Seasonality of Suicide in Shandong China, 1991-2009: Associations with Gender, Age, Area and Methods of Suicide

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Abstract

Backgrounds: Whether suicide in China has significant seasonal variations is unclear. The aim of this study is to examine the seasonality of suicide in Shandong China and to assess the associations of suicide seasonality with gender, residence, age and methods of suicide.

Methods: Three types of tests (Chi-square, Edwards' *T* and Roger's log method) were used to detect the seasonality of the suicide data extracted from the official mortality data of Shandong Disease Surveillance Point (DSP) system. Peak/low ratios (PLRs) and 95% confidence intervals (*CI*s) were calculated to indicate the magnitude of seasonality.

Results: A statistically significant seasonality with a single peak in suicide rates in spring and early summer, and a dip in winter was observed, which remained relatively consistent over years. Regardless of gender, suicide seasonality was more pronounced in rural areas, younger age groups and for non-violent methods, in particular, self-poisoning by pesticide.

Conclusions: There are statistically significant seasonal variations of completed suicide for both men and women in Shandong China. Differences exist between residence (urban/rural), age groups and suicide methods. Results appear to support a sociological explanation of suicide seasonality.

Keywords: suicide, seasonality, method of suicide, China

1. Introduction

Seasonality of completed suicide has been extensively studied. Mounting epidemiologic literature suggests that suicide typically peaks in spring and early summer and bottoms out in winter months in both northern and southern hemispheres (Ajdacic-Gross et al., 2003, Ajdacic-Gross et al., 2010, Chew and McCleary, 1995, Preti, 2002, Rock et al., 2003, Rocchi et al., 2007). However some evidence indicates a bimodal pattern (peaks in spring and autumn) exists in women (Parker and Walter, 1982, Yip et al., 2000). The additional autumn peak in female suicide seems more common in Western countries than in East Asian populations (Preti, 2002, Ho et al., 1997).

Despite the differences between East Asian and Western societies, previous studies generally suggest that seasonality is more pronounced in countries with geographically higher latitude, in rural areas, among the elderly (aged 65 years and over) and among those who utilise violent methods (such as hanging, strangulation and jumping from high places) (Ajdacic-Gross et al., 2003, Ajdacic-Gross et al., 2010, Preti, 2002, Chew and McCleary, 1995, Hakko et al., 1998). However, none of these findings are indisputable with the evidence being inconsistent. For example, suicide among young males (aged 15-24) in Australia and New Zealand shows greater 1-year cycle seasonality compared to other age groups (Yip et al., 1998). Over the past decades, there has been a decreasing trend of seasonal variations in both suicide attempts and completed suicide observed in many western countries (Ajdacic-Gross et al., 2003, Ajdacic-Gross et al., 2010, Hakko et al., 1998) although not all data is consistent (Rocchi et al., 2007).

The reason for the seasonality in suicide remains ambiguous. While biological, psychological, and general sociological models take into account the genetic, personality factors, and socio-political influences on suicidal behaviour in general (e.g., Fiori and Turecki, 2010, Brezo et al., 2006), there have been two main models proposed to explain suicide seasonality, being the bioclimatic and socio-demographic model (Ajdacic-Gross et al., 2003, Chew and McCleary, 1995). According to bioclimatic theory originally proposed by Ferri and Morselli in the 19th century, climatic factors, in particular environmental heat, increases the excitability of the nervous system which in turn causes the spring peak in suicide rates. This model is supported by evidence on differences in seasonality of suicide between temperate and tropical areas, and between violent and non-violent methods (Preti, 2002). In contrast to the Bioclimatic model, the Socio-demographic model based on Durkheimian principles proposes that the seasonal peak in spring and early summer is a result of higher levels of social and occupational activity (Zhang, 1996). One piece of supporting evidence of the Socio-demographic view is the more pronounced seasonality observed in suicides occurred in rural communities where social and occupational activities are more likely to be governed by seasonal changes (Chew and McCleary, 1995).

Although well recognized, most of the above findings are from Western countries. Research into suicide in China started only 30 years ago and has intensified since the publication of the research in *Lancet* conducted by Phillips and his colleagues on suicide rates in China between 1995-99 (Phillips et al., 2002). China has one of the highest suicide rates in the world and some unique characteristics exist in Chinese suicide, including the three-fold higher rate in rural versus urban communities, and the low or reversed male-to-female ratio in suicide rates which is related to the very high rate in young rural females (aged 15-34 years) (Yang et al., 2005, Phillips et al., 2002). In addition, self-poisoning using pesticide is the number one method of attempted and completed suicide, and higher rates in the aged population (aged 65 year and over) are also important characteristics of suicide in China (Yang et al., 2005, Phillips et al., 2002, Li et al., 2009).

The theories to explain suicidal behavior have been mainly developed in developed countries and may not have the same explanatory utility in the Chinese context. For example, western psychiatrists usually see suicide as a consequence of psychiatric disorders (mood disorders in particular) with over 90% of suicides being related to at least one type of disorder (Hawton and van Heeringen, 2009). In China, suicide is commonly perceived as a social rather than a mental health problem (Phillips, 2004). Although up to 63% of the suicide attempters had a psychiatric disorder at the time of suicide (Yang et al., 2005), many experts believe it is the social problems that cause both mental illness and suicide (Wu, 2009). The abnormally high suicide rate in females is postulated to be related to conflict with family members and domestic injustices toward women in Chinese families, especially in rural areas (Wu, 2009).

Although there has been evidence suggesting a unicycle seasonality for suicide in

Chinese populations (Lee et al., 2006, Yip and Yang, 2004), little is known about the seasonal variation in suicide rate in Mainland China, where one-fifth of the world population reside in. In addition, whether the seasonality differs across gender, age, residence (urban *vs*. rural) and method of suicide, and whether the seasonality varies over time remain unknown. Given the uniqueness of suicide in China, findings from western countries may or may not apply to the Chinese context. Although there has been a steady drop in suicide rates in recent years, completed suicide and suicide attempts remain a significant public health problem in China (Yip et al., 2005, Zhang et al., 2010, Phillips, 2004). It is therefore necessary to examine the seasonality in suicide in China.

Based on findings in the existing literature, it is expected that suicide deaths in Mainland China may follow a unimodal pattern of seasonality with a peak in spring and early summer and a dip in winter. The primary objective of the present study is to test this hypothesis using mortality data from a large province of China. There has been no universally accepted method for statistical test of seasonality and each method has limitations (Hakko et al., 2002, Nam, 1995). The use of multiple methods may reduce the risk of bias or error and uncertainty that are often related to individual methods and increase the interpretability of the results. Therefore, we employed several commonly used statistical tests to examine the seasonality in competed suicide in the present study. As the second objective, we also explored the potential differences in seasonality between genders, age groups, residence types (urban *vs*. rural) and suicide methods.

2. Methods

2.1. Data Source

Data of completed suicide were extracted from the mortality data of Shandong Disease Surveillance Points (DSP) system provided by Shandong Provincial Center for Disease Control and Prevention (CDC). Official population data from Shandong Statistic Bureau were also provided by Shandong CDC. Shandong is the second most populous province in China with a total population of 93.1 million in 2006 (Shandong Provincial Bureau of Statistics, 2007). It is also a typical Chinese province in terms of population structure (dominated by ethnic *Han* Chinese) as well as social and culture lifestyle patterns.

The Shandong DSP system currently consists of 19 county-level data collection sites with an average catchment population of 2 million before 2006 and 12 million in the years 2006 onwards. Before 2006, only part of the population in each surveillance county/district (usually a few townships or suburbs) was covered by the system. Since 2006, all of the regular residents in each surveillance point have been included.

In accordance with the national protocol (Yang et al., 2005), mortality data in the DSP system is collected by township hospital staff who are responsible for death registration using a standard form with information on demographic characteristics, causes of death and history of medical treatment. In Mainland China most (about half in urban areas and 80% in rural areas) deaths occur at home (Yang et al., 2005). For these deaths, the causes of death are retrospectively investigated (verbal autopsy method) based on family report and clinical documentations and an underlying cause is given by the investigator. For deaths that occurred in hospitals, information is obtained directly from the death certificates prepared by the physician who attended the death (Yang et al., 2005). Special trainings for township-level workers on death registration with a focus of the application of ICD codes are provided usually by local CDCs and on a yearly basis. Provincial CDC also provides training to local CDCs every year.

2.2. Categorization of suicide methods

Data on suicide methods were only available from 2004 onwards. Based on the 10th revision of the International Classification of Diseases and Related Health Problems (ICD-10; codes: X60–X84) (WHO, 1994), methods of suicide were categorized into medication overdose (X60-64), alcohol use (X65), self-poisoning using other toxins (X66-67; X69), pesticide poisoning (X68), hanging (X70), drowning (X71), fire use (X76), jumping (X80), stabbing/cutting (X78), other violent methods (X72-75, X77, X79, X81-83), and methods unspecified (X84). In accordance with previous studies, suicide methods were further grouped into violent (X70-83) and non-violent categories (X60-69) (Rasanen et al., 2002).

2.3. Data Preparation

The data were grouped by month (January to December). Because the number of days varies by calendar month, we first adjusted the number of suicide cases in each month to a number of cases in a standard 30 day span using the following equation:

$$Adjusted\ N_i = \frac{Actual\ N_i \times 30}{number\ of\ days\ in\ that\ month} \quad (1)$$

where N_i is the number of suicide deaths in month i (1,2,…12). The number of days differs across month (i.e. 31 or 30 days) and by leap/common year (i.e. 29 or 28 days in February). The adjusted yearly totals were slightly smaller than the original counts because the total days in a year were reduced to 360 days after adjustment. These adjusted monthly numbers were used in subsequent analyses.

2.4. Statistical Analysis

Three methods were independently used to assess the seasonal variation, including traditional Chi-square method, Edwards' method (Edwards, 1961) and Roger's Log method (Roger, 1977, Oh et al., 2010).

2.4.1. Chi-square method

The Chi-square method tests the difference between observed monthly distribution and expected frequencies. The null hypothesis is that all the frequencies are equal in each month. This is one of the common methods to determine the seasonality of suicide (Yip et al., 1998). The equation to calculate the statistic χ^2 is:

$$\chi^2 = \sum_{i=1}^{12} \frac{(x_i - x_E)^2}{x_E} \qquad (2)$$

where x_{i} denotes the adjusted number of suicides in month *i* (1, 2,…, 12) using equation (1), and x_{E} is the expected number in each month. Here x_{E} is a constant (x_{E} = adjusted yearly total / 12) because every month has been adjusted to a equal length (30 days). A χ^2 value greater than 19.675 (the critical value for significance of a chi-square distribution with a degree of freedom of 11 at the p =.05 level) indicates a statistically significant difference between the observed and expected monthly distribution at a significance level of α = .05.

2.4.2. Edwards' method

Edwards' (Edwards, 1961) model is among the most commonly used methods for examining seasonality in epidemiology and has been widely used for suicide and suicide attempts (Ajdacic-Gross et al., 2010, Ajdacic-Gross et al., 2003). It tests whether the distribution of events follows a simple harmonic curve that has one peak and one trough within a single 12 month period. Edwards' *T* is the statistic and is calculated using the following equation:

$$T = \frac{\left[8\sum_{i=1}^{12} N_i\right] \times \left[\left(\sum_{i=1}^{12} \sqrt{N_i}\sin\theta_i\right)^2 + \left(\sum_{i=1}^{12} \sqrt{N_i}\cos\theta_i\right)^2\right]}{\left(\sum_{i=1}^{12} N_i\right)^2} \qquad (3)$$

where N_i = adjusted yearly number of suicide cases in month i = month (1, 2,…, 12), $\theta_i = (2i - 1)\pi/12$. Edwards' *T* approximates the χ^2 distribution with 2 degrees of freedom and a *T* value higher than 5.99 (the critical value for statistical significance of a chi-square distribution with a degree of freedom of 2 at the p =.05 level) indicates significant seasonality at a significance level of $\alpha = .05$.

2.4.3. Roger's Log method

Roger's (Roger, 1977) Log method is considered as a revised form of the Edwards' Test and has been previously used for determining seasonality in disease onset (Oh et al., 2010). The statistic is a *z*-score which tests the difference between the peak season (three consecutive months with a highest total number of cases) and the trough season (three consecutive months with a lowest total number of cases) using the following equation:

$$z - score = (n/2)^{1/2} \cdot \ln(x_{\max} / x_{\min})/2 \qquad (4)$$

where *n* is the average frequency for the total number of all three consecutive months,

x_{max} is the number of cases in peak season, and x_{min} is the number of cases in trough season. A z-score higher than 1.64 indicates a statistically significant difference at the significance level of α = .05.

2.4.4. Peak/low ratios (PLRs)

Finally, to compare the magnitude of seasonality across year, gender, age and suicide method, we calculated peak/low ratios (PLRs) of seasonal suicide counts and 95% confidence intervals (*CI*s) using the maximum likelihood estimates (MLE) method (Nam, 1995). Higher values of PLRs indicate greater seasonality. The equation to compute *CI*s is as follows (Nam, 1995):

$$95\%CI = [-a \pm (a_1^2 - 4a_0 a_2)^{1/2}]/(2a_0) \quad (5)$$

Where $a_0 = x_4^2$, $a_1 = -[2x_2x_4 + n \cdot z^2_{(1-\alpha/2)} / 2]$, $a_2 = x_2^2$; x_2 is the number of suicide deaths in peak season (the highest number of the sum of three consecutive months); x_4 is the number of suicides in trough season; and n is the total number of deaths in that year. The lower and upper limits for the *CI* are the smaller and larger roots of equation (5). Statistically significant differences in seasonality between groups are detected if *CI*s are not overlapped in at least two groups (p = .05).

3. Results

There were a total of 14,450 reported suicides in the catchment population (75,465,321 person years in total) of Shandong Disease Surveillance Point (DSP) system between 1991 and 2009, with an average annual rate of 19.15 per 100,000 persons. There was a significant decreasing trend of suicide rate during this period (Table 1, regression coefficient B = -1.43; 95%*CI*: -1.63, -1.24).

Table 1 shows the results of the seasonality tests and the peak/low ratios (PLRs) for each year. Statistically significant seasonality was observed in most years with a peak generally occurring in May, June and July, and a trough in November and December. The total number of suicides in the three peak months accounted for 30.7% of the total suicide deaths in 1991-2009 combined; and the total number of suicide deaths in the three through months (November, December and January) accounted for 19.7% of the total suicides. The overall PLR in these years combined was 1.56 (95%*CI*: 1.49-1.64). There was no significant difference in the magnitude of seasonality over years in terms of PLRs and confidence intervals (Table 1). Therefore, the aggregated data were used to test the differences in seasonality in male and female suicides between residence types (urban/rural), age groups and methods of suicide in the subsequent analyses.

3.1. Residence type and seasonality

Only rural suicide exhibited significant seasonal variations and there was no significant seasonality in urban suicide (Table 2, Figure 1). The peak and trough seasons in rural suicide were the same with the seasonality in overall suicide. Rural males and females showed similar seasonality in terms of both peak/trough months and magnitude (PLRs). No statistically significant seasonality was observed in urban suicide regardless of gender (Table 2, Figure 1).

3.2. Age and seasonality

As shown in Table 2, significant seasonality was observed in all age groups for both men and women with minimal gender differences. Seasonal variation was more evident in younger groups especially for female suicide (Table 2). According to the monthly distribution (Figure 2), the peak months seemed to be later in younger groups while the trough was typically in December despite age. In age groups 15-24 and 25-34, the peak months were mostly June and July while May was the peak for most of the other age groups (Figure 2).

3.3. Method of suicide and seasonality

Suicide data in years 2004 to 2009 revealed that poisoning with pesticide and hanging were the most common means for suicide, accounting for 48.8% and 36.0% of all suicide cases, respectively. Other common means included medication overdose (6.1%), drowning (3.8%), poisoning with other toxins (1.8%), jumping from a high place (1.1%), stabbing and cutting with a sharp object (0.5%), other violent means (0.5%) and unspecified (1.4%).

Suicide following pesticide poisoning showed statistically significant seasonality with a peak in June for both men and women (Table 2, Figure 3). When all non-violent suicides are taken into account, the seasonality remains statistically significant but the peak month shifted to May (Table 2, Figure 3). Suicide by hanging and all violent methods in men also illustrated a significant seasonality. The seasonality of violent suicides in women was less evident in terms of both seasonality tests and PLRs (Table 2, Figure 3).

4. Discussion

As expected, suicide deaths in Shandong have shown significant seasonal variations over the past twenty years with one single peak in spring and early summer and one trough in winter. Both male and female suicide demonstrates a similar unimodal distribution. The absence of a bimodal distribution in female suicide is consistent with many studies in western countries (Ajdacic-Gross et al., 2010) and other Chinese populations (eg, Beijing, Hong Kong and Taiwan) (Zhang, 1996, Ho et al., 1997, Lee et al., 2006), but in contrast to findings in Australia and the UK where two peaks (spring and autumn) in female suicide have been observed (Parker and Walter, 1982, Yip et al., 2000).

There are differences in suicide rates and characteristics in Shandong compared to the national data. As also revealed in a national analysis (Yang et al., 2004), eastern and middle rural provinces including Shandong have higher than average suicide rates. In Shandong, the overall suicide rate was 27.2 per 100,000 persons during years 1995-99 (calculated based on the data in this study), which is 18% higher than the national estimate in the same period (Phillips et al., 2002). Suicide rates in recent years (2005-2009) were also higher in Shandong (12.4 – 15.2 per 100,000 persons) than national figures (9.1-12.5 per 100,000 persons) (Chinese CDC, 2010a, 2010b, 2010c, 2010d, 2011). Possible explanations for the higher rates include the dominance of traditional culture, poorer economic development and higher availability of suicide means, in particular, pesticide in rural households (Yang et al., 2004). The rural-urban ratio in suicide rates appears to be more pronounced in Shandong (4:1 in years 1991-2009) than the national ratio (3.3:1 in years 1995-99). In 2008, the ratio has dropped to 2:1 nationally (Chinese CDC, 2010d) and 3:1 in Shandong. The underlying reasons for the higher ratio in Shandong is unknown and need to be further explored. Despite these differences, based on this study and earlier findings with other Chinese populations (Zhang, 1996, Ho et al., 1997, Lee et al., 2006), it is safe to speculate that the national data may also follow the similar pattern of seasonality, i.e., a single peak in spring and early summer and a dip in winter.

The suicide seasonality for the overall sample is in effect determined by the seasonality in rural areas because the majority of suicide deaths occur in rural communities. Consistent with national data, in our sample, due to the relatively smaller population size and very low suicide rates in urban areas, urban suicides make up only 5% of the total suicide deaths. Phillips et al (Phillips et al., 2002) found that 93% of all suicides nationally occurred among rural residents between 1995 and 1999. Suicide rate in rural communities is 3-4 times as high as urban suicide rate (Phillips et al., 2002). In line with most findings from other countries (Chew and McCleary, 1995, Ajdacic-Gross et al., 2010), we found significant seasonality of suicide in China exists only in rural but not in urban areas. This may support Durkheim's social theory on suicide seasonality (Durkheim, 1951). In China, as well as other temperate countries, farming activities become more intensive in spring and early summer in rural areas that may deteriorate existing social hardships and interpersonal problems. However, traditionally autumn is also a busy season with many harvesting activities but has no increase in suicide. One possible explanation is that the family financial situation is much better in harvesting season than in spring when farmers need to invest large amount of money on planting.

Many studies found that older age is associated with a greater seasonality in suicide (Preti, 2002, Preti and Miotto, 1998). Preti and Miotto attribute this age divergence observed in Italy to the difference in the prevalence of primary and secondary mood disorders (Preti and Miotto, 1998). Interestingly, a reverse trend was found in our study with more pronounced seasonality occurring in younger groups for both men and women. Again, our results, together with another piece of evidence that a considerable proportion (37%) of Chinese suicide do not have a mental illness (Yang et al., 2005), are in favor of a social explanation but against the psychiatric perspective regarding suicide behavior in China. In rural areas of China, younger farmers make up the main workforce and bear heavy burden to look after the whole family, and thus are more likely to be stressed by intense activities in busy seasons.

Another interesting finding is the delay of peak months in younger age groups. Adolescents and young adults show a clear lagged peak in June and July while older groups generally have a peak in May. Although the reason for this phenomenon is not clear, it might be related to the academic failure and stress among students that occur more frequently in these months when most important exams are conducted. Academic failure and related stress are associated with an increased risk of youth suicide, especially in countries where a national college entrance examination that can virtually determine the candidates' future for a college entry exists (Liu et al., 2005, Aaron et al., 2004). In India, the exam season (May) is also a season for teenage suicide (AFP, 2008). In China, June is the end month of school year and the time for final examinations, including the most important college entrance exam (*Gao kao*) and transitional exam to enter a senior high school (*Zhong kao*). The results are normally revealed in July. Every year news reports about exam-related youth suicides peak in this period among those who failed or even feared of failure (Wu, 2010). In addition, for many youths who cannot go further in higher education, this time is the end of their student life and the beginning as a social youth. This significant change may place extra stress on the vulnerable and trigger suicidal behavior. However, these explanations have yet been supported by strong scientific evidence and more in-depth analysis with this data is not possible because of the lack of information on reasons for suicide. In addition, the similar trend among those who are aged 25 to 34 is difficult to be explained by school related issues because most of them are above the school age. Therefore, further investigations are warranted to address the underlying reason for the delayed peak in suicide among adolescents and young adults.

Data from some Western countries shows that violent methods, including hanging, drowning, jumping, shooting and other non-self-poisoning methods have greater seasonal variations than do non-violent methods which often show no evidence of clear seasonality (Preti, 2002). This supports the biological explanations of suicide seasonality because many biochemical, metabolic and immune system variables were found to have significant relationships with suicide occurrence only when suicide is committed by violent means (Preti, 2002). However, this feature fails to be replicated in our study. On the contrary, non-violent suicides, predominantly self-poisoning using pesticide shows stronger seasonality than do violent means (mainly hanging). Significant seasonality in hanging was observed only for men but not women. These results, again, support the social theory in Chinese suicide. That is, the observed spring and early summer peak in suicide is more likely to be caused by increased intensity of social activities in rural areas (e.g., planting-related activities) rather than a higher prevalence of mental disorders.

Given the large proportion of suicides using pesticide ingestion, the overall seasonality in suicide heavily depends upon the obvious seasonal variation of pesticide suicides. Therefore, the availability of pesticide may have certain effect on this seasonality. However, the peak of suicide using pesticide is inconsistent with the peak of the use of pesticide. Although the use of pesticide intensifies along with the increasing farming activities in spring, the peak usually occurs in late summer and early autumn. National surveillance data of pesticide poisoning show that the number of occupational pesticide poisoning due to farming activities peaks in July to September while non-occupational poisoning (mainly suicide attempt) peaks in May to July (Chen et al., 2005). These findings indicate that the spring peak of suicide has little to do with the availability of pesticide. Even there is no pesticide available, suicidal people would have sought other means to commit suicide and the peak would not be leveled. Nevertheless, the lethality of pesticides may pose an effect on the seasonality. Because of the universal availability of high toxic pesticide in rural areas, people who commit suicide in this season are more likely to use pesticide rather than other means simply because of the convenience. More lethal pesticides can cause more deaths and may exacerbate the existing peak. Therefore, tighter control and better management of pesticides, such as using low-lethal pesticide and safe storage within household may have some effect to reduce suicide deaths and in turn to easy the seasonal peak.

There are many limitations in both data and methods of this study. With regard to the data, first, we used the surveillance data that were mainly collected by verbal autopsy method. The accuracy may be poorer than real-time registered data. Underreporting has been also a concern in the DSP system and the suicide rate is very likely to be underestimated (Phillips et al., 2002). Nevertheless, this paper focuses only on the seasonality in suicide rather than an accurate estimate of mortality rate. Second, the catchment population was enlarged significantly in 2006 and accordingly there were more suicide deaths in recent years (Table 1). Although the increase in the population occurred within DSP counties/districts did not result in a great change of suicide rates, the larger number of deaths may lead to a more significant seasonality. Third, although the representativeness of the DSP system was well justified at the time of set-up, considering the large population (near 100 million) of the province and the rapid changes in economy and demography in recent years, whether the system can represent the current population in Shandong is questionable. This may negatively affect the generalisability of the findings in this study. Fourth, data on suicide methods are only available in recent years and thus the seasonality of less common methods could not be examined.

We used three common methods to test the seasonality and each of them has some weaknesses (Ajdacic-Gross et al., 2010, Hakko et al., 2002). For example, all of them are not suitable for the analysis with multimodal data. More complex method, such as harmonic analysis should be used if the distribution is less clear (Yip et al., 1998). The main reason we used these methods is that the suicide data appeared to be unimodal for both males and females by plotting. Our results are very consistent between methods suggesting that either of them may be sufficient if a unimodal distribution is assumed. The adjusted monthly numbers that were used in the test were slightly smaller than the actual numbers. This may to some extent underestimate the actual seasonality because the detection of significance for all methods is influenced by the sample size. Due to the same reason, the lack of statistical significance of the seasonality in urban suicides may be to some extent related to the much smaller numbers of suicide deaths in urban areas.

Despite these limitations, as far as we know, this is the first study to assess the seasonal variation with suicide data in mainland China using common statistical methods. Suicide in Shandong illustrates a significant seasonality for both male and female suicides, which is greater in rural areas, in younger suicides and in suicides using non-violent methods, and remains relatively stable over the past 20 years. Although the underlying causes for this seasonality are not clear, results mainly support social theories in suicide seasonality in Chinese populations. Findings from this study may provide some evidence for suicide prevention and interventions. Further research is needed to examine the reasons for the differences in seasonality in suicides between areas (urban/rural), age and methods of suicide. In-depth qualitative analysis may also be necessary to understand the underlying reasons for the seasonality in suicide.

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Table 1

Annual Suicide Rates and Seasonality in Shandong, China between 1991 and 2009

Year	Cases	Rate [a]	Peak (black shadow) and trough (grey shadow) months												Test for seasonality			PLR (95%*CI*)
			Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	χ^2	*T*	*z*-score	
1991	1044	37.51													65.96***	60.91***	3.94***	2.00(1.67-2.40)
1992	993	36.97													60.30***	44.04***	3.41***	1.88(1.55-2.27)
1993	798	31.42													46.46***	39.79***	2.94**	1.84(1.50-2.25)
1994	839	35.87													54.63***	48.03***	3.39***	1.96(1.61-2.40)
1995	549	30.03													33.21***	11.77**	2.39**	1.80(1.39-2.32)
1996	392	24.64													7.65	1.85	0.85	1.28(0.95-1.72)
1997	525	29.45													36.10***	26.35***	2.58**	1.94(1.49-2.51)
1998	450	27.01													36.31***	23.86***	2.47**	1.99(1.48-2.67)
1999	369	23.84													21.01*	13.95**	2.02**	1.83(1.35-2.47)
2000	352	22.84													16.51	12.22**	1.71*	1.68(1.23-2.31)
2001	361	21.44													36.18***	22.66***	2.72**	2.29(1.68-3.12)
2002	297	17.75													9.25	5.14	1.25	1.52(1.09-2.12)
2003	306	18.44													10.33	4.34	1.35	1.58(1.13-2.21)
2004	243	14.52													43.01***	19.51***	2.69**	2.69(1.83-3.97)
2005	243	14.39													16.07	4.08	1.25	1.59(1.12-2.25)
2006	1785	15.23													42.36***	31.79***	2.66**	1.43(1.26-1.63)
2007	1741	14.85													43.33***	30.00***	2.84**	1.49(1.30-1.72)
2008	1633	14.65													42.93***	26.53***	2.70**	1.47(1.26-1.70)
2009	1530	12.41													29.41**	15.40***	2.17**	1.37(1.19-1.59)

Note. *T* = Edwards' *T* statistic; PLR = peak/low ratio; *CI* = confidence interval

[a] per 100,000 persons

* $p < .05$; ** $p < .01$; *** $p < .001$

Table 2

Rates (per 100,000 persons) and Seasonality by Rurality, Age Group and Method in Shandong, China between 1991 and 2009

	Men						Women					
	Cases	Rate	χ^2	*T*	*z*-score	PLR (95%*CI*)	Cases	Rate	χ^2	*T*	*z*-score	PLR (95%*CI*)
Rurality												
Urban	402	5.86	16.88	3.68	0.96	1.32(0.99-1.75)	301	4.53	11.35	1.99	0.89	1.34(0.96-1.88)
Rural	7315	23.29	221.06***	200.00***	6.83***	1.59(1.48-1.70)	6432	21.04	211.97***	196.55***	6.68***	1.62(1.51-1.74)
Age												
15-24	516	8.22	28.81**	13.14**	2.09**	1.70(1.33-2.18)	654	10.60	79.66***	67.82***	4.07***	2.51(1.98-3.16)
25-34	794	11.68	31.07**	19.04***	2.64**	1.72(1.38-2.13)	963	14.73	63.35***	50.86***	3.76**	2.01(1.67-2.43)
35-44	1085	16.91	34.68**	31.07***	2.78**	1.63(1.37-1.94)	958	15.51	32.15**	25.26***	2.46**	1.58(1.32-1.91)
45-54	1262	23.97	55.78***	36.76***	2.85**	1.59(1.35-1.87)	900	17.98	57.11***	39.09***	3.21**	1.86(1.53-2.25)
55-64	1238	36.40	28.76**	24.10***	2.61**	1.54(1.30-1.81)	894	26.87	41.08***	30.07***	2.78**	1.71(1.41-2.08)
65+	2777	90.32	104.18***	85.79***	4.58***	1.65(1.48-1.85)	2332	66.84	32.52**	23.65***	2.39**	1.33(1.18-1.50)
Methods [a]												
Pesticide	1821	7.17	63.43***	49.70***	3.54***	1.60(1.40-1.84)	1603	6.48	73.79***	63.17***	3.73***	1.70(1.47-1.96)
All non-violent	2123	8.36	65.61***	51.88***	3.53***	1.55(1.37-1.75)	1851	7.48	78.37***	67.40***	3.88***	1.67(1.46-1.91)
Hanging	1505	5.93	45.98***	28.84***	2.58**	1.46(1.27-1.68)	1024	4.14	16.66	7.74*	1.33	1.27(1.07-1.50)
All violent	1771	6.98	38.31***	27.47***	2.54**	1.41(1.24-1.61)	1277	5.16	24.72*	10.76**	1.70*	1.31(1.12-1.53)

Note. *T* = Edwards' *T* statistic; PLR = peak/low ratio; *CI* = confidence interval

[a] Data of methods of suicide were only available since 2004

* $p < .05$; ** $p < .01$; *** $p < .001$

Figure 1.

Monthly Suicide Percentages in Shandong, China by Rurality and Gender (thick line = women; thin line = men), 1991-2009

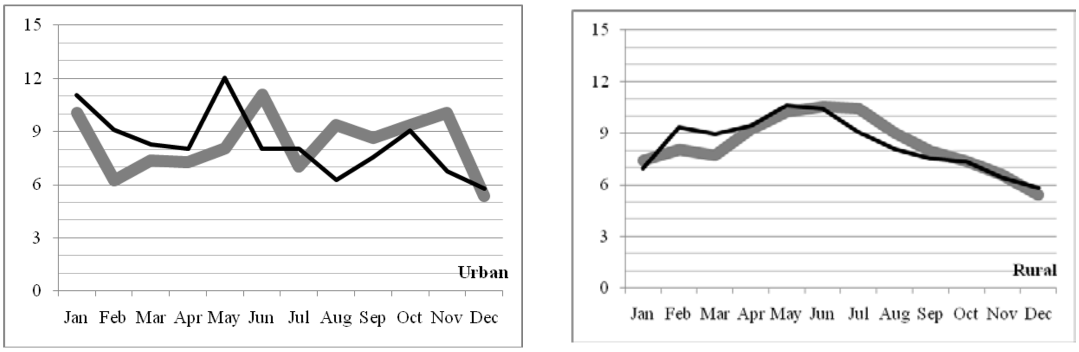

Figure 2.

Monthly Suicide Percentages in Shandong, China by Age Group and Gender (thick line = women; thin line = men), 1991-2009

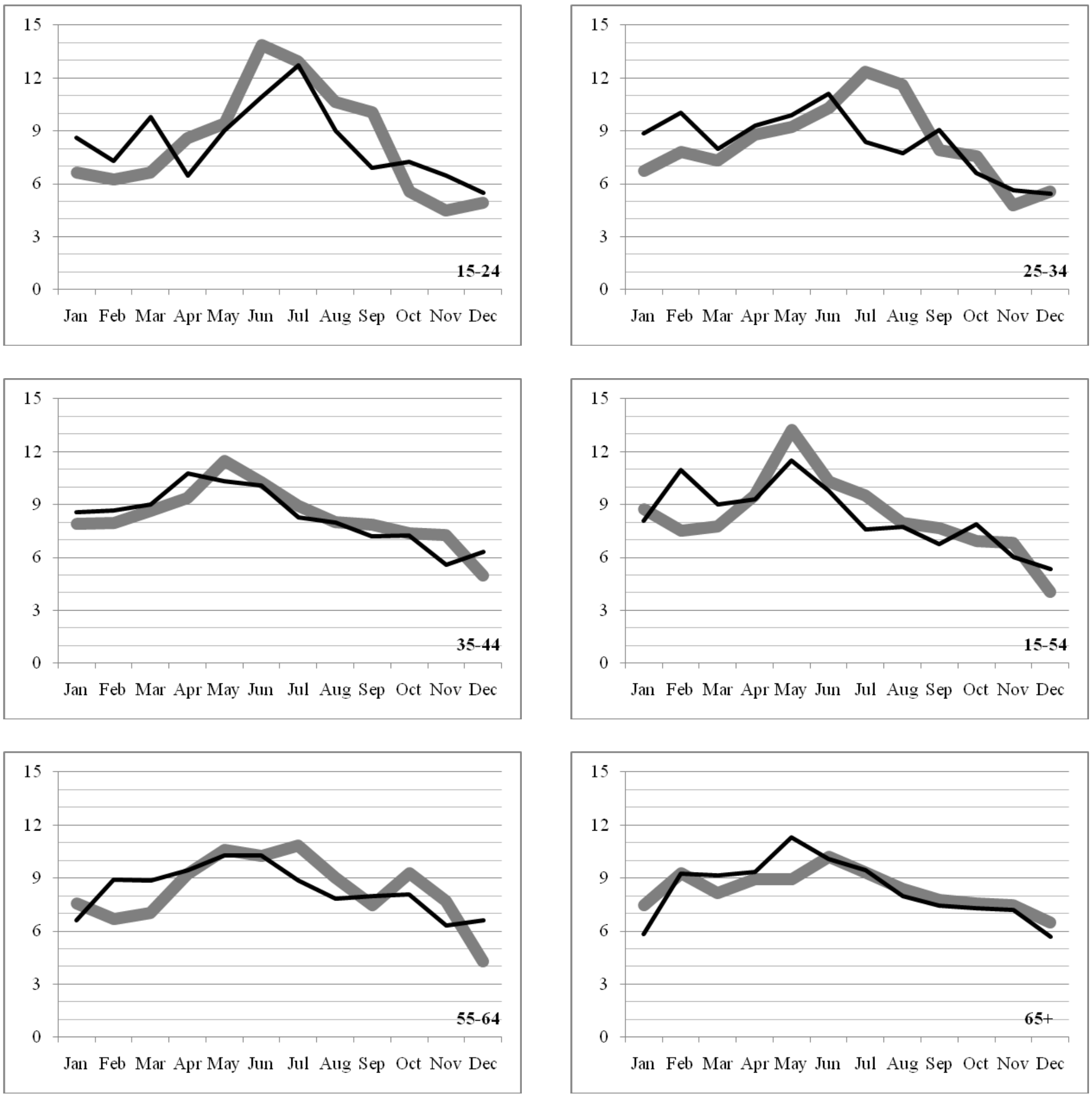

Figure 3.

Monthly Suicide Percentages in Shandong, China by Methods and Gender (thick line = women; thin line = men), 2004-2009