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ORIGINAL ARTICLE

Spatiotemporal variation and social determinants of suicide in China, 2006–2012: findings from a nationally representative mortality surveillance system

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Background. Suicide in China has declined since the 1990s. However, there has been limited investigation of the potential spatiotemporal variation and social determinants of suicide during subsequent periods.

Method. Annual suicide counts from 2006 to 2012 stratified by county, 5-year age group (⩾15 years) and gender were obtained from the Chinese Disease Surveillance Points system. Trends and geographic differentials were examined using multilevel negative binomial regression models to explore spatiotemporal variation in suicide, and the role of key socio-demographic factors associated with suicide.

Results. The suicide rate (per 100 000) in China decreased from 14.7 to 9.1, 2006–2012. Rates of suicide were higher in males than females and increased substantially with age. Suicide rates were higher in rural areas compared with urban areas; however, urban–rural disparities reduced over time with a faster decline for rural areas. Within both urban and rural areas, higher rates of suicide were evident in areas with lower socio-economic circumstances (SEC) [rate ratio (RR) 1.85, 95% confidence interval (CI) 1.31–2.62]. Suicide rates varied more than twofold (median RR 2.06) across counties, and were highest in central and southwest regions of China. A high proportion of the divorced population, especially for younger females, was associated with lower suicide rates (RR 0.60, 95% CI 0.46–0.79).

Conclusions. Geographic variations for suicide should be taken into account in policy making, particularly for older males living in rural areas and urban areas with low SEC. Measures to reduce disparities in socio-economic level and alleviate family relation stress are current priorities.

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Key words: Geographical variation, mortality, social determinants, suicide, trends.

Introduction

Suicide is a major public health problem for China (Phillips *et al.* 2002*a*). Despite previous studies showing decreasing trends in suicide over the period 1991 to 2000 (Phillips *et al.* 1999, 2002*a*; Yip *et al.* 2005), suicide in China remains an important public health priority and is the fifth most common cause of death in China (Phillips *et al.* 2002*a*; Yip *et al.* 2005), and second most common external cause of death (Ji *et al.* 2001; Yang *et al.* 2004).

Previous studies of suicide in China conducted prior to 2000 showed substantial regional and gender differences in China, including a threefold higher rate for rural than urban areas (Qin & Mortensen, 2001; Phillips *et al.* 2002*a*; Yip *et al.* 2005, 2008; Rebholz *et al.* 2011), higher rates in females than in males (contrary to gender differences reported internationally) (Phillips *et al.* 1999, 2002*a*; Ji *et al.* 2001; Qin & Mortensen, 2001; Yang *et al.* 2004; Yip *et al.* 2005, 2008) and an increasing male:female ratio in urban and rural areas, especially in urban areas (Yip *et al.* 2005). This pattern of suicide has changed in the past two decades, occurring contemporaneously with rapid demographic and social changes in China, for example the urban–rural disparity has narrowed (with

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slower declines in rural areas) and the rate in males is higher than in females in more recent periods (Cai *et al.* 2012; Zhang *et al.* 2014).

Similarly, studies of temporal trends (Phillips *et al.* 1999, 2002*a*, *b*, 2004; Qin & Mortensen, 2001; Yip *et al.* 2005; Hu *et al.* 2010; Rebholz *et al.* 2011; Sun *et al.* 2011) also mainly focused on the period before 2000, and geographic investigations were limited to broad 'urban–rural' categorizations. To date, there has been little exploration of regional and county differences at a small geographic scale, to provide more locally nuanced information on sociodemographic characteristics to inform prevention and control (Phillips *et al.* 1999). Accordingly, this study aimed to examine the most recent temporal trends and geographical variations among people aged 15 years and older in 31 provinces in mainland China between 2006 and 2012, and to identify potential sociodemographic determinants of these trends and variations. It is hypothesized that disparities between urban and rural areas in China have continued to narrow, and that male suicide rates continue to exceed female suicide rates, but that these disparities will vary when examined by small-scale geographic units.

Method

Data sources

Suicide counts (International Classification of Diseases-10 codes X60–X84, Y87.0) from 2006 to 2012 were acquired from the national Disease Surveillance Points system (DSPs), a population-based death registration system comprising 161 surveillance points (each point corresponds to one county or district) across 31 provinces nationwide (total population coverage of 6% or 73 million). Cause of death in this sample registration system is determined by trained coders in hospitals and local Center for Disease Control and Prevention (CDC) staff for all deaths in each surveillance point. Previous studies have demonstrated good national and regional representativeness of the DSPs (Yang *et al.* 2005; Lopez *et al.* 2006; Zhou *et al.* 2010). Cases of death are enumerated through both hospitals and the local staff using household surveys, data exchange with police stations, the civil affairs department, and maternal and children department. Decedents are counted as local residents if they have lived in the county for more than 6 months; otherwise they are coded to their previous county of residence. The DSPs more accurately reflects total mortality, the broad cause of death distribution and the geographic distribution of mortality compared with other mortality sources in China (Lopez *et al.* 2006).

Multiple strategies for addressing variation in data quality are routinely implemented, and have also included two under-reporting surveys conducted during 2006–2008 and 2009–2011 to adjust death counts in each corresponding year (Wang *et al.* 2011). Corresponding population counts cross-classified by 5-year age group and gender for each county or district of the DSPs were extracted from the National Bureau of Statistics.

Potential sociodemographic factors associated with suicide were also defined for the county/district level, based on data extracted from the Chinese census in 2010. These variables were limited to mean years of education as a proxy for area-level socio-economic circumstances (SEC), and the proportion of divorced population. Each of these variables was divided into tertiles representing 'low', 'moderate' and 'high' groups.

Population catchments for each DSPs surveillance point could be divided into urban and rural areas. 'Districts' within each county were defined as 'urban' and 'counties' were defined as 'rural'. In total there were 64 urban points and 97 rural points across the DSPs. Second, all points in the DSPs were allocated a regional classification based on Chinese National Bureau of Statistics categorizations, as follows: 'North' (Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia); 'East' (Shanghai, Shandong, Jiangsu, Anhui, Jiangxi, Zhejiang, Fujian); 'Central' (Hubei, Hunan, Henan); 'South' (Guangdong, Guangxi, Hainan); 'Southwest' (Chongqing, Sichuan, Guizhou, Yunnan, Tibet); 'Northwest' (Shaanxi, Gansu, Ningxia, Xinjiang, Qinghai); and 'Northeast' (Heilongjiang, Jilin, Liaoning) (Fig. 1).

Statistical analysis

Age-standardized (using the 2010 census population as the standard) and age-specific suicide rates were calculated, also stratified by gender and urban–rural residence, to investigate trends and differentials in suicide over the study period (2006–2012). Considering the over-dispersion of suicide counts (Lockhart *et al.* 1992; Vaneckova *et al.* 2008) and hierarchical structure of observed data, we used multilevel negative binomial regression models (Leyland & Goldstein, 2001; Yang & Li, 2007) to investigate for potential spatiotemporal variation across DSPs surveillance points, and also to investigate the extent to which available sociodemographic factors accounted for any observed spatiotemporal variation. As a strategy for all of multilevel models, null (or 'empty') models were firstly fitted with various possible levels, and two levels with statistically significant random effects were finalized in this study. The suicide count was specified as the outcome variable, cross-classified by county, year, age group and gender (level 1 or individual-level variable, $i = 1, 2, 3, \ldots, n$), and county was treated as the level 2 variable ($j = 1, 2, 3\ldots, 161$). The age groups were aggregated into 15–44, 45–64

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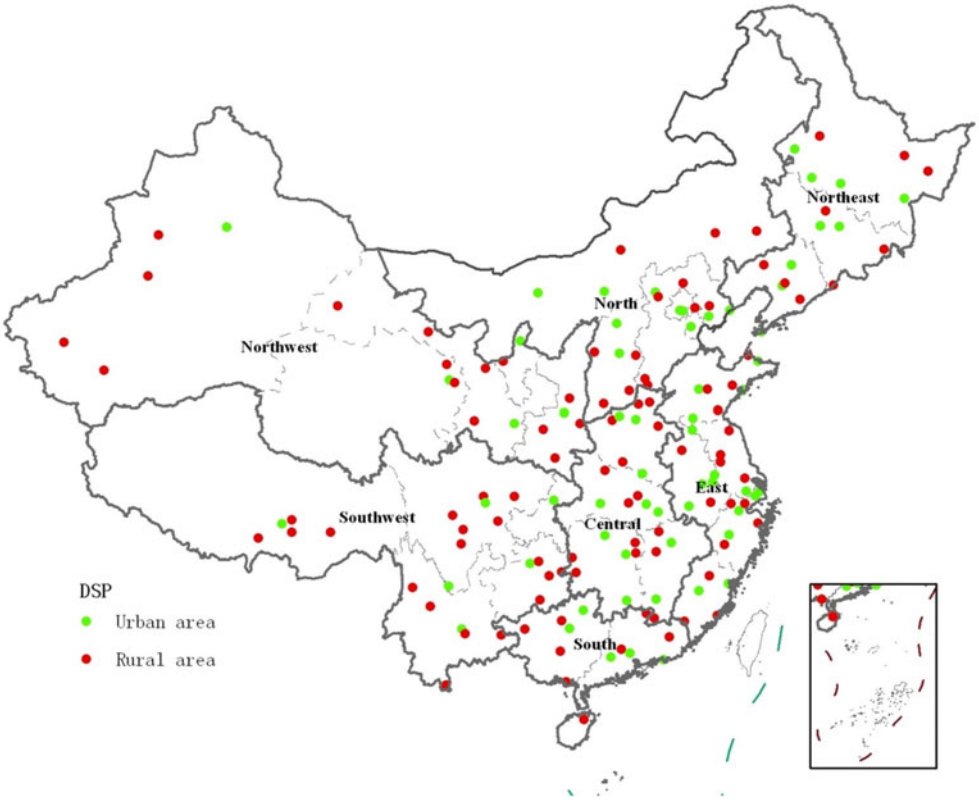

Fig. 1. Geographical distribution of seven regions and 161 Disease Surveillance Points (DSP) in China.

and ⩾65 years old based on the age-specific distribution of suicide rates over the study years. The equation for a two-level null model was defined as: $\log(\pi_{ij}) = \text{offset}_{ij} + \beta_{0j}\text{cons}$, $\beta_{0j} = \beta_0 + \mu_{0j}$, where offset_{ij} is the natural logarithm of the corresponding cross-classified population, β_{0j} is the mean log value of suicide counts at level 2, β_{0j} is the total mean log value for all cross-classified suicide counts, μ_{0j} is the residual at level 2 or random-effects coefficient. Subsequently models were fitted with variables (x_m, $m = 1, 2, 3, \ldots$) input to explore possible trends and explanatory factors, and the null model was extended as: $\log(\pi_{ij}) = \text{offset}_{ij} + \beta_{0j}\text{cons} + \beta_{1j}x_1 + \beta_{2j}x_2 + \cdots\beta_{mj}x_m$, where β_{1j}, β_{2j}, …, β_{mj} is the fixed-effects coefficient for each variable at level 1.

Trends in suicide were investigated by adjusting for age, gender (and potential interactions of age and gender) and year (to explore linear time trends) as individual-level fixed effects in regression models. Regional differences in trends were investigated initially by fitting a random slope for the year variable for each DSPs point. Further exploration involved adjusting for fixed effects of the urban–rural residence and regional variables, followed by interaction terms (urban–rural residence × region) fitted between each of these variables and year to investigate temporal variations in suicide by geographic context. To investigate the role of identified sociodemographic determinants associated with suicide, the mean years of education and the proportion of divorced population variables for each point of the DSPs were added sequentially to models.

Collective interpretation of the intercept variance, slope variance and covariance between intercepts and slope, and associated standard errors indicated the extent to which suicide rates varied spatiotemporally. The median rate ratio (MRR) (Merlo *et al.* 2006) was selected to estimate geographic variation between points of the DSPs, which was defined as the median value of the rate ratio (RR) between the point at highest risk and the point at lowest risk when randomly picking out two points. MRR was calculated by translating the area-level variance in RR scale as: $\text{MRR} = \exp(\sqrt{2 \times V} \times 0.6745)$, where V is the area-level variance and 0.6745 is the 75th centile of the cumulative distribution function of the normal distribution with mean 0 and variance 1. A MRR equal to 1 suggests no geographic variation in the outcome variable, whereas values above 1 indicate geographic variation. Proportional change in variance (PCV) (Merlo *et al.* 2005) was used to explain the contributions of variables entered into models, compared with the reference model. The equation for PCV is: $\text{PCV} = (\text{Vr} - \text{Vc})/\text{Vr}$, where Vr is the variance in the empty model (reference

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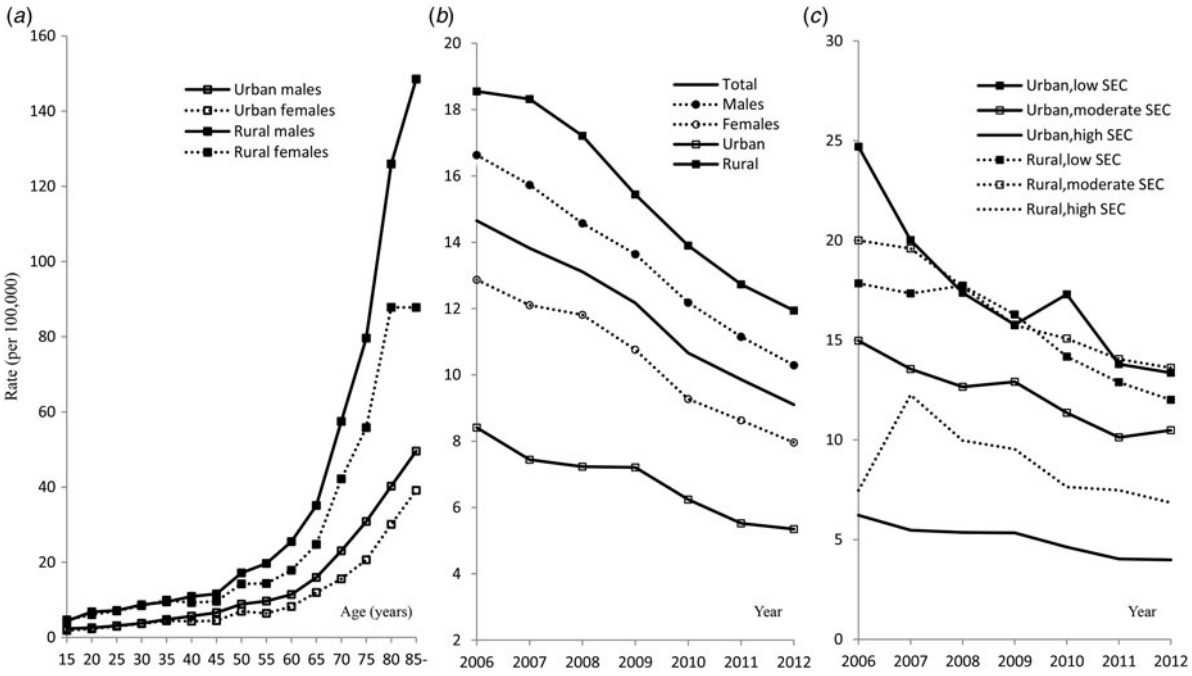

Fig. 2. (*a*) Age-specific suicide rate; (*b*) age-standardized suicide rate by gender and urban–rural residence among people aged 15 years and above; (*c*) age-standardized suicide rate by urban–rural residence and socio-economic circumstances (SEC) among people aged 15 years and above in China (per 100 000), 2006–2012.

model) and Vc is the variance in the model with variables entered. All fixed-effect parameters were exponentiated and expressed as RR with 95% confidence intervals (CIs). Data compilation and statistical analyses were conducted in SAS 9.3 (SAS Institute, Inc., USA) and MLwiN 2.30 (University of Bristol, UK).

Results

Suicide rates in China for the study period (2006–2012) were higher in older age groups compared with younger age groups (Fig. 2*a*). The rate was higher in those aged 15–44 years, and increased substantially in those aged older than 45 years, peaking in rural males aged over 75 years. Suicide rates across all age groups were highest in rural males, followed by rural females, urban males and urban females. Age-standardized suicide rates declined over the study period, from 15 per 100 000 in 2006 to 9 per 100 000 in 2012 (overall decline of 38%) with a similar decline in males and females, and in both urban and rural areas (Fig. 2*b*, online Supplementary Table S1).

There was substantial regional variation in suicide over the study period. Suicide rates were higher in Central China for rural areas and in Southwest and Northwest China for urban areas. North China had the lowest suicide rates in both urban and rural areas. Overall trends in urban areas remained relatively stable for North, East and Northwest China and declined in other regions, whereas suicide rates declined in all rural areas (online Supplementary Fig. S1, Table 1). Socio-economic differentials within urban and rural areas were also evident, with higher suicide rates evident in lower SEC areas (as measured by mean years of education) compared with higher SEC areas in both urban and rural areas (Fig. 2*c*). However, the absolute rate difference between the lowest and highest SEC groups was greater in urban areas than in rural areas (Fig. 2*c*).

Analysis of the geographic variation in suicide rates showed a twofold median difference in suicide rates between DSPs points (MRR: 2.06), and significant variation (variance = 0.002, S.E. = 0.001) in DSP slopes over time indicating spatiotemporal variation (Table 2). Approximately 23% of the DSP-level variation in suicide rates was explained by adjustment for geographic regions in model 2, which increased to 36% after including urbanicity of residence in model 3. Suicide rates were higher in Central (RR 2.21, 95% CI 1.53–3.19), Southwest (RR 1.95, 95% CI 1.37–2.76), East (RR 1.81, 95% CI 1.31–2.49) and Northwest China (RR 1.56, 95% CI 1.07–2.26) compared with North China in model 3 (Table 2). Model 3 also showed significantly higher rates of suicide in rural areas (RR 2.13, 95% CI 1.74–2.60) compared with urban areas (Table 2). No statistical differences were found for interactions of age and urbanicity, gender and urbanicity, and urbanicity and region.

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Table 1. *Age-standardized mortality (per 100 000) of suicide among people aged 15 years and above in China, by geographic region, 2006–2012*

Region	2006	2007	2008	2009	2010	2011	2012	Total
North	6.87	7.33	6.53	6.27	5.52	5.75	4.91	6.09
Urban	3.46	4.11	3.37	3.09	3.21	3.28	2.41	3.23
Rural	10.03	11.09	10.17	9.57	7.95	8.36	8.01	9.23
East	13.24	12.49	13.22	12.87	10.90	9.41	9.28	11.49
Urban	6.31	6.62	7.88	7.95	7.04	5.70	5.93	6.77
Rural	17.85	17.83	18.02	16.89	14.12	12.39	12.56	15.49
Central	23.14	21.49	21.48	17.88	17.02	15.89	14.22	18.54
Urban	12.14	9.80	10.86	10.11	9.26	7.33	7.29	9.37
Rural	27.73	26.14	25.05	20.49	20.21	19.29	17.37	22.13
South	9.92	8.85	8.93	8.95	7.58	7.79	7.25	8.36
Urban	6.23	6.33	6.20	6.25	4.09	4.89	3.16	5.33
Rural	12.86	10.62	10.50	10.60	10.37	8.74	8.71	10.09
Southwest	16.83	16.42	14.86	13.05	12.26	10.87	9.72	13.25
Urban	18.10	13.66	10.66	9.84	8.41	7.38	6.96	10.13
Rural	16.36	17.87	17.25	14.92	14.54	12.90	11.39	14.98
Northwest	13.28	16.00	13.16	12.25	9.14	8.80	8.04	11.35
Urban	15.21	14.59	10.31	9.81	6.33	6.86	5.51	9.36
Rural	12.51	16.41	14.15	13.34	10.46	9.39	9.18	12.13
Northeast	10.15	10.02	8.51	9.12	7.08	6.71	6.44	8.19
Urban	5.43	4.71	4.41	5.09	4.66	4.49	5.08	4.83
Rural	16.04	15.67	12.77	12.71	10.08	9.26	7.91	11.87

Additional models also incorporated adjustments for county-level social factors (Table 3). Model 4 showed significantly higher suicide rates for low-SEC areas compared with high-SEC areas (RR 1.85, 95% CI 1.31–2.62) which accounted for approximately 10% of the DSP-level variation. There was little statistical evidence for interaction effects between SEC and urbanicity of residence. A high proportion of divorced population was associated with lower suicide rates (RR 0.60, 95% CI 0.46–0.79) and accounted for approximately 7% of the geographic variation (model 5). In analyses stratified by age, lower rates of suicide associated with higher proportion of divorced population were more prominent in younger females (<50 years), whereas in younger males (<50 years) higher divorce rates were associated with increased risk of suicide (not shown).

Discussion

This study investigated trends and differentials in suicide in China for the period 2006–2012, and found that previously reported decreases in suicide for earlier periods (Phillips *et al.* 1999, 2002*a*; Yip *et al.* 2005, 2008) have continued. This is consistent with total mortality declines in China, although for other non-communicable outcomes (such as ischaemic heart disease, some cancers and road traffic injury) mortality has increased over this period (Yang *et al.* 2013).

Importantly, a number of reported epidemiological patterns appear to have changed in the most recent decade. Previous nationwide studies on suicide in China before 2000 showed higher rates in females than males (Phillips *et al.* 1999, 2002*a*; Ji *et al.* 2001; Qin & Mortensen, 2001; Yang *et al.* 2004; Yip *et al.* 2005, 2008); however, in the present study male suicide rates were higher than female suicide rates in both urban and rural areas (also noted in other recent studies) (Cai *et al.* 2012; Zhang *et al.* 2014). The male:female ratio has increased from 0.76 in 1991 and 0.95 in 2000 (Yip *et al.* 2005) to 1.28 in 2012, implying an upward trend for males in China relative to females (and similar to countries such as India and Pakistan) (World Health Organization, 2014). In western countries, the male:female ratio of completed suicide is usually greater than 2 (for example, Australia, the USA and UK) and in some cases greater than 3 (for example, Russia, Kazakhstan, Ukraine and Belarus) (Cantor, 2000; World Health Organization, 2014).

Additionally, previously reported higher rates of suicide among young adults aged 15–34 years, particularly for rural females (Phillips *et al.* 1999, 2002*a*; Yang *et al.* 2004), were not evident in age-specific analyses in the present study. This decrease in young adult suicide rates has occurred contemporaneously with continued increases in urbanization and economic development, and is perhaps associated with

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Table 2. *Geographical variations in suicide, adjusted for differences between geographic regions and between urban and rural DSP*

	Model 1		Model 2		Model 3	
	RR (95% CI)	*p*	RR (95% CI)	*p*	RR (95% CI)	*p*
Fixed effects						
Time (years)	0.92 (0.91–0.93)	<0.0001	0.92 (0.91–0.94)	<0.0001	0.92 (0.91–0.94)	<0.0001
Gender (ref: males)	1.00		1.00		1.00	
Females	0.93 (0.86–0.99)	0.0261	0.91 (0.86–0.97)	0.0040	0.91 (0.86–0.96)	0.0012
Age (ref: 15–44 years)	1.00		1.00		1.00	
Age2: 45–64 years	2.03 (1.89–2.17)	<0.0001	1.99 (1.87–2.11)	<0.0001	2.01 (1.89–2.13)	<0.0001
Age3: ⩾65 years	6.41 (6.00–6.87)	<0.0001	6.20 (5.83–6.60)	<0.0001	6.14 (5.79–6.51)	<0.0001
Gender × age (ref: age1: males × age1)	1.00		1.00		1.00	
Females × age2	0.80 (0.72–0.88)	<0.0001	0.81 (0.74–0.88)	<0.0001	0.80 (0.74–0.88)	<0.0001
Females × age3	0.77 (0.70–0.85)	<0.0001	0.78 (0.71–0.85)	<0.0001	0.79 (0.72–0.86)	<0.0001
Region (ref: North)			1		1	
East			1.73 (1.22–2.45)	0.0021	1.81 (1.31–2.49)	0.0003
Central			2.15 (1.44–3.21)	0.0002	2.21 (1.53–3.19)	<0.0001
South			1.26 (0.80–1.98)	0.3173	1.26 (0.84–1.91)	0.2654
Southwest			2.09 (1.43–3.06)	0.0001	1.95 (1.37–2.76)	0.0002
Northwest			1.66 (1.11–2.49)	0.0141	1.56 (1.07–2.26)	0.0207
Northeast			1.23 (0.81–1.87)	0.3335	1.37 (0.93–2.01)	0.1073
Urbanicity (ref: urban)					1.00	
Rural					2.13 (1.74–2.60)	<0.0001
Random effects						
DSP intercept variance (S.E.)	0.571 (0.066)	<0.0001	0.440 (0.051)	0.0230	0.368 (0.043)	0.0066
MRR	2.06		1.88		1.78	
PCV, %			22.94		35.55	
DSP slope variance by year (S.E.)	0.002 (0.001)	0.0455	0.003 (0.001)	0.0027	0.003 (0.001)	0.0027
Covariance between intercepts and slope (S.E.)	0.010 (0.005)	0.0455	0.001 (0.004)	0.7988	0 (0.004)	1.0000

DSP, Disease Surveillance Points; RR, rate ratio; CI, confidence interval; ref, reference; S.E., standard error; MRR, median rate ratio; PCV, proportional change in variance in model *x* compared with model 1.

commensurate increases in economic and educational opportunities and greater ideological emancipation for young adults.

This study also found substantial geographic variation in suicide across China's major geographic regions. The suicide rate varied over twofold across China. Central China had the highest suicide rates compared with the other six regions after adjustment for demographic factors and covariates. Southwest, East and Northwest China had higher suicide rates, while the North, South and Northeast China had lower rates. Numerous studies have shown that socioeconomic characteristics (Phillips *et al.* 1999; Rehkopf & Buka, 2006), and psychological and mental factors (Phillips *et al.* 1999, 2002*b*; Qin *et al.* 2000; Hu *et al.* 2010; Li *et al.* 2011; Sun *et al.* 2011) are associated with suicide rates, and the geographic variation found in our study implies that variation in these key determinants are likely to underlie this variation in suicide, and represent modifiable antecedents that can be used to inform local prevention and control strategies.

The present study also found that the disparity between urban and rural areas has narrowed in the most recent period. The rural:urban ratio was 2.13 after controlling for gender, age and regions, compared with previous studies where this ratio was greater than 3 (Qin & Mortensen, 2001; Phillips *et al.* 2002*a*). In the present study, 'district' was broadly defined as urban while 'county' was defined as rural, but, in fact, there are agricultural populations that reside within 'districts' and non-agricultural populations that reside in rural areas. If we defined the urban/rural areas completely according to whether the population resided in agricultural villages or non-agricultural townships, the disparity between urban and rural areas would probably be larger. Suicide in rural areas, particularly among the elderly, remains an important public health issue and worthy of attention in China (Cai *et al.* 2012).

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Table 3. *Geographical variations in suicide, adjusted for county-level risk factors*

	Model 4		Model 5	
	RR (95% CI)	*p*	RR (95% CI)	*p*
Fixed effects				
Time (years)	0.92 (0.91–0.94)	<0.0001	0.92 (0.91–0.94)	<0.0001
Gender (ref: male)	1.00		1.00	
Female	0.90 (0.85–0.96)	0.0007	0.90 (0.85–0.96)	0.0007
Age (ref: age1: 15–44 years)	1.00		1.00	
Age2: 45–64 years	2.01 (1.89–2.13)	<0.0001	2.00 (1.89–2.11)	<0.0001
Age3: ⩾65 years	6.07 (5.73–6.44)	<0.0001	6.04 (5.70–6.41)	<0.0001
Gender × age (ref: males × age1)	1.00		1.00	
Females × age2	0.81 (0.74–0.88)	<0.0001	0.81 (0.74–0.88)	<0.0001
Females × age3	0.79 (0.73–0.86)	<0.0001	0.79 (0.73–0.86)	<0.0001
Region (ref: North)	1.00		1.00	
East	1.61 (1.19–2.18)	0.0020	1.64 (1.23–2.18)	0.0006
Central	2.18 (1.55–3.06)	<0.0001	2.23 (1.62–3.07)	<0.0001
South	1.18 (0.80–1.74)	0.3994	1.20 (0.83–1.74)	0.3382
Southwest	1.60 (1.12–2.30)	0.0102	1.95 (1.38–2.75)	0.0002
Northwest	1.63 (1.15–2.32)	0.0062	1.73 (1.24–2.42)	0.0012
Northeast	1.17 (0.82–1.68)	0.3820	1.54 (1.08–2.22)	0.0181
Urbanicity (ref: urban)	1.00		1.00	
Rural	1.47 (1.11–1.95)	0.0071	1.32 (1.00–1.73)	0.0463
SEC[a] (ref: high)	1.00		1.00	
Moderate	1.75 (1.31–2.33)	0.0001	1.52 (1.15–2.01)	0.0033
Low	1.85 (1.31–2.62)	0.0005	1.63 (1.17–2.26)	0.0037
Percentage divorced[a] (ref: low)			1.00	
Moderate			0.91 (0.72–1.14)	0.4030
High			0.60 (0.46–0.79)	0.0002
Random effects				
DSP intercept variance (S.E.)	0.313 (0.037)	0.0014	0.274 (0.032)	0.0003
MRR	1.71		1.65	
PCV, %	45.18		52.01	
DSP slope variance by year (S.E.)	0.004 (0.001)	0.0001	0.004 (0.001)	0.0001
Covariance between intercepts and slope (S.E.)	0 (0.004)	1.0000	−0.001 (0.004)	0.7988

RR, Rate ratio; CI, confidence interval; ref, reference; SEC, socio-economic circumstances; DSP, Disease Surveillance Points; S.E., standard error; MRR, median rate ratio; PCV, proportional change in variance in model *x* compared with model 1.

[a] Each of these variables was divided into tertiles representing 'low', 'moderate' and 'high' groups.

Similar to previous studies, the suicide rate in China has continued to decrease continuously from 2006 to 2012 (in both males and females, and urban and rural areas). The present study extends this previous research to an investigation of possible explanatory factors and sources of geographic variation for the recent trends. We found a lower suicide rate in high-SEC areas than in low- and moderate-SEC areas, with SEC accounting for 10% of the DSP-level variation. As an important component of SEC, education has been recognized as an important and modifiable socio-economic determinant of suicide internationally (Qin *et al.* 2003; Rehkopf & Buka, 2006; Qi *et al.* 2010; Page *et al.* 2014).

We also found a negative association between suicide and the proportion of divorced population, which was stronger in younger-age (<50 years) women. Previous studies have shown a positive association between suicide and being divorced in aggregate studies (Hong & Knapp, 2013; Kõlves *et al.* 2013) and also in individual-level studies (Fukuchi *et al.* 2013). However, other aggregate (Burr *et al.* 1997) and individual-level (Ikeda *et al.* 2007) studies have also shown higher divorce rates and female labour force participation to be associated with lower suicide rates. This is also the case in East-Asian countries, for example Hong Kong, Japan and South Korea, where it has been suggested that East-Asian cultures are

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more collectivist and have a long-term orientation (in contrast to more individualistic and short-term orientated societies, such as the USA and Australia), which leads to lower suicide rates by facilitation of social networks, adaptation to circumstances, thrift and perseverance (Yip *et al.* 2015). In the Chinese context, higher divorce rates are more likely to benefit women, and perhaps reflect these cultural characteristics coupled with a more relaxed attitude to changes in marital status and greater economic independence in younger-age women in more recent periods.

A limitation of the study was that area-specific data on mental disorder was not available for the present study, and is a key risk factor for suicide, and has also been acknowledged as a critical health social problem by the Chinese government. The Chinese government has begun to focus on the management and treatment of severe mental disorders in recent years (National Health and Family Planning Commission, 2012, 2013), and implemented reforms for the first time to national mental health laws in 2012 (Standing Committee of the National People's Congress, 2012). This has included the development of mental health surveillance systems for incidence reporting and management of severe mental disorders, and also establishment of relevant information-sharing mechanisms between jurisdictions. Additional reforms include the regulation of the classification, diagnosis and treatment criteria for mental disorders, and the eligibility of health institutes and health professionals for the diagnosis and treatment of mental disorders. The reforms also include mechanisms for the provision of financial support for service access and treatment for mental disorders and a greater prominence of the development of mental health courses for students in medical colleges and universities. More in-depth investigations are required to explore the potential effects of mental health policy on mental disorders and other psychological antecedents associated with suicide in China.

An additional limitation was that the mortality counts we used were extracted from the DSPs without assessing the accuracy of cause of death. The DSPs is a nationally representative sample registration system (with a total population coverage of 6%), with cases of death enumerated through hospitals, household surveys, and data exchange with police stations and maternal and child health departments. Attribution of cause is made by trained coders in hospitals and CDC staff, and while strategies are in place to monitor data quality, misclassification remains a potential source of bias. For example, Wang *et al.* (2003) conducted an evaluation of misclassification of suicide within the DSPs for the period 1995–2000, and reported that 1.9% of suicides should be redistributed to other external causes, whereas 5.4% of 'other' external causes, 48.6% of 'unknown' external causes and 15.0% of deaths attributed to psychiatric disorders should be re-distributed to suicide. Thus, the rates in the present study are probably an underestimate of suicide in China, and it is not clear the extent to which misclassification differs across DSPs points and over the study period, limiting definitive inter-regional comparisons.

Second, this is an ecological study of a time series of suicide rates, and risk factor adjustment was limited to population-level point estimates derived from a single census year (2010). The strength or otherwise of putative aetiological associations between risk factors and suicide needs to be interpreted cautiously. For example, SEC in the present study related to the proportion of the county population with a given level of education, not the educational status of the individuals residing in the county. Additionally, it was not possible to incorporate other potentially important risk factors such as income, mental disorders, psychiatric management policies and mental health services in this time series due to a lack of reliable data on the DSPs scale. Although some variables, such as divorce, were considered in this study, these were ecological measures based on the geographic units of analysis. Approximately half of the DSP-level variation was accounted for by the fitted variables, suggesting that there were other important explanatory factors not included in the present study and efforts still need to be made to investigate and monitor the trends of these factors.

In conclusion, this study has shown spatiotemporal variation in suicide rates over the period 2006 and 2012, and recent shifts in age- and gender-specific patterns of suicide. The development of education, the improvement of social and economic circumstances, and perhaps greater ideological emancipation among younger age cohorts (than in older age cohorts) appear to be reflected in continued declines in suicide over time, particularly in younger age groups and women. Older age groups, especially residing in rural areas, continue to have the highest suicide rates, and elderly family support and aspects of the social security system relating to aged care remain key policy challenges in suicide prevention in China. There has been substantial migration of working-age adults in China from rural to urban areas, associated with declines in continuing care for the elderly people at home (Chan *et al.* 2013). The geographic variation in suicide signifies the importance of understanding the distribution of social and psychiatric determinants of suicide across different regions in China, in order to inform locally specific suicide prevention activities.

Supplementary material

For supplementary material accompanying this paper visit http://dx.doi.org/10.1017/S0033291715001269

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Declaration of Interest

None.

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