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Trends of suicide rates by gender and residence in China from 2002 to 2019

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ABSTRACT

Objective: China has undergone tremendous social changes in the last few decades. This study aimed to research the trends of the suicide rates from 2002 to 2019, and to differentiate effects attributable to age, period, and cohort by gender and residence in China.

Methods: Suicide mortality data were obtained from China's Ministry of Health Vital Registration System. Joinpoint regression model was used to estimate the average annual percentage change (AAPC) of the suicide rates and ratios by gender and residence. The age-period-cohort framework was performed to analyze the underlying mechanisms for suicide mortality trends.

Results: Over the observation period, the significant decrease in suicide mortality rates in China for the economic development and urbanization was observed but to different degrees across gender and regional subgroups. The male-to-female ratio of suicide rates increased year by year (AAPC: 1.9%, 95% CI: 0.2% to 3.7%) while the urban-rural ratio changed little (AAPC: 0.9%, 95% CI: −1.8% to 3.7%). The age-period-cohort analysis revealed a marked increased effect of age and overall decreased effect of both period and cohort on suicide mortality rates. However, the recent cohort has presented an inversely increasing effect.

Conclusion: The suicide rate has fallen sharply in China which has undergone tremendous socioeconomic changes. The varied changes in the suicide rate of different residence-, gender-, and age-groups as well as the age, period, and cohort effect on suicide risk further indicate the relationship of development and the suicide rates may be neither static nor identical on different subgroups in a rapidly changing society.

1. Introduction

Suicide is an important public health problem in the world. The world health organization (WHO) reports that an annual global crude suicide mortality rate is nearly 10.6 per 100,000 population, and 79% of suicide deaths occur in low- and middle-income countries in 2016 (WHO, 2016).

According to reports, from the 1990s to the 2000s, China was considered one of the countries with the highest suicide mortality rate in the world (Yip et al., 2008). In China, the suicide rate of women was significantly higher than that of men and differences between rural and urban areas are nearly the three-fold (Phillips et al., 2002). In contrast, in Western countries, the male-to-female ratio is frequently greater than 3:1 and there was no large discrepancy between rural and urban suicide rates. Thus, the unique suicide pattern of China raised many concerns (Yip et al., 2005). In recent years, the suicide mortality rate in China has dropped significantly, and suicide patterns have also undergone an epidemiological transition (Shao et al., 2016; Xu et al., 2016). Previous studies reported that the suicide mortality rate has been reduced to one of the lowest in the world in the years 2009–2011 (Wang et al., 2014) and the change in the disparity between males and females as well as that of rural and urban areas in suicide mortality has also been observed (Jiang et al., 2018).

The main explanations for the change in suicide rate were the significant development of the economy and the acceleration of urbanization (Wang et al., 2020; Ying & Chang, 2009; Zhang et al., 2010). This benefit of the growth of economy and urbanization seems against the theory of Durkheimianism, in which economic booms involving greater social change and urbanization, would erode social integration and social control thus leading to a higher suicide rate (Miley & Micklin, 1972). It suggests that the direction of influence on suicide rates may be different throughout the process of economic development. Moreover, a

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previous study showed that the impact of socioeconomic determinants differed between the genders in transforming China (Cai et al., 2022).

Given the possible disparity of correlation between suicide rate and social-economic factors among subgroups, recent changes in the trends of suicide rate in varied residences, genders, and age groups in China from 2002 to 2019 may manifest differently, which still needs further comprehensive exploration. Additionally, the latest changes in suicide patterns, i.e., the male-to-female and the rural-to-urban ratio of suicide rates in different age groups following varied changes in suicide rates for subgroups are also devoid of study. Furthermore, different age groups and cohorts may also exhibit different effects on suicide risks, but this problem has not yet been fully understood (Chen et al., 2019; Wang et al., 2016).

Thus, this article is dedicated to researching: 1) the varied changes for different residence-, gender-, and age-groups in the trends of suicide mortality rates in China over the observation period 2002 - 2019; 2) the latest changes in the rural-urban as well as the male-female ratios in different age groups; and 3) the effect of age, period and cohort on the suicide mortality through age-period-cohort analysis. We hope that the varied changes that possibly have occurred in the suicide rate of different subgroups could further provide possible reasons for suicide rates at the macro-level, especially in China where the change of suicide rates during the transformation period was not in line with Durkheimianism. We also hope the exploration of the age, period, and cohort effect during this period could advance the understanding of suicide risk and provide a basis for suicide prevention and control in China and other countries or regions undergoing similar social changes.

2. Materials and methods

2.1. Data sources

Annual suicide mortality data from 2002 to 2019 was extracted from China's Health Statistical yearbooks (named "China's Health and Family Planning Statistical Yearbook" in 2013–2016) (NHFPC, 2003-2020) based on China's Ministry of Health Vital Registration (MOH-VR) System and was the official figure submitted to the WHO. The MOH-VR is the largest regular nationwide monitoring system of causes of death, samples of which initially accounted for about 8% of the population of China in 2002, and had been expanded to cover 17% of the total population including 319 monitoring points by 2012 (Liu et al., 2016). In 2017, it included 154 districts and 355 counties or county-level cities (these three are administratively equal) (NHFPC, 2018). The data is based on death certificates, which are completed by clinical doctors in the hospital then submitted to the municipal, provincial, and national departments of health. The ICD-10 (the 10th version of the International Statistical Classification of Diseases and Related Health Problems) was adopted and the mortality rates of suicide were stratified by gender, age group (0–1, 1–84 in 5-year intervals and 85+ years), and area (urban or rural). For the pretty low mortality in the young age group (0–14) and open-ended data in the oldest group (>85), 15–84 age group were studied in this study. Age-adjusted incidence rates were calculated using a direct standardization method with the Chinese sixth population census as the standard population (NBS, 2011).

2.2. Data analysis

We used the Joinpoint Regression Model (JRM), which usually be used to study the trend of the change of rates (Park et al., 2016) and ratios (Sun et al., 2020), to analyze and calculate the annual percent change (APC) and average annual percentage change (AAPC) of suicide mortality and suicide rates ratio by each sex, residence and age group. To clarify the changes and compare age patterns of annual suicide rates, all ages were truncated into three age groups (15–34, 35 to 59, and 60–84 years). JRM, also known as the segmented regression model, is a statistical method that can check whether the trend of the rate has changed significantly (Park et al., 2016). The basic idea of JRM is to explore the number of connection points by calculating the sum of the residual error squares between the fitted value and the true value, and use model fitting to divide a long-term trend line into several trend sections. The connecting points of different trend segments are called joinpoints. The professional tool software Joinpoint 4.9.0.0 was used to conduct the analysis in the present study.

We further performed an Age-Period-Cohort model (APC model) to investigate the estimated effect of age, period, and cohort on suicide mortality, in which the 'intrinsic estimator' method was used to deal with the collinearity problem (cohort = period – age) (Sun et al., 2019). Single-year points (2003, 2008, 2013, and 2018) were used to represent each five 5-year calendar period (2000–2004, 2005–2009, 2010–2014, 2015–2019) to avoid the problem of overlapping birth cohorts (Chen et al., 2019). The APC model is a helpful tool enabling researchers to gain insight into the pure effect of age, period and cohort. The age effects represent a differing risk of age on the suicide rate; the period effects represent changes in the suicide rate over time; the cohort effects represent the variations in suicide risk across groups of individuals who were born in different years.

3. Results

3.1. Crude suicide rates

With regard to gender and area, the suicide rates were greatest for males in rural areas, followed by females in rural areas, males in urban areas and females in urban areas. Suicide rate in China has fallen sharply since 2002. The crude suicide rates of urban-male and urban-female decreased from 13.16 and 12.4 in 2002 to 5.02 and 3.27 in 2019 respectively (per 100,000). Similarly, that of the rural-male and rural-female decreased from 15.24 and 15.4 in 2002 to 8.17 and 5.88 in 2019 respectively (per 100,000).

3.2. The residence-, gender- and age-specific suicide rates

Joinpoint regression analysis results shown that all of the residence-, gender- and age-specific subgroups can witness a statistically significant decline in suicide rate between 2002 and 2019 and most of them are defined as two segments with the joinpoint around 2006. Factors such as socioeconomic transformations may be the reasons for the declines. Among all subgroups, females aged 15–59 years, especially those in rural areas, experienced large reduction of proportion in rates (AAPC for rural 15–34 age group: −8.8%, 95% CI: −10.8% to −6.9%; for rural 35–59 age group: −9.2%, 95% CI: −11.5% to −6.8%). In contrast, the unique upward trend among all subgroups with an APC of 1.9% (95% CI: 1.0%–2.9%) in 15–34 rural males was observed from 2005 to 2019. A similar increase can also be observed in 15–34 urban males with an APC of 1.9% (95% CI: −0.7%–4.7%), though not statistically significant (Table 1). Residence- and gender-specific trends in age-standardized suicide rates and by age groups are provided in Supplementary Fig. 1. Total trends of suicide rates for residence and gender and by age groups are provided in Supplementary Table 1.

3.3. Trends in suicide rate ratio

The male-to-female (M/F) ratios of suicide rates increased significantly from 2002 to 2019 (AAPC of the M/F ratios of all ages: 1.9%, 95% CI: 0.2%–3.7%), exceeding 1 from 2006 onwards further risen to 1.56 now. When stratified by age groups, a regularly stable increase in M/F ratios of suicide rates can be seen in groups aged less than 60 years, especially the figure for 15–34, increasing by 6.0% per year, which is greater than 3.5% per year in middle age group. As to the rural-to-urban (R/U) ratios of suicide rates, it mostly varied between 1.5 and 2.5 and AAPC of all ages is statistically insignificant (AAPC: 0.9%, 95% CI: −1.8% to 3.7%) (Table 2). Age-specific trends in M/F ratios and R/U

Table 1
joinpoint regression analysis of the residence-, gender-, and age-specific suicide rates (per 100,000), China, 2002–2019

Groups	Trend 1		Trend 2		AAPC (95%CI)
	Period	APC (95% CI)	Period	APC (95% CI)	
Urban-Male					
All ages	2002–2007	−19.8 (-32.3, −5.1)	2007–2019	**−1.0 (-5.3, 3.5)**	−7.0 (-11.8, −1.8)
15–34	2002–2008	−13.0 (-18.6, −7.0)	2008–2019	**1.9 (-0.7, 4.7)**	−3.6 (-6.1, −1.0)
35–59	2002–2007	−16.1 (-23.9, −7.6)	2007–2019	**−1.1 (-4.9, 2.8)**	−6.7 (-10.2, −3.0)
60–84	2002–2019	−6.9 (-10.8, −2.8)			−6.9 (-10.8, −2.8)
Urban-Female					
All ages	2002–2007	−22.7 (-36.0, −6.6)	2007–2019	**−2.7 (-7.4, 2.3)**	−9.0 (-14.3, −3.4)
15–34	2002–2008	−18.3 (-27.4, −8.0)	2008–2019	**−2.3 (-6.8, 2.5)**	−8.3 (-12.5, −3.8)
35–59	2002–2007	−20.7 (-29.0, −11.4)	2007–2019	**−2.3 (-6.5, 2.1)**	−9.2 (-13.2, −5.1)
60–84	2002–2019	−7.4 (-11.3, −3.3)			−7.4 (-11.3, −3.3)
Rural-Male					
All ages	2002–2004	−22.5 (-38.5, −2.3)	2004–2019	−3.3 (-4.2, −2.3)	−5.8 (-8.2, −3.3)
15–34	2002–2005	−22.7 (-29.8, −14.8)	2005–2019	1.9 (1.0, 2.9)	−2.9 (-4.6, −1.3)
35–59	2002–2004	−24.5 (-39.6, −5.7)	2004–2019	−3.7 (-4.6, −2.7)	−6.4 (-8.7, −4.0)
60–84	2002–2019	−5.3 (-6.8, −3.9)			−5.3 (-6.8, −3.9)
Rural-Female					
All ages	2002–2006	−15.2 (-21.2, −8.7)	2006–2019	−5.5 (-6.6, −4.3)	−7.8 (-9.5, −6.2)
15–34	2002–2006	−21.2 (-27.9, −14.0)	2006–2019	−4.6 (-6.0, −3.2)	−8.8 (-10.8, −6.9)
35–59	2002–2006	−17.8 (-26.0, −8.6)	2006–2019	−6.4 (-8.0, −4.7)	−9.2 (-11.5, −6.8)
60–84	2002–2019	−5.5 (-6.8, −4.2)			−5.5 (-6.8, −4.2)

Note. Statistically insignificant values are indicated in bold; AAPC: the average annual percentage change, APC: the average annual percentage change, CI: confidence interval.

ratios of suicide rates are shown in Supplementary Fig. 2.

3.4. Age period and cohort effect

The y-axis of the age-period-cohort model shows the relative risk (RR) of each particular age, period, or birth cohort relative to the mean effect of all combined ages, periods, or cohorts (Fig. 1). Overall, the curves of age effect of suicide mortality rates displayed an upward pattern and almost overlapped between urban and rural areas for both genders. A substantial increase from 60 years old can be observed, and there is a small peak in the middle adulthood age group around 50 (more dominant in males). Regarding period effects, an obvious decline from 2000–2004 to 2005–20094 in each stratified group by gender and area

Table 2
joinpoint regression analysis of the R/U ratio and M/F ratio of suicide rates (per 100,000) by age group, China, 2002–2019

Age Groups	R/U ratio		M/F ratio	
	Period	APC (95%CI)	Period	APC (95%CI)
All ages	2002–2019	**0.9 (-1.8, 3.7)**	2002–2004	**−8.4 (-16.3, 0.2)**
	–	-	2004–2007	9.5 (0.1, 19.8)
	–	-	2007–2019	1.9 (1.3, 2.4)
15–34	2002–2019	**0.8 (-1.2, 2.8)**	2002–2019	6.0 (5.0, 6.9)
35–59	2002–2019	**0.5 (-2.0, 3.1)**	2002–2019	3.5 (2.7, 4.3)
60–84	2002–2019	**1.5 (-2.1, 5.2)**	2002–2019	**0.3 (-0.4, 0.9)**

Note. Statistically insignificant values are indicated in bold; R/U: rural-to-urban, M/F: male-to-female, APC: the average annual percentage change, CI: confidence interval.

can be found, though the downward trend is more moderate in recent years, especially in rural areas. The cohort effect weakened over time and can be divided into three segments in general, albeit existing some gender differences: (1) during 1920–1960; (2) during 1960–1980; and (3) during 1980–2000. Moreover, the cohort effect for females shows overall fluctuations with a rapidly declining segment during 1960–1980, followed by a stable trend after 1980, and it for males shows a continued downward trend in the first two segments, but the decrement slowed down even reverse from 1980.

4. Discussion

This study explored the trend of suicide mortality and ratio for gender and residence in China from 2002 to 2019 through the Joinpoint analysis and investigated age period and cohort effect using the age-period-cohort framework. Downward trend of suicide mortality in different residences, genders, and age groups from 2002 to 2019 in China were shown.

Considering the downward trend and lower suicide mortality rate in urban areas, the rapid development of the social economy and process of urbanization likely have a positive effect on the decline of the suicide rate. It seems to challenge Durkheimianism which indicates the development of the social economy and acceleration of urbanization should increase suicide rates, as development weakens social control over individuals, and disrupts traditional forms of social organization that produce cohesion (Cai et al., 2022). The classic theory about suicide has also been challenged by researches in other countries such as Japan, where urbanization was a major determinant for a decrease in suicide mortality during 1970–1990 and suicide mortality of males was inversely associated with economic development (Otsu et al., 2004).

The present study seems to suggest that Durkheim's contention is less effective in explaining under different social-historical backgrounds or social-cultural settings. It can be explained that many other factors may be stronger than main social integration according to Durkheim's theory in explaining suicide, which is a result of the interplay of plenty of economic and sociological elements (Lester, 2001). These rapid socio-economic changes in transforming China may be associated with improved living standards, better educational and employment opportunities as well as reduced psychological strains, which lead to the decline in suicide rates. Urbanization and modernization also contributed to a reduction of the pesticide misuse problem in farming activities in rural areas, which is an important factor accounting for the high lethality then high mortality of suicide in Chinese rural females (Eddleston & Gunnell, 2006), and therefore the protective effect of urbanization is shown. Additionally, the economic growth and urbanization itself may not solely operationalize the rooted effect of the concept of anomie and erosion of social control, some social indicators-divorce rate or rural-to-urban migrants might manifest the effect better (Li et al., 2016). A study on the out- and in-flow of migrants in rural China indicated that villages with the highest level of out-migrated workers had significantly higher suicide rates when compared to those having

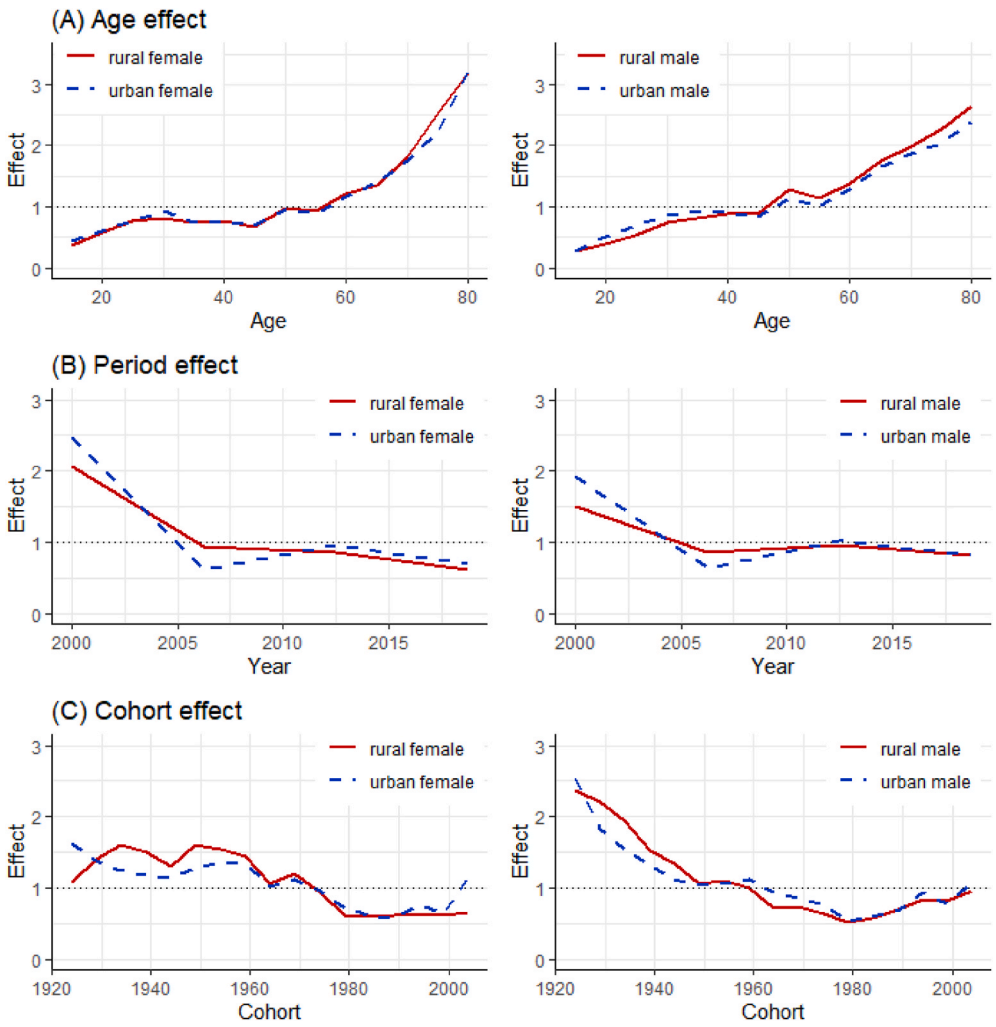

Fig. 1. Age-period-cohort effect on suicide rates, China, 2002–2019.

lower proportions (Li et al., 2016).

Moreover, although economic development and urbanization have contributed to the changes in suicide rates, the effects may be neither static nor identical on different residences- gender- and age-groups over time. The joinpoint regression results which show that the reduction of suicide rates varied in degree among subgroups support it. A significant decrease in suicide rate was found among young and middle-aged females. Factors such as changes in role, higher social status, and the ease of tension in traditional family relationships in recent 20 years play an important role (Zhang et al., 2022). In contrast, our study suggested that the decline in suicide rates of males in the 15–34 age group, especially those in rural areas, has slowly diminished and even reversed from 2005. It is consistent with one previous literature in Zhejiang Province, which similarly revealed that the suicide rate of young men aged 20–34 has increased since 2013. The economic instability and constant pressure of facing unemployment may contribute to this phenomenon (Fei et al., 2019).

The unique pattern that the suicide rate of Chinese women was significantly higher than that of men in the 1990s was changed for the rapid decline in the female suicide rate while slowdown or even increase in the male suicide rate (Fei et al., 2019). Our joinpoint analysis further found that change among older adults contributed little to the increase in the male-to-female suicide ratio. It may suggest that the factors causing the change in the male-to-female ratio did not impact much on the elderly. When compared with other countries, the current male-to-female suicide ratio in China is close to that of middle-income Asian countries and some countries in the Eastern Mediterranean region (Phillips & Cheng, 2012). But it is still far lower than the 3:1 ratio of many high-income Western countries (Hee Ahn et al., 2012) and the 1.75:1 ratio global in 2016 (WHO, 2016). However, another feature of China's suicide rate pointed out by previous research, the gap between suicide rates in rural and urban areas, have remained relatively stable (Weiyuan, 2009). The reason may be that the wealth gap and the discrepancy in the opportunities such as access to jobs, education resources, and health services has not been largely improved. The urban-rural differences in China are similar to those in Australia, Sri Lanka and India (Cutright et al., 2007), but different from those in high-income countries where the urban-rural differences are very small (Phillips & Cheng, 2012).

This study also presents an enhanced understanding of the change in suicide risk using the age period cohort model. In terms of the age effect, two previous studies have discussed the age effect of suicide mortality in the Chinese mainland using the age-period-cohort model but drawn inconsistent results (Chen et al., 2019; Wang et al., 2016). Our finding was approximately similar to one of them that suicide risk generally increased with age (Chen et al., 2019) and opposite another one which reported Chinese people's suicide risk peaks at the 20–24 years within the same birth cohort (Wang et al., 2016). This study indicated that older adults are the population at the highest risk of suicide deaths which might due to poor physical health condition and severe isolation caused by the death of relatives and retirement (Wang et al., 2016). In addition, the age effect pattern also shows a small peak in the suicide

rate among people aged 50–54 years, especially for males. Different social elements might be behind it, though solid explanations and theories have yet to be provided. Whether the small peak will continue in the future is still unclear, and requires further research to delineate the mechanisms behind it.

Time trends based on the period effect, which can be more accurate to show the pure effect of the period than that based on annual rates for the reduced age and cohort effect, also display a falling pattern from 2000 to 2019. However, the downward trend has stabilized or even disappeared since around 2005. It may be due to some changing elements in the environment and economic status (i.e., the global economic recession and an accelerating aging population) impeding the rapid decline of suicide mortality. In addition, the drastic changes in society which promote the decrease in suicide rates also hide potential hazards, such as the negative impact of the problems of left-behind children and the elderly outweigh whatever positive effects the migrations bring on suicide mortality (Li et al., 2016). Furthermore, challenges like rich-poor polarization, less upward mobility than before, and inadequate emphasis on psychological services increasingly emerged, making it less likely to decrease further (Jiang et al., 2018; Wang et al., 2014).

The cohort effect on suicide mortality gradually weakened in both male and female populations during the period 1950–1980, as also has been reported in the United States whites (Yu & Chen, 2020) and Russia (Jukkala et al., 2017), though different from Korea and Japan (Kino et al., 2019). It indicates a decreasing effect of cultural and economic elements inducing higher suicide mortality in a prior cohort in China. The cohort effects for those born after the rapid growth and development since open policy and economic reform were relatively dominantly lower than the cohort born before 1960, a period corresponding to more poor socioeconomic status and unstable social conditions. However, those born after 1985, particularly males, seem more vulnerable to suicide, self-centered personality and limited opportunities for developing resilience may cause the phenomenon (Chen et al., 2019).

To our knowledge, this is the latest comprehensive interpretation of suicide rates and ratios among the different residence, gender, and age groups in China using recent 2002–2019 data. The finding indicates that Durkheimianism is not consistently effective in explaining in different social-historical settings and the association of developments and modernization with the suicide rates may be neither static nor identical in different subgroups. Second, the study firstly applies the joinpoint model to quantitatively examine changes in suicide patterns, the M/F, and the R/U ratios by different age groups, finding change among older adults contributed little to the increase in the M/F suicide ratio. Third, this article presents further research on the inconsistent age pattern in prior studies and finds an increase in suicide risk in the recent cohort from 1980, providing evidence on suicide prevention and control.

There are also some strengths of the data this study used. As China does not have a complete mortality registration system, the data we used was extracted from the MOH-VR system. It is the largest system for the regular surveillance and monitoring of causes of death in China and it provides detailed residence-, gender-, and age-specific mortality rates (Phillips et al., 2002). Another death registration system in China- the Disease Surveillance Points (DSP), though well representative, covers only 1% of the population and may not be suitable for trend analyses for the irregular compilation and publication of the DSP statistics and thus was not used in this study (Yang et al., 2005).

Limitations of this study also need to be noted. First, problems like under-reporting and misclassification are common when suicide rates were extracted from the MOH-VR system, the suicide rates especially in rural areas therefore may be underestimated. However, studies suggest that the results on the trends and patterns of suicide rates are less affected by concerns about underreporting (Yip et al., 2005). Second, though the surveillance points and sampled population were primarily in eastern and central regions before 2013, not representative of China's suicide mortality conditions, it is methodologically acceptable to consider the gender-residence-age-specific suicide rates as unbiased point estimates (Zhong et al., 2016a). Third, China's official definition of rural and urban regions changed, so the same area in China might be classified differently over time, but the surveillance samples are very large, which can be omitted in our analysis (Zhong et al., 2016b).

5. Conclusion

The suicide rate has fallen sharply in China, which has undergone tremendous socioeconomic changes, and seems unlikely to continue to decline in the future. The suicide pattern in China is undergoing the transition from the unique Chinese feature that higher rates in women and rural areas to that more similar to the western pattern. The varied changes in the suicide rate of different residence-, gender-, and age-groups further indicate the relationship between developments at the macro level and the suicide rates may be neither static nor identical on different subgroups in a rapidly changing society. The age, period, and cohort effect on suicide risk provides a basis for suicide prevention and control in China and other countries or regions undergoing similar social changes.

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Author contributions

YH and HY initiated the study. QY, ZH, RL and JP collected the data. YH performed the statistical analysis. YH and JP drafted the manuscript. HY and GZ revised the manuscript. All authors read and approved the final manuscript.

Ethical approval

Ethical approval is not required as the data used is the public data from China's Health Statistical yearbooks.

Availability of data and material

The data sources in the study are available from China's Health Statistical yearbooks which are based on China's Ministry of Health Vital Registration (MOH-VR) System (named " China's Health and Family Planning Statistical Yearbook" in 2013–2016).

Declaration of competing interest

None declared.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2023.101342.

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