

Updated information concerning trends in suicide rates in elderly in China, 2002–2020

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Abstract: The aim of this study was to investigate trends in suicide rates (SRs) among the elderly in China. Annual data on SRs among Chinese people \geq the age of 65 were collected from China's Health Statistics Yearbook from 2002 to 2020. Then, data were stratified by age, region, and sex. Standardized SRs were calculated and analyzed using a conventional joinpoint regression model. Results revealed that overall, SRs among the elderly in China tended to decline from 2002–2020. Fluctuations in SRs, including in 2004–2005 due to the SARS epidemic, in 2009–2010 due to the economic crisis, and in 2019–2020 due to the COVID-19 pandemic, were also observed. Data suggested a relatively greater crude SR among the elderly (*vs.* young people), in males (*vs.* females), and in people living in a rural area (*vs.* those living in an urban area). SRs tended to rise with age. Joinpoint regression analysis identified joinpoints only for males ages 65–69 and over the age of 85 living in a rural area, suggesting that individuals in these groups are more sensitive to negative stimuli and more likely to commit suicide, necessitating closer attention. The findings from this study should help to make policy and devise measures against suicide in the future.

Keywords: elderly, suicide, suicide rates, joinpoint, joinpoint regression model

Introduction

Suicide is not only a serious public health problem now but has also a serious social issue through the ages. It is a serious topic for those who have lost a loved one and also for personnel working in suicide prevention. Suicide is estimated to account for approximately 1.3% of all deaths worldwide, and most of those (77%) occurred in low- and middle-income countries (1). In general, the global suicide rates (SRs) tended to decline, but the problem of suicide among the elderly has been highlighted with the aging population. Indeed, the SRs among the elderly remain the highest in comparison those in other age groups (2). Studies from the different countries have found that the risk of suicide may increase with age (2–4), particularly among males (5). Globally, SRs among the elderly were approximately 16.17/100,000 among people ages 50–69 and 27.45/100,000 among people over the age of 70 in 2017 (6). The threshold of being elderly is commonly defined as \geq the age of 65 (7). The problem of suicide among the elderly is a complex social problem, rather than a mere biological issue, that is influenced by a battery of social factors, such as allocation of social resources, social welfare policy, education, religion, cultural tradition, medical care, and family ties. Males

over the age of 80 in particular are more likely to commit suicide because they are prone to have more physical and mental problems (8). Curtin *et al.* reported that the SRs in the US increased in 2021 (9), which might be attributed to the impact of the COVID-19 pandemic (10). In light of a study by De Leo, elderly in high-income countries enjoy good health as well as a satisfactory social existence like younger people do, whereas the situation is quite different in low- and middle-income countries: the elderly seems to be excluded from active social participation (7). Accordingly, closer attention should be paid to the problem of suicide among the elderly in low- and middle-income countries, where SRs are deemed to be an important index.

The trends in suicide in China are in line with global trends. In general, SRs in China also tended to decline among all age groups (11), including the elderly population, males and females, and people living in a rural or urban area (12). The crude SR among males and females living in a rural area dropped from 15.24 to 9.58 and 15.40 to 7.16 per 100,000 people, respectively, from 2002 to 2015. SRs among males and females living in an urban area dropped from 13.16 to 5.85 and 12.40 to 4.27 per 100,000 people, respectively (11). This can reasonably be interpreted as the benefits of better

social welfare, better medical care, *etc.* as a result of urbanization due to economic growth in China. Previous studies reported marked sex differences in SRs in China (11,13-15). The most marked change was a rapid decline in the SR among women living in a rural area. Women, and particularly young women living in a rural area, reportedly had three major risks of suicide in the past, namely subordination in the family, conflicts, and the availability of pesticides (13). Hou *et al.* contended that the young women living in a rural area previously had a high SR because of many complex reasons such as stress, concepts of traditional culture (traditional gender roles according to Confucianism, humiliation, or shame), and family conflict (14). Suicide might be a way to deal against these factors (11). However, this situation changed with social development. Females in China were granted more opportunities, a higher income, and a higher status, which might be the main reasons for the decline in the SR. In addition, timely intervention in psychological strain may play a role in this decline (15). Nevertheless, SRs, and particularly those among the elderly, might sometimes fluctuate due to complex changes in social factors, *e.g.*, urbanization might act as a double-edged sword in influencing SRs (13). On the one hand, urbanization can bring better social services, while it can also bring stress and a heavier financial burden, easily affecting the elderly. Second, suicide among the elderly is also a noteworthy social problem in China. The elderly accounted for approximately 24% of all suicides before the 1980s in China (16). Nonetheless, after 2000s, their proportion dramatically increased to 79.19% (16). SRs among the elderly are highest in China and are approximately five times higher than the SRs among younger people (17). A recent study investigated the SRs among the elderly in China in 2003, 2008, 2013, and 2018 using an annual percentage change (APC) model. The results were highly complex: *i*) the risk of suicide also increased with age among the elderly living in a rural or urban area, *ii*) there were great fluctuations in both rural and urban areas during the years in question and in both males and females. The SR among the elderly living in an urban area was greater than that among less elderly living in a rural area (\leq the age of 70); however, the trend was reversed among the older elderly ($>$ the age of 74, those living in a rural area $>$ those living in an urban area) (3). The aforementioned studies provided limited information on the changes in SRs among the elderly in China since it only investigated four time points.

Based on previous studies (3,11) and findings, trends in SRs need to be stratified by sex, age, and region. Moreover, analyses over a relatively long period, involving the impacts of several important events such as outbreak of SARS in 2003, the economic crisis in 2008, as well as the potential impact of the COVID-19 epidemic, are helpful to gain a better understanding of the trends in SRs in China. Accordingly, the current

study investigated the trends in SRs among Chinese elderly stratified by sex, age, and region using a joinpoint regression model often used to study SRs (18). In order to perform a comprehensive analysis, data were collected from 2002 to 2020. A more rigorous analysis was attempted to provide more detailed information regarding the trends in and the *status quo* of suicide among the elderly in China. The findings from study may help to gain a more comprehensive understanding, which is important for suicide prevention in the future.

Materials and Methods

Data collection

To analyze the potential impact of SARS in 2003, annual data on SRs from 2002 to 2020 (at the initiation of this study, data until 2020 were available) were collected from the China's Health Statistics Yearbook (CHSYB), which is based on the authoritative Ministry of Health Vital Registration (MOH-VR) System. Data in this MOH-VR system are deemed to be official Chinese data that are routinely submitted to the WHO (11). Data on SRs are officially stratified by sex, age, and region. Region is divided into urban and rural areas as per the official definition. Briefly, cities are urban while counties and towns are rural (11). In this study, only data on elderly were included. Here, "elderly" were defined as "people \geq the age of 65" in line with the CHSYB as well as several previous analogous studies (13,17,19). Age was grouped as ages 65–69, ages 70–74, ages 75–79, ages 80–84, and \geq the age of 85. Four stratified groups, namely males living in a rural area, females living in a rural area, males living in an urban area, and females living in an urban area, were created.

Statistical analysis

SR data were standardized using the Segi's World Standard Population (20). The age-adjusted SRs of the four groups were calculated. SRs in this study were specified as per 100,000 people per year. The probability of a type I error was maintained at 0.05.

The Poisson approximation method was used to calculate the age-specified standard error (21). Joinpoint regression analysis (Joinpoint Regression Program, Version 4.5.0.1) (22) was used to identify the changes in SRs. After performing a grid search, a permutation test, and using the Bayesian information criterion, the best-fitting combination of segments and joinpoints can be identified (23). Once the joinpoint was identified, the trend line was then divided into several segments with different slopes by joinpoint, indicating significant changes in the slope. In light of statistical criteria in the joinpoint model, the SRs are assumed to vary at a constant percentage at an estimated time and frequency. Therefore, the APC was calculated to characterize trends

in rates over time. The default value for the maximum number of joinpoints depends on the number of data points. In this study, the minimum number of points was set at 0, and the maximum number of joinpoints was set at 3 based on the grid search method (24). Likewise, the average annual percentage change (AAPC) was calculated as a weighted average of the APCs over a period including several years, which may summarize the trend over a pre-specified period. If the trend is unchanged, APC should be equal to AAPC.

Results

Figure 1 shows the crude SRs among Chinese elderly from 2002 to 2020. Figure 1A shows the trends in SRs stratified by age for these people. Broadly, the SRs in five groups from 2002 to 2020 tended to decline even though there were fluctuations in certain years. For example, there were marked increases in 2004–2005 and 2008–2010 among all groups, along with slight increase in 2006–2007 among all groups and in 2019–2020 among people ages 65–69, ages 70–74, ages 75–79, and ages 80–84. A point worth noting is that in 2008–2010, several groups (ages 80–84 and over the age of 85) exhibited a markedly higher SR (Figure 1A). Figure 1B shows the trends in SRs stratified by region and sex. Overall, the SRs were highest for males living in a rural area > females living in a rural area > males living in an urban area > females living in an urban area. Likewise, SRs tended to broadly decline for all groups from 2002 to 2020, though there were certain fluctuations particularly from 2002 to 2010. The crude SRs were 509.13 to 209.7

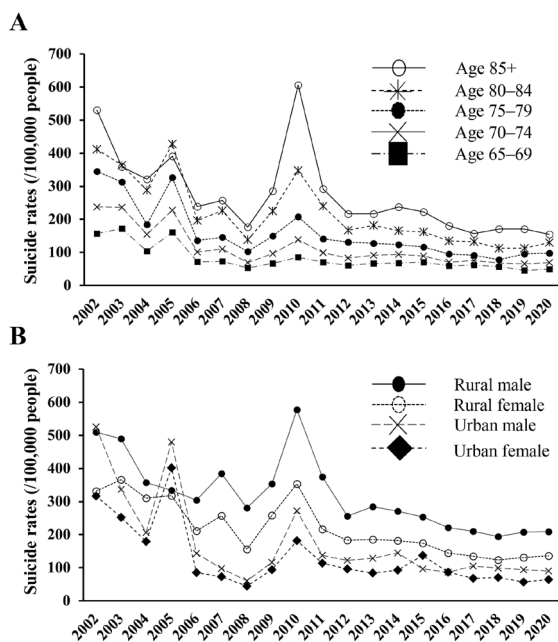


Figure 1. The crude suicide rates among Chinese elderly from 2002–2020. (A) Suicide rates among Chinese elderly stratified by age; **(B)** Suicide rates among Chinese elderly stratified by region and sex.

among males living in a rural area, 331.46 to 136.66 among females living in a rural area, 525.91 to 90.39 among males living in an urban area, and 316.78 to 65.08 among females living in an urban area (per 100,000 people, 2002 vs. 2020). The highest reduction was among males living in an urban area (82.81%), whereas the lowest was among females living in a rural area (58.77%) (Figure 1B).

Figure 2 and Table 1 show the trends in standardized SRs among Chinese elderly stratified by age, region, and sex analyzed using a joinpoint regression model. A joinpoint was identified for only two groups, namely males over the age of 85 and those ages 65–69 living in a rural area. Three joinpoints were identified for males over the age of 85 living in a rural area; the trend line was divided into four linear segments (periods) with different slopes. The first period was 2002–2006, when the SR decreased 12.5%. The second period was 2006–2010, when the SR markedly increased (32.8% annual change), followed by a sharp decrease in the third period (2010–2013, 28.5% annual decrease). There was a gradual decline in the fourth period (2013–2020, 3.2% annual decrease). Nonetheless, the AAPC for this group was the lowest among all groups (3.5% average annual decrease). One joinpoint was identified for males ages 65–69 living in a rural area; the trend line was divided into two linear segments (periods). The first period was 2002–2006, when a sharp decline was evident (14.5% annual decrease). The second period was from 2006 to 2020, when a gradual decline occurred (3.2% annual decrease). No joinpoints were identified for the other groups (Figure 2). The data on APCs (equal to AAPCs) shown in Table 1 suggest that the greatest decline in the SR was 10.8% among males ages 75–79 living in an urban area, whereas the slightest decline was only 5.0% among females ages 80–84 living in a rural area (Table 1).

Discussion

The current study analyzed the trends in SRs among the elderly from 2002 to 2020 stratified by sex, age, and region using a conventional joinpoint regression model. Overall, SRs in both sexes and all age groups and regions have tended to decline, although there were certain fluctuations. *i)* Data suggested that the SR among older elderly was higher than that among younger elderly, namely the age of 85 > ages 80–84 > ages 75–79 > ages 70–74 > ages 65–69 (Figure 1A). *ii)* The SR among males was greater than that among females in the same region overall, particularly after 2006, namely males > females. *iii)* The SR among people living in a rural area was greater than that among people living in an urban area, namely people living in a rural area > people living in an urban area (Figure 2B). The joinpoint regression model revealed joinpoints only for males over the age of 85 and ages 65–69 living in a rural area, whereas no joinpoints were identified for

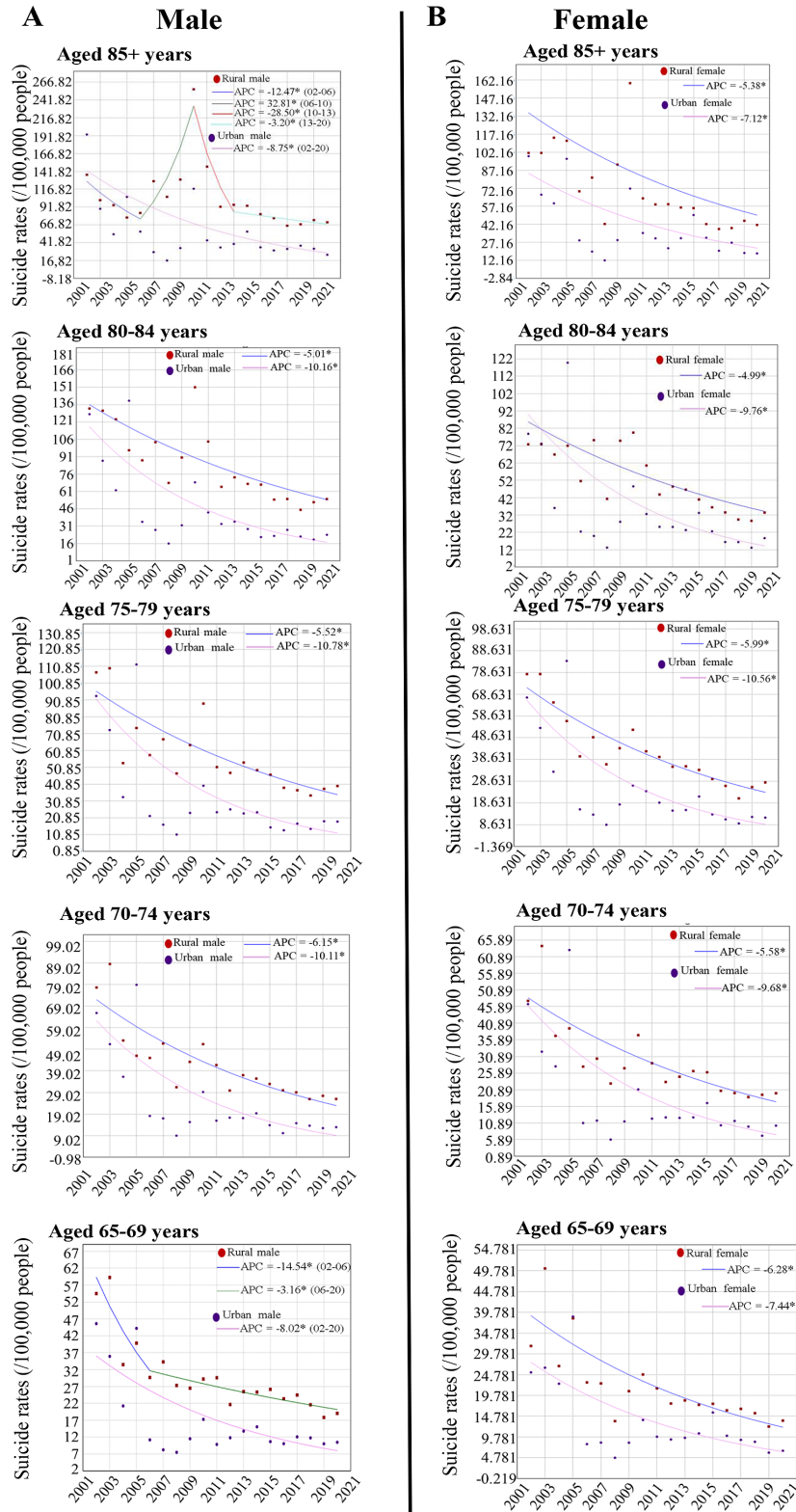


Figure 2. Standardized suicide rates stratified by age, region, and sex in Chinese elderly (over the age of 65) from 2002–2020, with line segments from joinpoint regression models. (A) Data on males: Three joinpoints were identified for males over the age of 85 living in a rural area, and one joinpoint was identified for males ages 65–69 living in a rural area; (B) Data on females. No joinpoints were identified.

the other groups (Figure 2 and Table 1). These results indicated that the trends in SRs among males living in a rural area were easily influenced by external factors. To the extent known, this is the first study using SR data

over 19 years and focusing on the problem of suicide among the elderly in China. These findings could help to better understand the trends in and the *status quo* of the problem of suicide among the elderly in China and

Table 1. Joinpoint regression analysis of trends in suicide rates among Chinese elderly stratified by region and sex (per 100,000 people age 65 and over from 2002-2020)

Group Age	Segment 1			Segment 1			Segment 1			Entire range		
	Period	APC (95% CI)	Period	APC (95% CI)	Period	APC (95% CI)	Period	APC (95% CI)	Period	APC (95% CI)	APC (95% CI)	
Males living in a rural area												
65-69	2002-2006	-14.5 (-22.1, -6.2)	2006-2020	-3.2 (-5.2, -1.1)	2010-2013	32.8 (18.1, 49.4)	2013-2020	-3.2 (-7.6, 1.4)	2002-2020	-5.8 (-8.1, -3.5)		
70-74	2002-2020	-6.2 (-7.8, -4.5)								-6.2 (-7.8, -4.5)		
75-79	2002-2020	-5.5 (-7.4, -3.6)								-5.5 (-7.4, -3.6)		
80-84	2002-2020	-5.0 (-7.3, -2.6)								-5.0 (-7.3, -2.6)		
85+	2002-2006	-12.5 (-21.3, -2.7)	2006-2010	32.8 (18.1, 49.4)	2010-2013	32.8 (18.1, 49.4)	2013-2020	-3.2 (-7.6, 1.4)	2002-2020	-3.5 (-10.7, -4.3)		
Males living in an urban area												
65-69	2002-2020	-8.0 (-10.8, -5.2)								-8.0 (-10.8, -5.2)		
70-74	2002-2020	-10.1 (-13.4, -6.7)								-10.1 (-13.4, -6.7)		
75-79	2002-2020	-10.8 (-14.3, -7.1)								-10.8 (-14.3, -7.1)		
80-84	2002-2020	-10.2 (-13.5, -6.7)								-10.2 (-13.5, -6.7)		
85+	2002-2020	-8.8 (-12.4, -4.9)								-8.8 (-12.4, -4.9)		
Females living in a rural area												
65-69	2002-2020	-6.3 (-8.1, -4.4)								-6.3 (-8.1, -4.4)		
70-74	2002-2020	-5.6 (-7.2, -3.9)								-5.6 (-7.2, -3.9)		
75-79	2002-2020	-6.0 (-7.2, -4.8)								-6.0 (-7.2, -4.8)		
80-84	2002-2020	-5.0 (-7.0, -2.9)								-5.0 (-7.0, -2.9)		
85+	2002-2020	-5.4 (-9.3, -1.3)								-5.4 (-9.3, -1.3)		
Females living in an urban area												
65-69	2002-2020	-7.4 (-10.6, -4.2)								-7.4 (-10.6, -4.2)		
70-74	2002-2020	-9.7 (-13.2, -6.0)								-9.7 (-13.2, -6.0)		
75-79	2002-2020	-10.6 (-14.0, -7.0)								-10.6 (-14.0, -7.0)		
80-84	2002-2020	-9.8 (-13.4, -5.9)								-9.8 (-13.4, -5.9)		
85+	2002-2020	-7.1 (-10.5, -3.6)								-7.1 (-10.5, -3.6)		

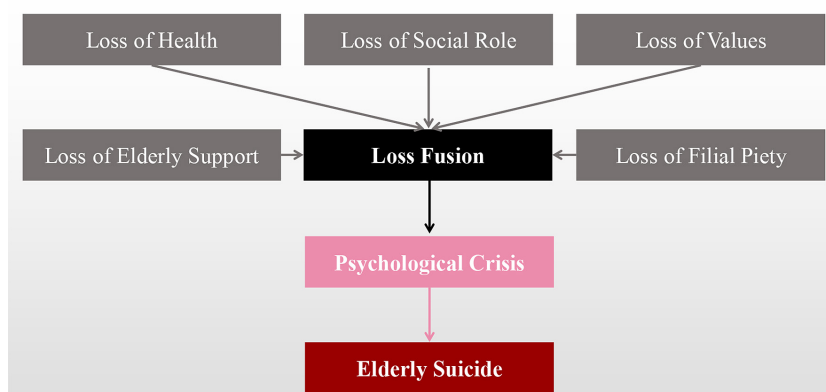


Figure 3. Diagram of the loss theory. Loss theory might be a plausible interpretation for suicide among the elderly. Loss of health, loss of one's social role, and loss of values can be considered personal loss, whereas loss of support and loss of filial piety can be considered social loss. Both personal loss and social loss comprehensively contribute to a psychological crisis in certain older individuals, resulting in self-abandonment and potentially leading to the worst outcome, namely suicide.

to make policy and devise measures to prevent suicide.

Interpretations

Overall trends

Suicide is a social problem rather than a pure biological/medical issue. Suicide is presumably influenced by many complicated social-biological factors, so investigation of the trends in SRs is a powerful tool. The overall downward trend in SRs in China since 2002 is in line with trends in countries such as Russia, Eastern European countries, and Japan (18) but differs from countries with rising SRs such as South Korea (2), the US, and the Philippines (18). The long-term decline in SRs in China is generally acknowledged to potentially be due to economic development (25) and urbanization (13), which mean better healthcare, insurance, pension systems, a more healthy lifestyle, etc. There were several fluctuations from 2002 to 2020. The most noticeable increase was in 2009–2010 and was noted among almost all ages (Figure 1A), both sexes, and all regions (Figure 1B). This short-lived rise was also noted in other countries, such as Greece, the Netherlands, and United Kingdom (26) and might be attributed to the global 2008 financial crisis, that is referred to as "a whole crisis effect" (18). The current data are the first to reveal such a "crisis effect" in China, which indicates that China is greatly affected by and part of "globalization". Another marked rise in 2004–2005 was not reported in the other countries. This increase might be attributed to the 2003 SARS epidemic that mainly affected China. A study from Hong Kong found that the SARS epidemic was associated with an increased SR among elderly females but not males or younger populations, which might be a result of a breakdown of social networks and limited access to health care (27). A slight rise was noted in 2019–2020, which might be associated with the advent of the COVID-19 pandemic. Unfortunately, at the point the current study was conducted, data on SRs in 2021, 2022, and 2023 in China were not available, thereby hampering

further investigation of the influence of COVID-19, which will be included in a future study. Another slight rise was noted in 2006–2007, but a reasonable reason for this slight rise has yet to be found.

Old vs. Young

The current results indicated that SRs increased with age, which is in line with a previous study in China (11) and in the other countries (8). Li *et al.* attempted to explain this phenomenon with a "loss theory" (Figure 3). In light of this theory, aging is a social/physiological process, namely gradual but continuous loss of life resources including health, one's social role, and support. One can easily imagine how such social problems as well as physiological frailty (28) are increasingly aggravated with increasing age, resulting in a psychological crisis and ultimately potentially leading to suicide.

Male vs. Female

SRs were higher among males than females, which is in accordance with global trends, namely male SRs are over double those of female rates (29). One plausible interpretation is that older males in China usually have a heavier social/family burden and are easily affected by the sense of loss due to frailty as per Chinese cultural tradition. Moreover, analysis of standardized SRs with a joinpoint regression model identified joinpoints only for males living in a rural area, namely those ages 65–69 and those over the age of 85. These findings seem to imply that males are more "sensitive" to the influence of negative stimuli. Chang *et al.* found that SRs among males increased markedly due to the 2008 economic crisis (26). Kim *et al.* reported that SRs among males were rising markedly. All of these findings seem to imply that men are more sensitive to postretirement economic hardship (2). However, a study in Hong Kong yielded the reverse conclusion. Chan *et al.* found that the SARS epidemic in 2003 only increased suicide by older women; the SR among males was unchanged (27). Indeed, the social roles of males and females are

quite different among regions, due to differences in sex-related social recognition, cultural traditions, and economic roles. In this regard, the impact of suicide might be heterogeneous among different regions. The current data precluded an interpretation of crude trends in SRs among males and females from 2002–2006 and the crossover between males and females living in an urban area in 2015–2016, which are believed to be associated with the complex social and economic conditions at that time. A previous study in China also reported the existence of a reverse gap in 2006 (11). The study contended that improvement in the social status of women with social development in China might have contributed to a decrease in the SR among females (11). Accordingly, investigation of the sex differences in suicide should fully consider complicated sociopsychological factors, such as social status, culture, and incomes in the region.

Living in a rural area vs. living in an urban area

The current results suggested that people living in a rural area have a markedly higher SR than those living in an urban area, which may be due to the notable differences between urban and rural areas in China. Overall, older individuals living in an urban area are usually in a relatively better financial situation, have extensive insurance coverage, and have better access to medical care/care services in comparison to elderly individuals living in a rural area. Moreover, due to urbanization, many young people swarm into the city to make a living, and the older individuals left behind (elderly family members live in a rural area while the young family members live in an urban area) usually have to face loneliness and a lack of care. All these factors comprehensively influence the living conditions of the elderly in rural areas. Accordingly, the finding that elderly living in a rural area have a higher SR than elderly living in an urban area is plausible.

Strengths and Limitations

The current study had several strengths. First, continuous annual SR data were collected, allowing an analysis of trends annually. The influence of SARS (2003), the economic crisis (2008) and the potential influence of COVID-19 were evident. Second, data were stratified by age, region, and sex, and standardized SRs were calculated and analyzed using a conventional joinpoint regression model. Results revealed that males ages 65–69 and over the age of 85 living in a rural area were quite sensitive to negative impacts, necessitating closer attention.

Nonetheless, this study had several limitations. First, SR data were collected but other associated data such as financial data, data on medical care, and data on health insurance were not collected. This precluded a deeper investigation of the root causes of suicide, which are

also important for suicide prevention. Second, SR data could not be obtained 2022 and 2023, so the impacts of COVID-19 on suicide could not be identified. All of these issues will be addressed in future research.

Measures based on the current findings and prospects for the future

Suicide is a global problem. Finding factors in which to intervene and then devising/implementing measures to intervene in these factors are the main tasks of suicide prevention. In light of the current findings, several measures have been proposed: Overall, the economic/mental problems of the elderly, and particularly males and those who are living in a rural area (and especially elderly family members who have been "left behind") are highly concerning. Better medical/psychological care should be instituted to provide timely medical/psychological intervention. Community- or family-based support should be advocated. Mood disorders, like depression and anxiety, should be promptly identified and dealt with. The current data indicated that males ages 65–69 and over the age of 85 living in a rural area were quite sensitive to negative impacts, which means both family members and social workers should pay attention to elderly individuals in these age groups and alleviate the negative influences on these people to the extent possible. In addition, according to a previous study indicating that educational campaigns might play a role in suicide prevention (2), community-based health education campaigns, should be conducted along with cultural campaigns. This may improve the knowledge of, awareness of, and responses to suicide and make people's lives more fulfilling, thereby improving their well-being and ultimately reducing suicide.

Conclusions

Overall, SRs among the elderly in China tended to decline from 2002 to 2020. Several fluctuations were noted, such as in 2004–2005 due to the SARS epidemic, in 2009–2010 due to the economic crisis, and in 2019–2020 potentially due to the COVID-19 pandemic. The overall trends in SRs were males > females, and people living in a rural area > people living in an urban area. Joinpoint regression analysis revealed joinpoints for males ages 65–69 and over the age of 85 living in a rural area, suggesting that these populations are potentially more sensitive to negative stimuli and thus require closer attention. The findings from this study could help with suicide prevention in the future.

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