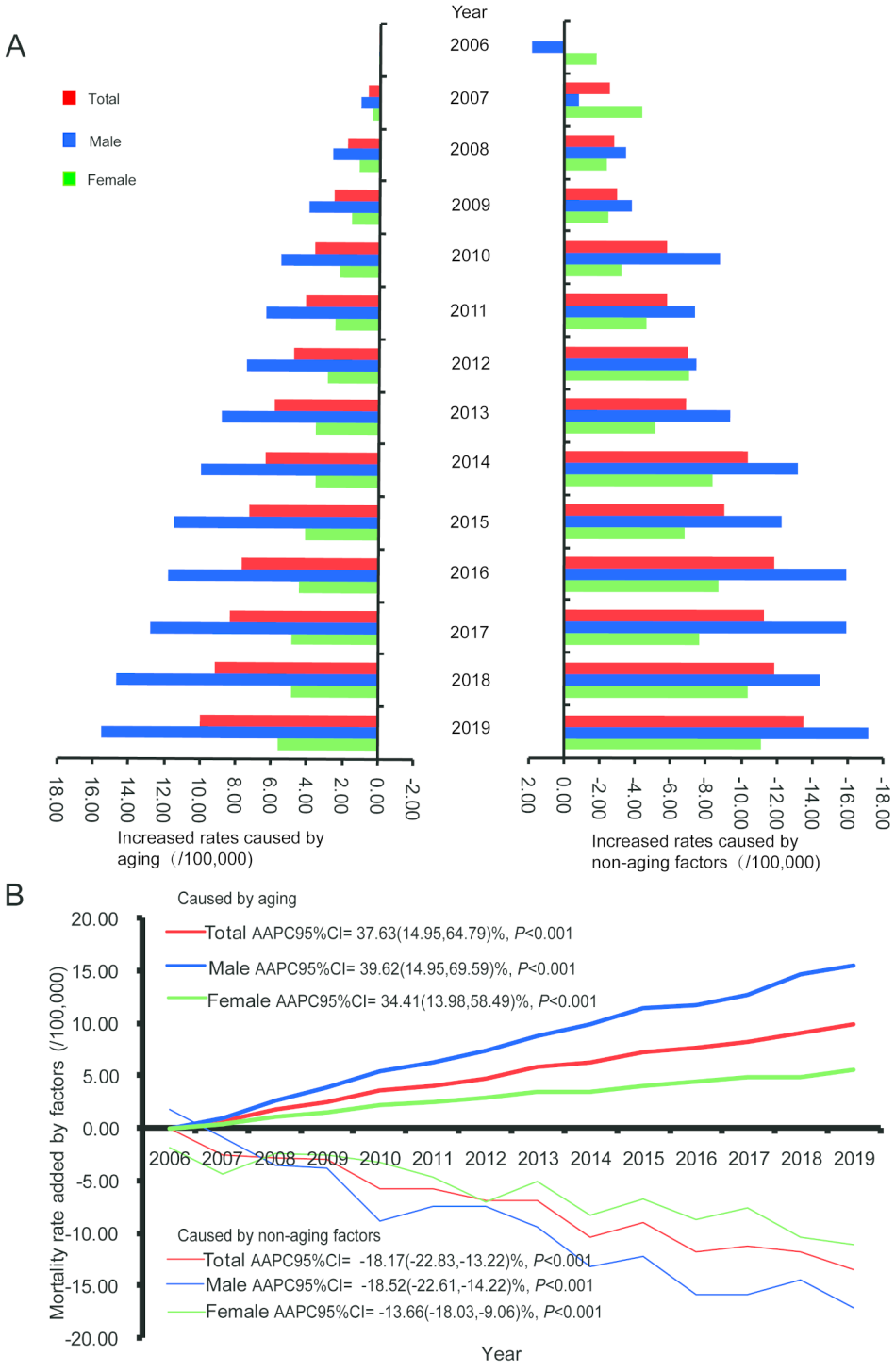

Fig. 3 The rates caused by aging and non-aging factors and their proportion during the period from 2005 to 2019 in PNA, Shanghai, China. (**A**) The increased rates caused by demographic and non-demographic age structure; (**B**) The trend of the mortality rate caused by aging and non-aging factors AAPC, average annual percent change; CI, confidence interval

care is the best of choice. Our findings also showed that the main comorbidities involved the circulatory, respiratory and urinary systems. Multidisciplinary management is essential for the management of these kinds of patients with comorbidities. Thus, treatment should be individualized based on the patient's performance status, comorbidities, and genetic factors [16]. Meanwhile, we have noticed that in 2019, the standardized

mortality rate and YLLr of stomach cancer in Shanghai PNA was much lower than the national level ($8.73/10^5$ vs. $22.16/10^5$, $263.92/10^5$ vs. $508.92/10^5$) and similar to the global level ($11.53/10^5$, $267.38/10^5$), but higher than that in high socio-demographic index (SDI) regions ($7.05/10^5$, $148.48/10^5$) [17], which is consistent with previous research results that the more developed the economy, the better people's living and medical conditions, and the more outstanding the prevention and treatment of stomach cancer. Furthermore, the CMR, ASMRW, and YLL for stomach cancer decreased significantly from 2005 to 2019. The decrease in mortality may be in relation to the increase in the survival rate [18] and the upward trend of medical expenditure in the country during the study period [19]. Thus, it is critical to facilitate earlier cancer diagnosis and improve the availability of optimal treatments to have a more immediate impact on the existing disease burden of cancer in China.

There were significant differences in mortality and YLL between different age groups. People aged over 60 years had significantly decreasing CMR and YLL, and these deaths accounted for 81.48% of the total death. The age group of 60–69 years had the highest YLL, followed by the age groups of 45–59 and 70–79 years. It is inferred that 60–69-years-old patients are a key population for cancer prevention and control. Similar to our findings, other study findings showed that most cancer deaths in males and females occur in the age range of 60–74 years and a downward trend in ASMR was also observed for stomach cancer [2]. Aging is recognized as the underlying reason for these phenomena. As the largest metropolis in China, Shanghai is the first city to enter the aging society, and becomes the most aging city. The modeled death proportion of people aged over 80 years increased from 24.07% in 2005 to 37.44% in 2019. The modeled death proportion showed a significant upward trend from 2005 to 2019 (Supplementary Table S5). The burden of stomach cancer was concentrated in the elderly population, and the CMR and YLL varied among the different age groups (Supplementary Table S3). In subgroup analysis, the decline in YLLr and the combined YLLr slowed down among females aged 45 and over after 2007, perhaps due that it is a new implementation of early screening and early diagnosis policies since 2005 and the radical treatment of *Helicobacter pylori (H pylori)*. Even though the trend of decline in the early death rate of middle-aged and elderly females with stomach cancer has slowed down, its YLLr is still much lower than that of males, which indicates that male's stomach health also needs to be strengthened. Thus, when we analyzed the disease characteristics of stomach cancer and intervention strategies, it is necessary to consider the age difference.

The etiology of stomach cancer is complex and involves interplay between demographic and non-demographic factors. *H pylorus* is the main risk factor for stomach cancer, with almost 90% of new cases of non-cardia gastric cancer attributed to this bacterium [20]. *H pylori* treatment and vitamin supplementation are associated with a significantly reduced incidence of stomach cancer [21]. The incidence differs based on sex and geographical variability as well. Males are two to three times susceptible than females and more than 50% of new cases are from developing countries [6]. Although some risk factors for stomach cancer, such as age, sex, race, and genetics, are unmodifiable, this evidence suggests that lifestyle changes, such as consuming more vegetables and fruits, and increasing physical activity may help reduce the incidence of stomach cancer. Moreover, this study shows that the mortality rate of elderly gastric cancer patients in the local area is lower than that of young patients, especially for patients over 80 years old, with a decreasing mortality rate of only 1.88%. The reason may be as follows: the immune system and physiological functions of the human body gradually decline as age increases, which may lead to a decrease in the responsiveness of elderly patients to treatment, thereby affecting treatment effectiveness and survival rate [22]. It may also be accompanied by other chronic diseases or health issues in elderly patients, which may affect their tolerance and recovery from stomach cancer treatment, thereby affecting the rate of mortality reduction [23]. In addition, it is also related to the fact that young patients may be more likely to receive early diagnosis and more aggressive treatment, while older patients may not be able to receive the same level of treatment due to physiological or other factors [24].

The decomposition method has been used to analyze the relative contributions of various factors to the differences in mortality rates. Their analysis showed that the global pattern of increased disease-related deaths is attributed to population aging between 1990 and 2017. The impact of population aging on death varied by sex, country income level, country, and cause of death [25]; this variation is caused by the heterogeneity in the age structure and age-specific mortality rates. In our study, we quantitatively identified the impact of aging and non-aging factors on the long term trend of mortality rates using the decomposition method. The number of deaths caused by aging was significantly increased both in males and in females. However, after adjustment, non-aging factors found that the death caused by stomach cancer was significantly reduced. In our findings, the CMR increased gradually with age. It is speculated that aging was the main demographic factor in relation to the increase in the CMR and the YLL rate of stomach cancer.

This population-based study has great superiority including a large number of population (3.17 million) and a relatively long study period (15 years). Meanwhile,

Shanghai PNA is representative region of urbanization and reform in China and provides insights into the changing disease spectrum in transitioned region in developing countries, as the study period (2005–2019) coincides with its urbanization development, and the analysis results of stomach cancer mortality and trends may may become a typical representative of Chinese inland cities that are still in the process of development or international regions of the same type. However, there were a few limitations. First, there is no record on medical history, histological type of cancer, and treatment strategies, so it is impossible to determine the exact cause of changes in the mortality. Second, although the mortality registration system is reliable and of high quality, the study included only one area of Shanghai, and the representativeness is limited. Third, Shanghai's economic level and medical technology are developing rapidly, which can not reflect the regional differences across the whole country.

Conclusions

In summary, this population-based study identified the various causes of death in patients with stomach cancer and the findings showed significantly decreasing trends in the mortality and disease burden of stomach cancer from 2005 to 2019 in one representative area in transitioning countries. Stomach cancer patients are often accompanied by a variety of diseases. Based on the analysis of the whole life cycle cause of death chain, circulatory, respiratory and urinary system diseases are the main co-fatal diseases of patients with stomach cancer, and the main metastatic sites of death are liver, lung, retroperitoneum and peritoneum. Our findings showed that demographic factors, particularly age, greatly contributed to an increasing mortality of stomach cancer. This study will help to better understand the specificity of stomach cancer in elderly people. These findings may help to optimize the distribution of medical resources for stomach cancer treatment in transitioning countries.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12885-025-14024-z.

Supplementary Table S1: The case number of death, CMR and ASMRW in gender during the period from 2005 to 2019 in PNA, Shanghai, China. (ASMRW, age-standardized mortality rate by Segi's world standard population; CMR, crude mortality rate)

Supplementary Table S2: The modeled rates of CMR and ASMRW by Joinpont regression in gender during the period from 2005 to 2019 in PNA, Shanghai, China. (ASMRW, age-standardized mortality rate by Segi's world standard population; CMR, crude mortality rate)

Supplementary Table S3: The CMR and modeled CMR by Joinpont regression in age groups during the period from 2005 to 2019 in PNA, Shanghai, Chin. (CMR, crude mortality rate)

Supplementary Table S4: The YLLr and modeled YLLr by Joinpont regression in gender and age groups during the period from 2005 to 2019 in PNA, Shanghai, China. (YLL, the rate of years of life lost)

Supplementary Table S5: The proportion and modeled proportion by Joinpont regression in age groups during the period from 2005 to 2019 in PNA, Shanghai, China

Supplementary Table S6: The annual percent change and average annual percent change in CMR, ASMRW, YLL rates of persons with underlying cause of death from stomach cancer in genders and age specific proportion in PNA, Shanghai, China, 2005–2019. (CMR, crude mortality rate (per 100,000); ASMRW, age-standardized mortality rate by Segi's world standard population (per 100,000); YLL, year of lost; APC, annual percent change; AAPC, average annual percent change; CI, confidence interval)

Supplementary Table S7: The increase value of CMR caused by aging and non-aging factors during the period from 2005 to 2019 in PNA, Shanghai, China. (CMR, crude mortality rate)

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Author contributions
G-F M and X-P L drafted and revised the manuscript and participated in the collection, analysis and interpretation of data. Y-C C and Y-Y H contributed to data collection and suggestion for analysis. G-F M, G L and Z L conceived the study, and participated in its design and coordination and critically revised the manuscript. All authors read and approved the final version of the manuscript.

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Data availability
Data is provided within the manuscript or supplementary information files.

Declarations

Ethics approval and consent to participate
The study was approved by the ethics committee of the Shanghai Pudong New Area Center for Disease Control and Prevention (IRB#2016-04-0586).

Consent for publication
All authors approved the final manuscript and the submission to this journal.

Competing interests
The authors declare no competing interests.

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