ABSTRACT

Introduction: Cancer is a major health problem in China. Integrated interventions have been implemented in key areas of Anhui, Henan, Jiangsu, and Shandong provinces with historically higher than average cancer mortality. Assessing the cancer mortality trend and its impact on life expectancy (LE) could help evaluate the effectiveness of interventions in these regions.

Methods: Based on the National Cause-of-Death Surveillance, we analyzed the standardized mortality rate (SMR) of cancer, cause eliminated life expectancy (CELE), potential gains in life expectancy (PGLEs), and rate of life lost in key areas of 4 provinces from 2008 to 2018. Joinpoint program was used to compute the average annual percentage change (AAPC) of cancer mortality. Arriaga’s decomposition method was used to estimate the contribution of cancer to LE in each age group.

Results: From 2008 to 2018, cancer SMR decreased in the study region (AAPC=−3.09%, \(P<0.001\)), which increased LE. The positive effect was the greatest in the 75–79 age group (0.120 years, 2.90%), and the negative effect was the greatest in the 50–54 age group (−0.094 years, −2.20%). Compared to 2008, cancer CELE increased by 3.95 years, PGLEs increased by 0.32 years, and rate of life lost increased by 0.21% in 2018.

Conclusions: Cancer SMR decreased in key areas of 4 provinces from 2008 to 2018. This change had a positive effect on the increase of LE. However, the rate of life lost due to cancer increased. Integrated interventions should continue to further reduce the cancer burden.

INTRODUCTION

Cancer has become a major threat to public health in China (1). GLOBOCAN 2020 showed that there were approximately 4.6 million new cancer cases and 3.0 million cancer deaths in China in 2020, accounting for 23.7% of the total new cancer cases and 30.2% of cancer deaths worldwide, although China only makes up 18.6% of the global population (2). The burden of cancer continues to increase as population aging accelerates and exposure to cancer-related risk factors increases (3).

Previous reports have noted that the cancer mortality in areas along the Huai River in Anhui, Henan, Jiangsu, and Shandong provinces was higher than the national level during 2004–2006 (4–5). An integrated cancer prevention and control program has been implemented to reduce cancer risk in the region since 2007. The program selected 14 representative rural counties and districts along the Huai River as key areas for cancer intervention including cancer screening, environmental improvement, and health education, etc. It has also gradually improved the integrated health and environment surveillance system that tracks deaths, birth and birth defects, drinking water quality, etc. (1,6).

Evaluating cancer mortality trends and analyzing the impact of cancer on life expectancy (LE) can help better understand the burden of disease caused by cancer and provide a basis for assessing the effectiveness of cancer intervention program (7). Therefore, based on the National Cause-of-Death Surveillance data, this study analyzed the trends of cancer mortality and the impact of cancer death on LE in key areas along the Huai River of the 4 provinces from 2008 to 2018.

METHODS

Based on cancer prevalence level, geographical features, and routine environmental monitoring sites, 14 counties (districts) were selected as the key areas of the cancer prevention and control program in the 4 provinces to reduce the cancer burden in the region along the Huai River: Lingbi County, Mengcheng County, Shou County, Yindong District, and Yongqiao District in Anhui Province; Fugou County, Luoshan County, Shenqiu County, and Xiping County in Henan Province; Jinhu County, Sheyang County, Shangcun County, and Yixing County in Jiangsu Province; and Chaozhou County, and Yangzhou County in Shandong Province.
Abbreviations: SMR = standardized mortality rate; AAPC = average annual percentage change.

TABLE 1. Cancer mortality in key areas of 4 provinces and in national rural areas in China, 2008–2018.

| Year | Death | Crude mortality rate (/100,000) | Under-reporting adjusted mortality rate (/100,000) | SMR in study area (/100,000) | SMR in national rural areas (/100,000) |
|------|-------|---------------------------------|-----------------------------------------------|-----------------------------|-------------------------------------|
| 2008 | 19,441 | 156.12                          | 171.63                                         | 198.30                      | 181.62                              |
| 2009 | 19,032 | 150.07                          | 164.02                                         | 187.21                      | 174.11                              |
| 2010 | 19,646 | 155.80                          | 170.22                                         | 193.18                      | 172.49                              |
| 2011 | 19,880 | 174.07                          | 187.89                                         | 189.14                      | 160.51                              |
| 2012 | 19,222 | 167.40                          | 180.52                                         | 164.75                      | 161.82                              |
| 2013 | 19,131 | 166.88                          | 179.69                                         | 165.29                      | 159.78                              |
| 2014 | 19,446 | 169.25                          | 183.19                                         | 164.60                      | 160.58                              |
| 2015 | 20,027 | 173.55                          | 184.86                                         | 163.49                      | 150.12                              |
| 2016 | 20,387 | 174.50                          | 186.03                                         | 155.10                      | 142.47                              |
| 2017 | 20,180 | 172.34                          | 183.43                                         | 153.38                      | 142.70                              |
| 2018 | 19,687 | 167.80                          | 178.40                                         | 140.99                      | 139.80                              |

AAPC (%) | 0.40 | 1.15 | 0.81 | 0.10 | 0.037 | <0.001 | <0.001

Abbreviations: SMR = standardized mortality rate; AAPC = average annual percentage change.
Overall, changes in cancer mortality contributed positively to the increase in LE in the key areas of 4 provinces between 2008 and 2018. The higher positive contribution was in the age group 55 years or older, the greatest contribution was in the age group of 75 to 79 years old (0.12 years, 2.90%), and the greatest negative contribution was in the age group of 50 to 54 years old (−0.09 years, −2.20%). Compared to men, the change in cancer mortality in women contributed less to the increase in LE (Figure 2).

LE in the key areas of 4 provinces increased by 4.27 years from 2008 (74.07 years) to 2018 (78.34 years), with an increase of 3.94 years for men and 4.54 years for women. Cancer CELE increased by 4.59 years, PGLEs increased by 0.32 years and the rate of life lost increased by 0.21%. Between 2008 and 2018, LE and cancer CELE were consistently higher for women than for men, and PGLEs and rate of life lost rates were consistently lower for women than for men (Table 3).

CONCLUSIONS

The study presented a decreasing trend of cancer mortality and a positive effect of this change on LE in the key areas of the four provinces between 2008 and 2018, based on the long-term and high-quality surveillance data of cancer mortality. The results indicated that the integrated cancer intervention program was effective in reducing cancer mortality in

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**TABLE 2. Cancer mortality for different age groups in key areas of 4 provinces in China, 2008 and 2018.**

| Age group (years) | Cancer mortality (/100,000) | Change (/100,000) |
|------------------|---------------------------|------------------|
|                  | 2008                      | 2018             |                  |
| 0                | 5.07                      | 5.44             | 0.37             |
| 1–4              | 5.06                      | 3.21             | −1.85            |
| 5–9              | 3.76                      | 4.58             | 0.82             |
| 10–14            | 3.03                      | 6.11             | 3.08             |
| 15–19            | 5.34                      | 3.58             | −1.76            |
| 20–24            | 5.73                      | 4.25             | −1.48            |
| 25–29            | 10.97                     | 13.32            | 2.34             |
| 30–34            | 18.04                     | 18.69            | 0.65             |
| 35–39            | 31.72                     | 25.32            | −6.40            |
| 40–44            | 64.99                     | 34.95            | −30.04           |
| 45–49            | 123.61                    | 85.07            | −38.54           |
| 50–54            | 192.87                    | 264.52           | 71.65            |
| 55–59            | 297.78                    | 200.37           | −97.40           |
| 60–64            | 537.19                    | 401.48           | −135.71          |
| 65–69            | 805.56                    | 614.98           | −190.58          |
| 70–74            | 1,141.87                  | 878.25           | −263.61          |
| 75–79            | 1,539.41                  | 1,035.42         | −504.00          |
| 80–84            | 2,028.91                  | 1,196.76         | −832.15          |
| 85+              | 3,771.44                  | 1,410.41         | −2,361.02        |

except for the 50–54 age group, in which cancer mortality increased 71.65/100,000 (Table 2).
this region. However, the increase in the rate of life lost illustrated the increased contribution of cancer to LE during the study period, highlighting the necessity of the constant and strengthened cancer prevention and program and cancer surveillance in this region.

To extend healthy LE and improve health equity, the Chinese government has initiated Healthy China 2030 — a national strategy which aims to mobilize governments and relevant departments at all levels to actively create a healthy ecological and social environment, encouraging individuals to adopt a healthy lifestyle. Cancer prevention is a critical component of this national strategy. Our results found that the cancer mortality in key areas of four provinces was still higher than the national average level in rural areas, although the cancer mortality in key areas decreased more strikingly. Sustained efforts on intensive environmental improvement, healthy lifestyles promotion, cancer screening, and cancer early diagnosis and treatment are still needed in the region to continue the downward trend in cancer death and realize the goal of Healthy China 2030.

The analysis of the contribution of cancer mortality by age group to LE found that the decline in cancer mortality in the age of 55 years or older played a greater positive role in the increase in LE of the study population. The greatest contribution was seen in the age group of 75 to 79 years old, the group with the highest cancer incidence, suggesting that the effects of interventions were more pronounced in those with a high prevalence of cancer. In contrast, the change in cancer mortality in the age group of 50 to 54

TABLE 3. LE, cancer CELE, PGLEs and rate of life lost in key areas of 4 provinces in China, 2008 to 2018.

| Year | LE (years) | CELE (years) | PGLEs (years) | Rate of life lost (%) |
|------|------------|--------------|---------------|----------------------|
|      | All        | Men          | Women         | All                  | Men          | Women         | All                  | Men          | Women         |
| 2008 | 74.07      | 71.68        | 76.79         | 76.82               | 74.85        | 78.90         | 2.75                | 3.17        | 2.11         |
| 2009 | 74.33      | 72.47        | 77.52         | 77.47               | 75.52        | 79.54         | 2.64                | 3.05        | 2.02         |
| 2010 | 74.83      | 71.73        | 77.35         | 77.00               | 74.83        | 79.34         | 2.67                | 3.10        | 1.99         |
| 2011 | 75.49      | 71.61        | 77.71         | 77.33               | 74.86        | 79.90         | 2.84                | 3.25        | 2.19         |
| 2012 | 75.85      | 73.00        | 79.09         | 78.80               | 76.32        | 81.43         | 2.95                | 3.32        | 2.34         |
| 2013 | 76.15      | 73.58        | 79.01         | 79.16               | 76.99        | 81.41         | 3.01                | 3.41        | 2.40         |
| 2014 | 76.60      | 73.87        | 79.68         | 79.70               | 77.40        | 82.12         | 3.10                | 3.53        | 2.44         |
| 2015 | 76.91      | 74.15        | 79.97         | 80.06               | 77.76        | 82.42         | 3.15                | 3.61        | 2.45         |
| 2016 | 77.67      | 74.95        | 80.67         | 80.90               | 78.67        | 83.18         | 3.23                | 3.72        | 2.51         |
| 2017 | 77.85      | 75.16        | 80.85         | 81.06               | 78.83        | 83.36         | 3.21                | 3.67        | 2.51         |
| 2018 | 78.34      | 75.62        | 81.33         | 81.41               | 79.12        | 83.77         | 3.07                | 3.50        | 2.44         |

Abbreviations: LE=life expectancy; CELE=cause eliminated life expectancy; PGLE=potential gains in life expectancy.
years old played a negative role in LE. Considering the statistical principles, the increased cancer mortality in the age group of 50 to 54 years old could partially explain the increase in the rate of life lost due to cancer in this age group. The same result has been observed in the contribution of cancer mortality to LE in the overall rural areas of China, according to the National Cause-of-Death Surveillance Dataset. Although further exploration is needed for its specific reason, this finding implies that greater attention should be paid to the cancer prevention and control in this age group.

This study found that cancer CELE increased in key areas of the 4 provinces from 2008 to 2018, while PGLEs and the rate of life lost increased, suggesting an increase in the proportion of life lost due to cancer among all causes of death. This could be due to population aging increasing the burden of cancer (12) or this may be associated with a more rapid decline in the disease burden of other chronic diseases and infectious diseases (13). These results indicated that the burden of cancer in the study region could not be overlooked. Constant efforts in cancer prevention and control are needed to reduce the rate of life lost from cancer in the context of an aging population.

There were some limitations in this study. First, although we have adjusted the under-reporting of mortality in the data analysis, we could not fully rule out the under-reporting of mortality that might have led to the overestimation of LE. Second, this study provided a comprehensive analysis of the overall disease burden of cancer without the estimates for cancer of different types. Further studies on the estimation of disease burden and risk factors of different cancer types in sub-counties (districts) are needed to provide a reference for policy formulation tailored for different cancer types and risk factors.

In summary, cancer SMR in key areas of 4 provinces in China gradually decreased from 2008 to 2018 and the changes in cancer mortality made a positive contribution to the increase of LE, indicating the success of the comprehensive cancer prevention and control program in the region. However, the increase in the rate of life lost due to cancer call for sustained cancer control effort to further reduce the burden of cancer. Local governments need to further strengthen environmental improvement, enhance health education on cancer prevention, and carry out cancer early diagnosis and treatment programs, particularly for the population aged 50 to 54 years old. Continuous surveillance is needed to assess the long-term effects of these interventions.

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