

Suicide rates in China from 2002 to 2011: an update

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Received: 31 July 2013 / Accepted: 28 October 2013 / Published online: 16 November 2013
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Abstract

Purposes The aims of this study were: (1) to present the time trend of suicide rate among people aged 15 or above in China over the period 2002–2011 and (2) to examine the current profile of completed suicides during 2009–2011.

Methods Data on suicide rate in 2002–2011 were provided by the Chinese Ministry of Health (MOH). The trends of region-, gender-, and age-specific suicide rates were examined using Poisson regression models. The mean number of completed suicides for each cohort during 2009–2011 was calculated and a mean national suicide rate was estimated.

Findings The overall suicide rate decreased significantly over the past decade, but rates in young males and rural older adults did not reduce and in fact increased among older adults in both urban and rural areas towards the end of the study period. For 2009–2011, 44 % of all suicides occurred among those aged 65 or above and 79 % among rural residents. The estimated mean national suicide rate was 9.8 per 100,000 and was slightly higher for males than females.

Conclusion The benefits of economic growth, such as higher employment and more educational opportunities for the rural population in particular, may have contributed to the reduced suicide rate in China. However, the recent rapid changes in socioeconomic conditions could have increased stress levels and resulted in more suicides, especially among the elderly. Despite the significant reduction reported here, the latest figures suggest the declining trend is reversing. It will be important to continue monitoring the situation and to examine how urbanization and economic changes affect the well-being of 1.3 billion Chinese.

Keywords Suicide rate · Mortality · Time trend · Male-to-female ratio · China

Introduction

Suicide is a major public health issue worldwide, accounting for 780,000 premature deaths in 2008 [1]. Suicide in China, the most populous country in the world at 1.3 billion, has attracted much attention during the past decade. Based on 1990s mortality data, several important features of suicides in China were identified and documented. It was reported that China had one of the highest suicide rates in the world (accounting for about a quarter of all reports worldwide) and that suicide was ranked as the fifth leading cause of death among the general population [2, 3]. It was also documented that suicides in China showed a unique gender difference, with more women than men completing the act in contrast to the approximately 3:1 male–female ratio observed in Western countries. The rate was also substantially higher in rural than urban Chinese communities [3–8]. To date, however, no study has

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examined changes in the national rate and pattern of suicide in China over the last decade of significant and rapid socioeconomic transformation.

Following Durkheim's seminal study of suicide in the late nineteenth century [9], the association between suicide and macro-socioeconomic changes is well understood. Since the early 1980s, China has experienced one of the most astounding and enduring periods of economic growth in the history of humankind, with an average annual per capita gross domestic product (GDP) growth rate of 8.6 % [10]. Such a level of economic achievement has been particularly evident over the last decade. During this period China's nominal GDP surpassed that of France, the United Kingdom, Germany, and Japan, such that since 2009 it has been the second largest economy in the world after the United States [11]. These rapid socioeconomic changes may be associated with substantial shifts in the living conditions and well-being of the population. It is, therefore, important to explore the relationship between these developments and the pattern of suicide in a rapidly changing society, given the important policy implications for suicide prevention in other countries in the region that are undergoing similar changes.

According to one school of thought based on Durkheim's theories, economic growth as epitomized by industrialization, urbanization, and modernization usually leads to higher levels of social anomie and lower levels of social integration as a result of popularized individualism and egoism. This subsequently increases the suicide rate [9]. Some studies find positive relationships between the suicide rate and urbanization [12, 13], modernization [12, 14], and economic growth [15, 16], providing support for this theory. However, such studies are usually based on data from high-income Western countries. On the other hand, other work conducted mainly in Asia or the developing countries shows a negative correlation between the suicide rate and economic growth [17, 18] or urbanization [19], posing a challenge to the Durkheim's theory. Urbanization seems to provide additional employment and educational opportunities, especially in rural regions redesignated as urban as a result of development. These opportunities can serve as protective factors against suicide. Conversely, another school of Durkheimian thought postulates that during economic recession or crises, the suicide rate may increase because of the sudden deterioration in social status some people experience. For instance, recent work indicates a significant rise in suicide in some East and Southeast Asian countries following the 1997–1998 economic crisis [20]. A similar trend has been observed in Europe [21] and the United States [22] and globally [23] following the economic recession of 2008.

Such findings suggest that economic growth is not invariably followed by a decrease in suicide rate for a given

country. Recent studies indicate that the relationship between suicide rate and economic growth as measured by per capita GDP may follow an inverted U-shaped curve, with the downward trend in suicide rate reversed at a certain threshold of economic development [24, 25]. One earlier study examines suicide mortality in China 1987–1994 [6] and later work looks at the same topic 1991–2000 [26]. Both studies suggest a significant decline in the suicide rate for men and women, old and young, and rural and urban populations. With further economic growth having taken place since these studies were conducted, it is unclear whether the suicide rate in China has continued to decline or not.

The first aim of this paper is, therefore, to examine the time trends of suicide rate among those over age 15 in China over a 10-year observation period 2002–2011. The second is to estimate the annual number and rate of suicides and to examine current suicide patterns in China during the last 3 years (2009–2011). We hope that the findings of this study will illustrate the changes that have occurred in China during the first decade of the twenty-first century and provide up-to-date information about the features of suicide in China. It is also interesting to examine whether or not Durkheim's theories remain valid and applicable to the new, modern China.

Methods

Data

Suicide mortalities figures 2002–2011 were estimated based on the China's Ministry of Health Vital Registration (MOH-VR) System, which covers 41 urban areas including large, medium, and small cities and 85 rural areas including towns and villages, and accounts for roughly 8 % of the national population [27]. The data are based on physicians' death certificates, which are submitted to police departments by family members and then forwarded to the municipal, provincial and national departments of health. Families are required to present the death certificate to get permission for cremation or burial [3]. Annual suicide rates were obtained from the Chinese Health Statistics Yearbooks (2003–2012). These data are also provided to the World Health Organization (WHO) as the official mortality figures for China, which include suicide rates by gender for eighteen 5-year age groups for both urban and rural residents (72 cohorts). The gender-merged suicide rates for these 18 age groups by region are also provided (36 cohorts). Several studies have been conducted using MOH-RV data from the 1990s [3, 6, 26]. Thus, using more recent data from the MOH-VR system makes our results more easily comparable to the findings from previous studies.

Although the MOH-VR data were coded using the ninth version of the International Classification of Diseases (ICD-9) in the 1990s and the ICD-10 since 2002, it has no apparent impact on the total number of suicide deaths since there is almost no difference in the coding scheme for suicide between the two versions [20].

Analysis

In this study, the suicide rate is specified per 100,000 persons for each of the age-, gender-, and region-specific groups. Time trends within the study period were calculated with 95 % confidence intervals (CI) for each cohort separately. Linear regression was then used to examine the statistical significance of linear trends in suicide rates. A value of $p < 0.05$ was set as the level of statistical significance. The average annual percentage change (AAPC) in the suicide rate was used to measure linear trends, which were then analyzed using Poisson regression models [28]. The AAPC was calculated using the following equation: $AAPC = [\exp(\beta) - 1] \times 100$, where β is the slope from a regression of log rates on year. Standardized suicide rates were used to assess time trends within the 10-year period. To calculate standardized suicide rates, the region-, gender-, and age-specific rates in the MOH-VR system were projected to the total population for each year. The proportion of the total population assigned to each of the 72 cohorts is based on the mean values found in the Fifth National Census conducted in 2000 [29] and the Sixth National Census of 2010 [30].

To examine the current profile of suicides in China, we calculated the total number of completed suicides for each cohort in each year during the last 3 years for which data were available (2009–2011) by multiplying the crude suicide rate to the population of the specified cohort in each year. Given the difference in the definitions of the urban and rural populations used in the MOH-VR system (counties and towns are classified as rural for calculations of mortality) and by the Statistics Bureau (which regards both cities and towns as urban areas for calculations of the population), we projected the urban mortality data from the MOH to the city population reported by the Statistics Bureau and the rural mortality data to the combined town and county population. Previous work suggests that this gives a fairly good although not perfect match [3]. The mean number of suicides for different cohorts was taken as the simple mean over the 3 years, and the mean rate was the combined number of suicides divided by the combined size of the cohort over the 3-year period. The mean national number and rate of completed suicides were calculated by combining the numbers from all cohorts. To estimate the suicide rate at a national level, we adjusted the overall crude suicide rate by an estimated rate of uncounted

deaths as reported by Phillips and colleagues [3], due to the lack of availability of relevant data giving the proportions of uncounted deaths by region, gender, and age. Although there is considerable variance in the reported rates of uncounted deaths in Chinese mortality data due to suicide, as discussed elsewhere [3], we regard the rate reported by Phillips et al. as more acceptable since they adjust for unreported deaths to the MOH-VR data based on the Bureau of Statistics mortality rates.

Results

Time trends of suicides over 2002–2011

The region- and gender-specific suicide rates for 2002–2011 are depicted in Fig. 1. Overall, rates decreased significantly over the 10-year period. In urban areas, the crude suicide rates decreased from 12.79 in 2002 to 5.28 in 2011. Standardized suicide rates decreased from 13.80 in 2002 to 4.28 in 2011. The AAPC was -5.8% (95 % CI -9.7 to -1.8 ; $p < 0.05$). The largest decrease was observed between 2002 and 2008, but there was a striking increase in 2005. The lowest suicide rate was observed in 2008 with a slight increase thereafter. In rural areas, crude suicide rates decreased from 15.32 in 2002 to 9.28 in 2011. The standardized suicide rates decreased from 17.32 in 2002 to 8.55 in 2011. The AAPC was -3.5% (95 % CI -5.1 to -1.8 ; $p < 0.01$). Annual suicide rates declined significantly between 2003 and 2006, and fluctuated mildly thereafter. The lowest suicide rate was observed in 2008.

Figure 2 presents the time trends for the male-to-female (M/F) ratios of suicide rates 2002–2011. In urban areas, rates were roughly equal for males and females up to and including 2005. From 2006 onward, urban males had higher suicide rates than urban females, with the M/F ratios of around 1.2. The AAPC of the M/F ratios in urban areas was 1.07% (95 % CI 0.26 – 1.86%); this increase was statistically significant ($p = 0.016$). In rural areas, females had higher suicide rates than males up to and including 2005 (M/F ratios < 1.0), but lower rates from 2006 onward (M/F ratios > 1.0). The AAPC of the M/F ratios was 1.55% (95 % CI 0.54 – 2.53%), which was highly statistically significant ($p = 0.007$).

Time trends for the rural-to-urban (R/U) ratios of suicide rates are shown in Fig. 3. Overall, the R/U ratios increased significantly for both males and females from 2002 to 2008, but more recently decreased. For most of the years studied, the R/U ratios varied between 1.5 and 2.5. The R/U ratios were generally higher for females than males.

The AAPCs of the region-, gender-, and age-specific suicide rates 2002–2011 are presented in Table 1. In urban areas, the AAPC of the total suicide rate was -4.3%

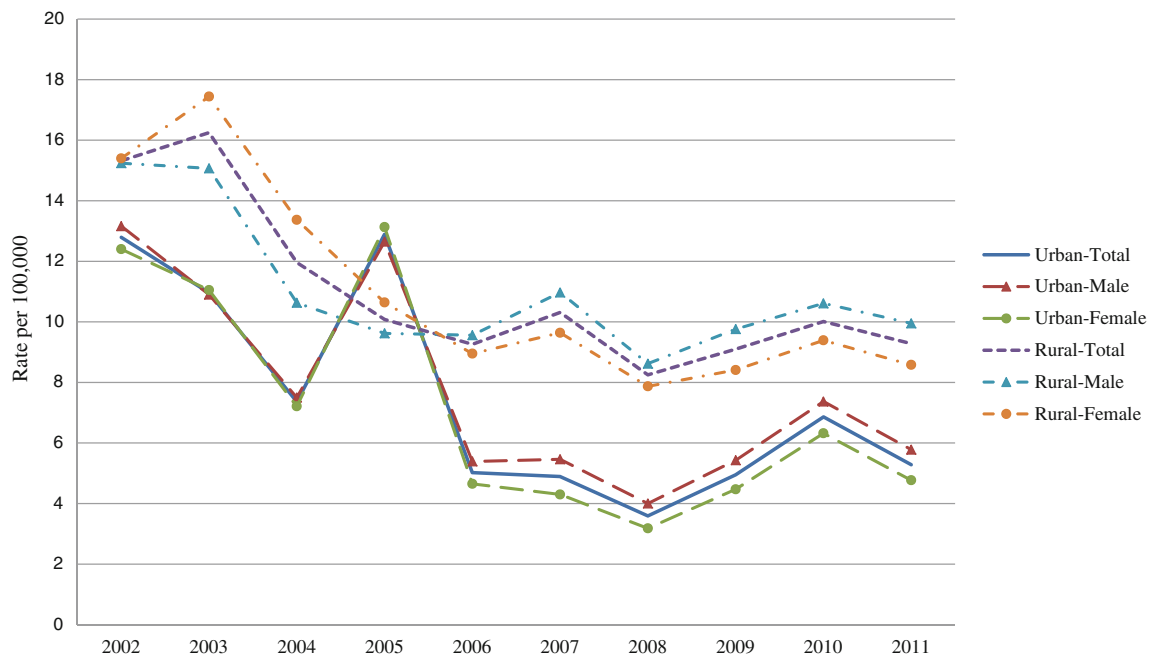
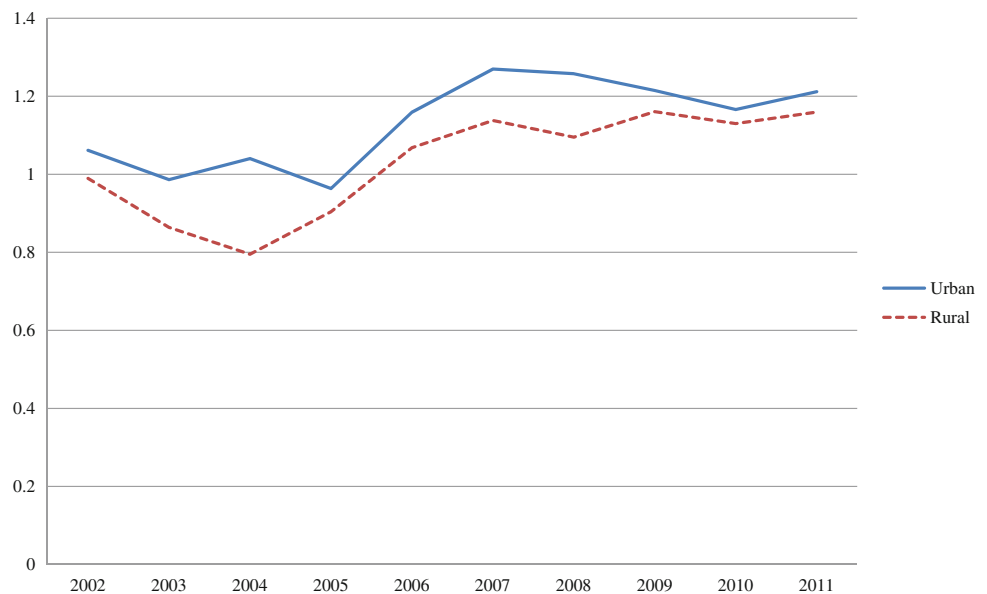


Fig. 1 Time trends of gender-region-specific crude suicide rates, China, 2002–2011

Fig. 2 Time trends of region-specific male-to-female ratios for suicide rates, China, 2002–2011



($p = 0.025$). Specifically, it was -3.9% for urban males ($p = 0.029$) and -4.9% for urban females ($p = 0.022$). In rural areas, the AAPC of the total suicide rate was -2.5% ($p = 0.006$). Specifically, it was -1.8% for rural males ($p = 0.036$) and -3.3% for rural females ($p = 0.002$). As shown in Table 1, the time trends of the AAPCs across different age groups were substantially different. The most significant decrease in suicide rates was observed in two age groups (30–34 and 35–39), with the AAPC ranging from -4.7% for rural males aged 35–39 ($p < 0.001$) to -8.2% for both urban and rural females aged 30–34 ($p < 0.001$). A statistically significant decline in suicide

rate was observed in most of the age groups, but not for urban males aged 15–24 ($p = 0.086$ – 0.213), rural males aged 15–29 ($p = 0.323$ – 0.451), urban older adults and rural older males aged 75 and above ($p = 0.063$ – 0.435), and rural older females aged 80 or above ($p = 0.500$ – 0.665). For urban older age groups (those aged 75 or above), large values (-4.8 to -6.4) of AAPC were observed though these changes were not statistically significant.

Time trends for region- and age-specific suicide rates 2002–2011 are further presented in Fig. 4. Overall, a downward trend was observed for most cohorts, but with

Fig. 3 Time trends of gender-specific rural-to-urban ratios for suicide rates, China, 2002–2011



some fluctuations. The age-specific data demonstrate different patterns of change between rural and urban areas. In 2005, suicide rates increased dramatically for most age groups in urban but not rural areas, whereas in 2010 they also increased strikingly for older people in both urban and rural areas, but less so for those in other age groups.

Current profile of suicides in China

Figure 5 depicts the region- and gender-specific suicide rates by age during the last 3 years studied (2009–2011). A stable increase in rate with age can be seen especially among those aged 65 or above living in rural areas. The mean number of completed suicides for each cohort 2009–2011 is presented in Fig. 6. The largest proportion was found among those aged 65 and above living in rural areas. A total of 79 % of completed suicides occurred among rural residents, with 68 % among those aged 50 or older, 44 % among those aged 65 or older, and 13.5 % among those aged under 30. Rural adults aged 50 or more accounted for 59 % of all deaths due to suicide. In terms of numbers, four peaks were observed in rural areas, with the largest number of suicides among the 75–79 age group, followed by the 55–59, 40–44, and 20–24 age groups, respectively. In urban areas, the largest number of suicides came from the group aged 35–49, but the four-peak pattern was less obvious. Overall, there were more suicides among males than females over nearly all age groups in both urban and rural areas. The R/U ratios of suicide numbers roughly increased with age. For groups aged 60 and above, the number of completed suicides in rural areas was 5- to

7-fold higher than in urban areas, though the R/U ratios were less than 3:1 for all age groups.

Projecting these suicide rates to the corresponding population groups without adjusting for uncounted deaths resulted in a mean annual number of 110,880 deaths due to suicide giving a corresponding overall suicide rate of 8.3. After adjusting for unreported or misclassified suicide rate, using an estimated overall rate of 18 % reported in a previous study [3], our estimate of the mean suicide rate 2009–2011 was 9.8. The corresponding total number of deaths was 130,850. Currently, suicide ranks 18th in the list of most important causes of death for the urban population and 13th for rural dwellers (Table 2). However, it was the second most important cause of death (after road-traffic accidents) among individuals aged 20–34 in both urban and rural areas.

Discussion

This study has examined time trends of suicide rate in China over a 10-year observation period. The statistical analyses detected significant further decreases in suicide rates and a further increase in M/F ratios in both urban and rural areas, following a steady trend in this direction in the 1990s as previously reported [26]. The decreasing pattern found in this study is consistent with a recently released report on suicide trends in one local area, Shandong Province [31]. Our estimate of the mean suicide rate in China over the last 3 years (2009–2011) of data was 9.8. Compared to a mean national suicide rate of 23.2 in the late 1990s as reported by a previous study using the same

Table 1 Average annual percent changes (AAPCs) of the age-, gender-, and region-specific suicide rates in China, 2002–2011

	Urban-all			Urban-male			Urban-female			Rural-all			Rural-male			Rural-female		
	AAPC (95 % CI)	p value		AAPC (95 % CI)	p value		AAPC (95 % CI)	p value		AAPC (95 % CI)	p value		AAPC (95 % CI)	p value		AAPC (95 % CI)	p value	
Total	-5.8 (-9.7 to -1.8)	0.011		-5.3 (-8.9 to -1.6)	0.011		-6.4 (-10.6 to -2.0)	0.010		-3.5 (-5.1 to -1.8)	0.002		-2.8 (-4.5 to -1.0)	0.007		-4.1 (-5.7 to -2.4)	0.001	
15–19	-2.2 (-4.3 to -0.02)	0.048		-1.4 (-3.7 to 1.0)	0.213		-3.2 (-5.8 to -0.4)	0.029		-2.0 (-3.5 to -0.6)	0.013		-0.7 (-2.9 to 1.5)	0.451		-3.4 (-5.4 to -1.3)	0.006	
20–24	-4.1 (-7.2 to -0.7)	0.023		-2.5 (-5.3 to 0.4)	0.086		-5.7 (-9.5 to -1.7)	0.011		-2.2 (-4.0 to -0.4)	0.022		0.1 (-1.9 to 2.2)	0.896		-4.4 (-6.8 to -2.0)	0.003	
25–29	-4.8 (-7.2 to -2.3)	0.002		-3.8 (-6.0 to -1.7)	0.003		-5.8 (-9.0 to -2.4)	0.005		-3.7 (-7.1 to -0.2)	0.042		-2.0 (-6.2 to 2.4)	0.323		-5.0 (-7.8 to -1.9)	0.005	
30–34	-6.9 (-9.6 to -4.1)	<0.001		-5.6 (-7.9 to -3.1)	<0.001		-8.2 (-11.6 to -4.7)	<0.001		-7.2 (-8.9 to -5.4)	<0.001		-5.9 (-7.9 to -3.9)	<0.001		-8.2 (-9.9 to -6.4)	<0.001	
35–39	-6.4 (-9.1 to -3.6)	<0.001		-5.1 (-7.5 to -2.5)	0.002		-8.0 (-11.4 to -4.4)	<0.001		-5.7 (-7.4 to -4.0)	<0.001		-4.7 (-6.5 to -3.0)	<0.001		-6.6 (-8.7 to -4.5)	<0.001	
40–44	-5.2 (-8.0 to -2.5)	0.003		-4.8 (-7.0 to -2.6)	0.001		-5.7 (-9.5 to -1.7)	0.011		-3.5 (-4.9 to -2.0)	<0.001		-2.9 (-4.9 to -0.9)	0.011		-3.9 (-5.8 to -1.9)	0.002	
45–49	-6.4 (-9.7 to -2.9)	0.003		-5.4 (-8.0 to -2.7)	0.002		-7.6 (-11.8 to -3.1)	0.005		-4.6 (-7.8 to -1.2)	0.014		-3.4 (-7.0 to 0.2)	0.062		-5.6 (-9.0 to -2.1)	0.006	
50–54	-6.6 (-10.2 to -2.9)	0.004		-5.9 (-9.6 to -2.1)	0.008		-7.5 (-11.1 to -3.7)	0.002		-5.2 (-6.6 to -3.7)	<0.001		-4.5 (-6.1 to -2.8)	<0.001		-5.9 (-7.4 to -4.4)	<0.001	
55–59	-5.4 (-9.3 to -1.3)	0.016		-4.8 (-9.2 to -0.1)	0.046		-6.1 (-9.5 to -2.5)	0.005		-2.8 (-4.3 to -1.2)	0.004		-1.6 (-3.2 to 0.1)	0.037		-4.0 (-6.0 to -2.0)	0.002	
60–64	-5.9 (-10.8 to -0.8)	0.029		-5.8 (-10.4 to -1.0)	0.024		-6.0 (-11.3 to -0.4)	0.039		-3.3 (-4.7 to -2.0)	<0.001		-3.8 (-5.2 to -2.3)	<0.001		-2.6 (-4.4 to -0.8)	0.010	
65–69	-6.7 (-11.7 to -1.3)	0.021		-7.0 (-12.0 to -1.7)	0.016		-6.2 (-11.6 to -0.4)	0.039		-3.3 (-5.4 to -1.1)	0.009		-3.2 (-5.1 to -1.4)	0.004		-3.3 (-6.3 to -0.2)	0.040	
70–74	-6.9 (-12.5 to -0.9)	0.029		-7.0 (-12.3 to -1.3)	0.022		-6.7 (-12.7 to -0.4)	0.041		-2.9 (-5.3 to -0.5)	0.023		-3.0 (-5.4 to -0.5)	0.024		-2.9 (5.4 to -0.4)	0.029	
75–79	-6.3 (-12.6 to 0.5)	0.064		-6.4 (-12.9 to 0.5)	0.063		-6.1 (-12.4 to 0.6)	0.067		-2.7 (-5.1 to -0.3)	0.033		-2.2 (-5.1 to 0.8)	0.127		-2.9 (-4.8 to -1.0)	0.009	
80–84	-5.1 (-11.4 to 1.5)	0.111		-5.5 (-11.7 to 1.1)	0.087		-4.8 (-11.2 to 2.0)	0.140		-1.2 (-4.0 to 1.6)	0.332		-0.9 (-3.5 to 1.7)	0.435		-0.5 (-2.8 to 1.9)	0.665	
85+	-5.0 (-11.6 to 2.1)	0.142		-5.0 (-11.9 to 2.4)	0.151		-4.9 (-11.4 to 2.2)	0.146		0.3 (-3.1 to 3.8)	0.846		2.7 (-0.7 to 6.3)	0.106		-1.3 (-5.3 to 2.9)	0.500	

Statistically insignificant values are indicated in bold

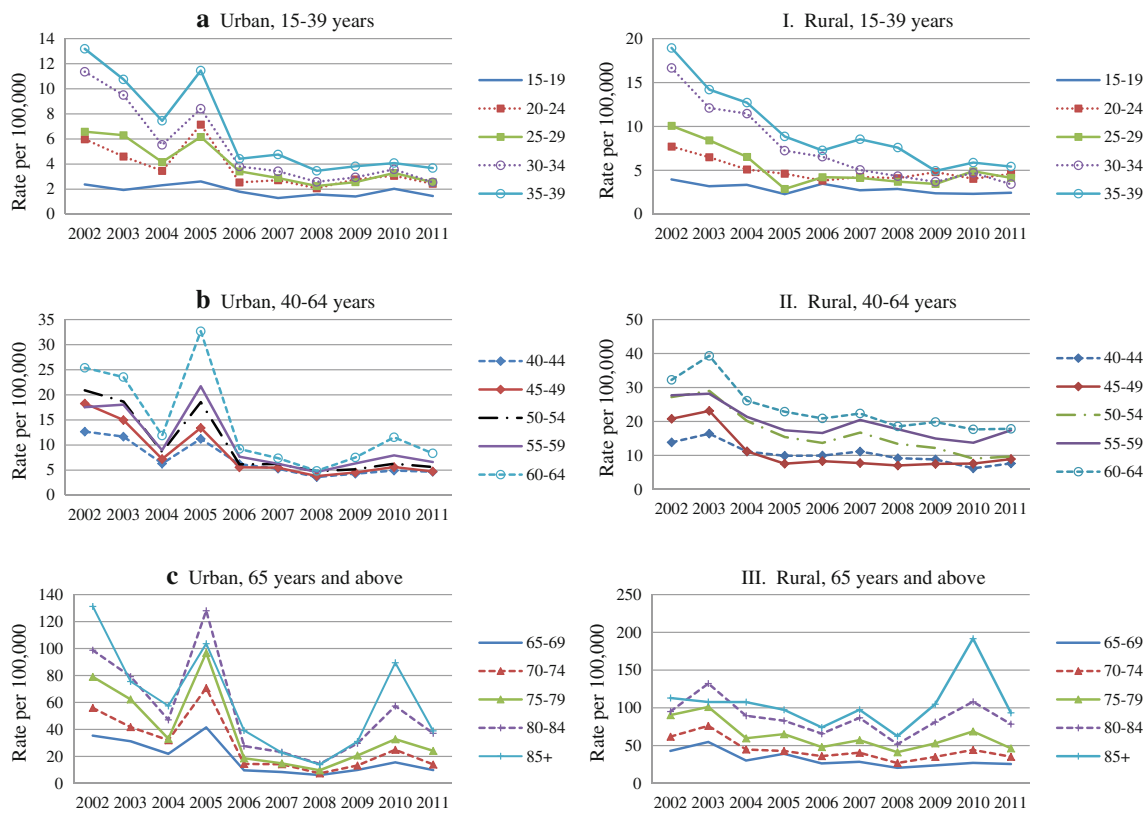
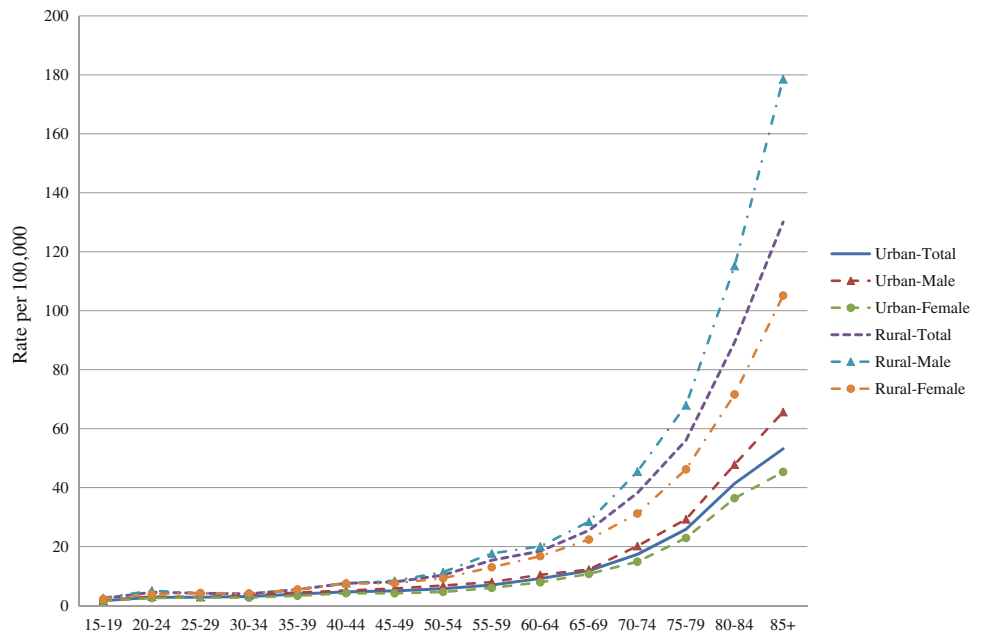


Fig. 4 Time trends of region- and age-specific suicide rates, China, 2002–2011

Fig. 5 Age-, gender-, and region-specific suicide rates, China, 2009–2011



data-reporting system and similar analysis strategies [3], this indicates that the national suicide rate has declined by 58 %. Our estimate of the national suicide rate in China is a little lower than the latest suicide rate for the world as a whole, which is estimated at 11.6 [1], and is much lower

than the overall suicide rate in Asia, which is about 30 % higher than the global figure [32]. A recent study indicates that the country or region with the highest suicide rate in Asia is South Korea (31.0), followed by Japan (24.0), Sri Lanka (23.0), Taiwan (17.6), and Hong Kong (13.8) [32].

Fig. 6 Mean number of completed suicides by gender and region, China, 2009–2011

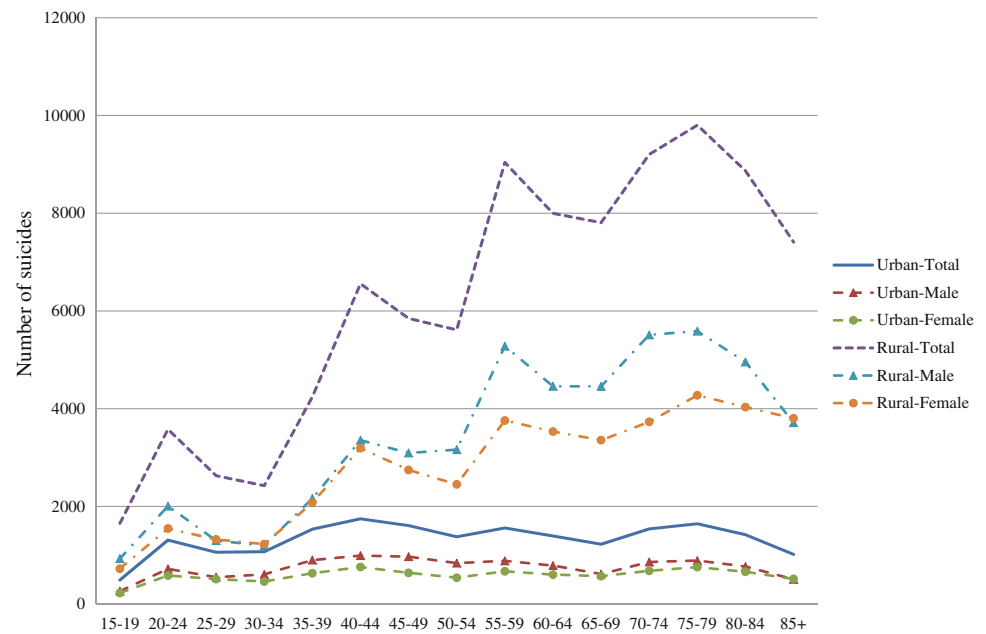


Table 2 Leading causes of death by observed rates in urban and rural areas based on the Chinese MOH-VR data, 2009–2011

Urban areas			Rural areas		
Rank	Cause of death	Observed rate ^a	Rank	Cause of death	Observed rate ^a
1	Cerebrovascular disease	125.6	1	Cerebrovascular disease	145.52
2	Other coronary heart diseases	49.56	2	Chronic bronchitis, emphysema, asthma	77.11
3	Tracheal, bronchial, and lung cancers	48.85	3	Acute myocardial infarction	45.55
4	Acute myocardial infarction	42.85	4	Tracheal, bronchial, and lung cancers	35.92
5	Chronic bronchitis, emphysema, asthma	41.56	5	Liver cancer	28.44
6	Liver cancer	23.71	6	Other coronary heart diseases	26.52
7	Gastric cancer	18.82	7	Gastric cancer	22.59
8	Diabetes mellitus	17.68	8	Pulmonary heart disease	19.46
9	Pneumonia	15.08	9	Esophageal cancer	18.22
10	Colon and rectal cancers	13.79	10	Road-traffic accidents	15.65
11	Pulmonary heart disease	12.59	11	Other hypertension-related diseases	12.62
12	Other hypertension-related diseases	10.45	12	Hypertensive heart disease	11.49
13	Esophageal cancer	9.60	13	Suicide	9.46
14	Hypertensive heart disease	9.55	14	Pneumonia	9.07
15	Road-traffic accidents	8.57	15	Colon and rectal cancers	8.24
16	Liver disease	7.76	16	Liver disease	7.22
17	Falls	6.42			
18	Suicide	5.70			

^a Rate per 100,000 individuals

The decreasing rate identified here is contrary to that found in other countries or regions in Asia such as Japan, South Korea, and Taiwan, where suicide rates have increased significantly over the same period [32]. However, the declining trend of suicide rates in China over the past two decades as shown here and in a prior study [26] is

similar to that found in some other countries. Studies analyzing time trends of suicide mortality in the Nordic nations (Denmark, Finland, Iceland, Norway, and Sweden) over a longer period (1980–2009) [33] and in Spain 1991–2008 [34] show that rates decreased significantly for both males and females over these periods.

The downward trend in the suicide rate in China over the past decade may be attributed to rapid macro-socio-economic changes and urbanization [26, 31]. According to Census data, the proportion of the population living in urban or town communities has increased rapidly from 36.2 % in 2000 to 49.7 % in 2010 [30]. From 2000 to 2010, China's GDP increased from 10.9 trillion to 40.1 trillion Chinese Yuan Renminbi [30]. Along with this rapid economic growth and macro-social changes, increased income and improved standards of living coupled with better educational opportunities, especially in rural areas, might have resulted in fewer serious suicide attempts being made [8, 17, 26, 31]. Furthermore, improvements in medical services and transportation and the better management of pesticides in rural areas (self-poisoning being a popular method for suicide in rural China) might have led to a reduction in the fatality rate of attempted suicide [31].

Contrary to the steady economic growth observed in China during the past decade, suicide rates decreased over the observation period (with some fluctuation), especially in urban areas. A striking increase in the suicide rate in urban areas was observed in 2005, with a similar peak among older adults in both urban and rural areas in 2010. The underlying mechanisms for these fluctuations are unclear, but may be due to the effect of the interaction between China's social and political status in recent years [35, 36].

Comparing the age-specific suicide rates between urban and rural areas, our data showed that suicide rates in older age groups in rural areas did not decrease significantly from 2002 to 2011. This pattern has also been observed in a study of the period 1991–2000 [26]. In urban areas, our results indicated a downward trend in suicide rates among older groups, but the AAPCs were not statistically significant, possibly due to the substantial variance of the suicide rates over the study period. In recent years, suicide rates among older Chinese have increased significantly in both urban and rural areas. These results differ from the sustained decline in suicides among those aged 65 or above in the United States from 1987 to 2006, though the overall suicide rate also declined by 18 % during 1987–2000 and then increased by 7 % in 2006 [37].

Previous studies indicate that conflicts with family members, chronic illness or physical disability, economic difficulties, and social isolation [38, 39] coupled with no strong religious or legal prohibitions against suicide [3], are the most important events in Chinese society triggering suicide in the elderly. Although one retrospective study documents a low prevalence of mental illness in Chinese suicides [8], which is inconsistent with the strong association of suicide with mental illness in the Western countries [40–42], other work indicates that depressive symptoms and perceived stress are also important risk

factors for suicide in China [43, 44]. Another important risk factor for suicide among older Chinese people may be social isolation and insufficient family support. With the one-child policy having been in place since the early 1980s, the family structure in China has downsized significantly and the 4:2:1 structure (four grandparents, two parents and one child) has become the norm [38]. On the other hand, modernization and urbanization have led to a surge of migrant laborers, with more and more young adults forced to migrate domestically to find work. Consequently, many older people are living in an “empty nest” and becoming socially isolated. Insufficient family support may prompt strong suicidal feelings or actions among older people, especially if they suffer a debilitating or terminal illness, lose their spouse, and/or find themselves without social support. The imbalance in medical and social welfare between urban and rural areas also puts older residents living in the country at greater risk [38].

As has been widely documented, the suicide rate is much higher in rural than urban China. It has been suggested that 93 % of all suicides over the period 1995–1999 were among rural residents [3]. Our study suggests that this proportion dropped to 79 % over the period 2009–2011 as a result of the rapid urbanization during the past decade. From 1995 to 1999, 79.4 % of the Chinese population lived in rural areas including counties and towns [3], but this reduced to 69.7 % in 2010 [30]. The rural–urban differences in suicide rates in China are most noticeable among middle-aged and older people. Prior studies reported a 3- to 5-fold difference in suicide rates between urban and rural older adults [3, 26, 31]. Our study has indicated that the rural–urban difference in suicide rates was less than threefold, but the region-difference in terms of suicide number was between 3- and 7-fold for different groups of middle-aged and older people. In recent years, the overall R/U ratios of suicide rates in China have decreased significantly, but this has been mainly due to increased rates in urban areas rather than a decrease in rural areas. The rural–urban difference in China is similar to that in India, but quite different from the picture in high-income countries where such differences are small, while varying by location [45]. The higher suicide rates in rural China may be attributed to income inequality and differences in delivery of social welfare [38], which have increased substantially over the past three decades in spite of the rapid and sustained economic growth [46].

Like most countries worldwide, China sees suicide rates rise as a function of age, with older adults having the highest rates of completed suicide. However, the age-distribution pattern is different in some of the developed countries. In Canada and the United States, for example, rates peak at midlife for both genders, but then decline slightly for older adults [42]. Persons aged 65 and older

account for only 18 % of all suicides in the United States [47]. A recent study reports that the rate of suicide among those aged 65 and above in Wisconsin was 12.4 per year for the period 2001–2006, lower than the national average of 14.7 [48]. Given the high rate of suicide among the elderly in China, which has continued to soar in recent years (particularly in rural areas), improved social welfare and medical systems for senior citizens are required. This should be a public health priority given that the elderly are the fastest growing segment of the population in China. Currently, more than 8.87 % of its 1.3 billion citizens are aged over 65 [30] and the older population is projected to grow to more than 20 % of the total population by 2035 [49]. It is, therefore, important to expand direct suicide prevention strategies and community-based programs. National targets to reduce the rate of suicide in older people, as advocated in other countries [50], are also warranted for China.

Analyses using 1990s data report that China was one of very few countries to have higher rates of completed suicide among females than males [4–7]. This pattern has since altered. One study of time trends in M/F ratios of suicide rates in China 1991–2000 shows that the gender ratio increased from 0.83 in 1990 to 1.04 in 2000 in urban areas and from 0.77 in 1991 to 0.94 in 2000 in rural [26]. Our data indicated that the M/F ratios of suicide rates increased further during the period 2002–2011, with higher rates in males than females in both urban and rural areas since 2006. This shift in the gender difference has been largely driven by a rapid decrease in the rate of suicide in females, which parallels their improved socioeconomic conditions in mainland China. Some important factors have been identified as contributing to the high rate of suicide among Chinese women in the 1990s [3, 6, 51–56], such as low status, limited opportunities, love affairs, marital infidelity, family conflict, powerlessness, social pressures, mental health problems, and the easy availability of pesticides. China's economic boom in recent years has resulted in more and more women, especially those from rural areas, becoming migrant workers. Relocation provides these women with an escape from familial obligations and undesired marriage proposals, and employment provides them with the financial means to pursue career or marriage goals [57]. In the past, Chinese women have often been trapped in lives considered to be of little value except for childbearing [54]. Now, however, they have better education and employment opportunities. The traditional tensions within Chinese families and associated social pressures have also been alleviated and divorce has become a more acceptable way of dealing with marital conflict [56].

Our study has also indicated that the latest M/F ratio of suicide rates in China was around 1.20. This is slightly lower than some countries in Asia [32] and the Eastern

Mediterranean region [1], but much lower than high-income countries (where it is often greater than 3:1) [33, 45, 58]. The underlying mechanism may be that gender-based employment discrimination is still a major social problem in China, visible in hiring, dismissal, and wage differences, denial of certain social welfare benefits, sexual harassment, and fines for violation of family planning regulations [57]. Attention should be paid to the ongoing issues affecting the health and human rights of Chinese women.

In contrast to the rapid decrease of suicide rates in young women, we have also found that rates among young men, especially those living in rural areas, have not declined significantly. This may be due to the fact that young men are under constant pressure from possible unemployment [59, 60]. In addition, the rapid pace of economic growth and social change in China has been accompanied by increased rates of mental health problems among adolescents and young adults [61]. A recent study indicates that hopelessness, depression, impulsivity, and maladaptive coping are common factors predicting suicidal intent among Chinese people aged 15–34 [62]. Suicide is still one of the leading causes of death for young adults in China. Unlike in some Western countries [63], we did not observe here an upward trend in suicide for young Chinese men. However, this may be a concern during the coming decade. Despite the relatively lower rate of completed suicides in adolescents and young adults compared to other age groups, the burden of suicide, calculated in terms of loss of productivity, is much higher for young people. Particular attention should be paid to suicide prevention work with this age group.

Limitations of the study

A complete mortality registration system in China is not feasible, due to the sheer size of the population [64]. Apart from the MOH-VR system, there is another system for counting deaths, namely the Disease Surveillance Points (DSP) System, which is monitored by the country's Center for Disease Control and Prevention. The DSP system initially recorded annual deaths in 145 urban and rural sites around the country, capturing a total of 1 % of the national population [27]. Amid growing concern that the DSP system may not reflect the true situation across the whole country, its coverage has since been extended to 6 % of the national population [64]. Although it is assumed that the sample sites in the DSP system are representative of the population as a whole, some indicators in the system may not be reliable [64]. This system includes a category not found in the ICD that probably contains some suicides, and does not provide detailed region-, gender-, and age-specific mortality rates [3]. Moreover, compilation and publication of the DSP statistics are irregular [27]. Thus, the data in the DSP system may not be suitable for trend analyses.

Although the MOH-VR system is the largest system for the regular surveillance and monitoring of causes of deaths in China, its mortality data have suffered from quality issues such as underreporting and misclassification [3, 26]. The data are based on roughly 8 % of the national population, mainly in areas with relatively good reporting mechanisms, so there is a higher proportion of urban residents in the sample than is present in the population as a whole. Thus, there is a concern about the representativeness of a sample drawn from the MOH-VR system given that some cities and towns are inaccessible. However, comparison of the mortality data from the MOH-VR system with that from the more representative DSP shows that the impact on suicide figures is not significant [3]. Another concern may be that the MOH-VR system is generally based on the registered population. Deaths among rural residents who go to work in the cities are usually registered as rural deaths because their residence permits remain unchanged. Given the large number of domestic migrants, this phenomenon may affect the accuracy of the mortality data. In addition, some deaths due to suicide in rural areas may be misclassified. However, studies suggest that the results of work on the time trends or patterns in suicide rate are less influenced by concerns about underreporting and misclassification [26].

In terms of our estimate of the national suicide rate, we adjusted the overall crude suicide rate by an estimated rate of uncounted deaths reported in a prior study, due to the lack of unavailability of more recent data. Therefore, the national suicide rate reported here may be an underestimate. The extent to which crude suicide rates in China are influenced by underreported or misclassified deaths should be explored in further studies. We regarded the estimated rate of uncounted/misclassified death reported by Phillips and colleagues [3], applied in the current study, as acceptable since there is little evidence that data quality in the MOH-VR system has either improved or worsened over the past decade. Moreover, our estimate of the national suicide rate was supported by findings, based on DSP data, that the suicide rate has ranged from 9.0 to 12.5 over the period 2005–2009 [65–69] (cited in [31]). Thus we regard our estimate of national suicide rate over 2009–2011 as reliable and comparable to that identified in related work.

Conclusion

Our study has shown that suicide rates in China have reduced substantially and their profiles changed continuously over the past decade. The benefit of socioeconomic achievement and prosperity may have contributed to the reduction of suicide rates in China in both urban and rural areas as a result of better employment opportunities and improvements in education. In recent years, slightly more

suicides were observed in males than females, and rates have remained higher in rural than urban areas. A notable feature of these figures is the high rate of suicide among older adults, especially in rural areas, which has increased in recent years. Further studies are required to investigate the underlying mechanisms for this trend. Developing and implementing effective suicide prevention strategies for older adults is an urgent issue.

The suicide rate in China, especially in urban areas, is already one of the lowest in the world. However, great challenges remain for suicide prevention in China, since there may be less potential for further reduction even with additional improvements to the economy and to medical services [31]. According to the theories of Durkheim as well as recent empirical findings, the decline in the suicide rate in China may reverse over the next decade because of the social stresses associated with the slowdown of economic growth, the rapid aging of the population, increased economic burdens, income inequality, and social instability. First, the global economic slowdown since 2008 has forced a large number of small and medium-sized enterprises in China into bankruptcy [70]. The pace of economic growth may, therefore, slow down and unemployment may increase. Second, China is entering a period of rapid population aging. The limited coverage of the pension system and the lack of resources to support the elderly, coupled with the trend towards smaller family networks, may make it very difficult to reduce suicide rates among the elderly. Third, income inequality has increased rapidly in China since the economic reforms and the Gini coefficient currently have exceeded 0.5—the highest in Asia [46]. There is a correlation between income inequality and suicide rates [71]. Fourth, there is evidence that social unrest has been growing in China due to stagnant of sociopolitical reform [35], which may also increase the risk of suicide for some groups. Finally, urbanization, which is still a policy priority for the Chinese government, may increase the risk of suicide among those who are unemployed or who struggle to adjust to life in the city. Urbanization may also lead to a weakening of ties with family, friends, local institutions and the original place of residence [72]. All these factors suggest that it may be difficult to maintain and stabilize the favorable downward trend in the suicide rate in China without effective intervention or prevention strategies. We have noted that the lowest suicide rate is observed in 2008, when China first hosted the Olympics. After that, there was a slight increase. It is still unclear whether or not 2008 was a turning point for a reverse in the downward trend in the suicide rate. A longer period of time is required to verify this possibility. With the population undergoing rapid transition, it remains challenging to enhance the well-being of the community as a whole and to construct a healthy environment that will prevent suicide among its citizens.

Conflict of interest The authors declare that they have no conflict of interest.

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