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An ecological study of social fragmentation, socioeconomic deprivation, and suicide in rural China: 2008–2010

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ABSTRACT

China accounts for a large number of suicides worldwide, and most occur in rural areas. Suicide research in China has primarily focused on individual-level risk factors, few have studied the influence of neighborhood contexts. This ecological study examines the association of suicide rates with social fragmentation and socioeconomic deprivation in Chinese rural villages. Data from the community survey of the China Health and Retirement Longitudinal Study were analyzed using negative binomial regression. A total of 307 rural villages were included. The community survey collected data about the villages from local leaders. Suicide counts were measured by the leaders' report of the number of suicide deaths in the villages. Social fragmentation was indicated by out-migration, in-migration and ethnic diversity; socioeconomic deprivation was indicated by physical infrastructure, illiteracy rates and public transit accessibility. Results show that higher incidence rates of suicide occurred in villages with high proportions of out-migration (vs. low), inflow of migrants (vs. no migrants), mixes of Han and ethnic minority residents (vs. Han only), high degrees of infrastructure deficiency (vs. low) and poor access to public transportation (vs. excellent). Villages with higher percentages of older adults also had higher suicide rates. This is one of the first studies to examine the association between neighborhood contexts and suicide in China. The findings have implications for suicide prevention in rural China.

Introduction

Suicide is a tragic end of life and a major public health issue that accounted for 804,000 deaths worldwide in 2012 (WHO, 2014). China was the second top contributor to that number, due partly to its large population. Suicide rates have been consistently higher in rural China than in the country's urban areas (Liu et al., 2015; Phillips et al., 2002; Wang, Chan, & Yip, 2014). During the period 2009–2011, 79% of completed suicides in China occurred among rural residents (Wang et al., 2014) although only about half of the Chinese population lived in rural areas (National Bureau of Statistics of China, 2012).

Most suicide research in China has focused on individual-level risk factors (see Li, Li, & Cao, 2012 for a review). The knowledge generated from this line of research, while valuable, has limitations for suicide prevention and may mask plausible fundamental causes of suicide (Rehkopf & Buka, 2006). Some studies have employed aggregate data to identify gender, age, and rural-urban

patterns of suicide in China (Liu et al., 2015; Phillips, Li & Zhang, 2002; Wang et al., 2014). One found that counties with higher socioeconomic levels (as measured by the inhabitants' mean years of education) had lower suicide rates, and that higher proportions of divorced people were associated with lower suicide rates in young females (Liu et al., 2015). Another study found that perceived community stress and problems were correlated with the risk of suicide among rural young adults (Zhang & Wang, 2012). Overall, few studies have examined the influence of neighborhood-level factors on suicide in China. Using data from a nationally representative survey, this ecological study examines the associations between village characteristics that are related to social fragmentation and socioeconomic deprivation and suicide rates in Chinese rural villages.

Social fragmentation and suicide

French sociologist Émile Durkheim, in his influential book *Suicide*, suggests that even though suicide is an individual act with individual causes, suicide rates are social facts and can be explained by two dimensions of the social environment—integration and regulation (Durkheim, 1897). Social integration refers to the degree to which

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members of a social group share collective sentiments and bind together, and social regulation is the degree to which individuals are constrained by social norms and values. Durkheim develops a typology of suicide and suggests that the two most common types—egoistic and anomie suicide—are results of low levels of social integration and social regulation, respectively.

Based on Durkheim's theory, many studies have examined the association between social fragmentation and suicide (Collings, Ivory, Blakely, & Atkinson, 2009; Gunnell, 2005; Hong & Knapp, 2013; Hooghe & Vanhoutte, 2011), although the term "social fragmentation" has been used without great precision. Generally, social fragmentation is used to mean, "relatively low levels of community integration linked to high number of nonfamily households (e.g., one person households, unmarried adults) and high residential turnover" (Congdon, 2012, p.161). Gunnell (2005) reported that a common finding across epidemiological studies of suicide was that areas characterized by high levels of social fragmentation had the highest rates of suicide. Some multilevel studies (Denney, Wadsworth, Rogers, & Pampel, 2015; Martikainen, Mäki, & Blomgren, 2004) have also confirmed Gunnell's observations. For example, Denney et al. (2015) found that adults living in American cities with low percentages of family households had higher odds of suicide, controlling for individual-level socioeconomic status, marital status, family size and other characteristics. In contemporary China, social fragmentation might have increased for the reasons detailed below.

Since the transition to a market economy in the late 1970s, Chinese society has undergone rapid socioeconomic and demographic changes. One of the most salient of these changes is internal migration. China began implementing a household registration system (hukou) which restricts individuals from moving to another location in 1958 (Wang, 2005). This restriction was relaxed though not completely removed in the 1980s, as the demand for cheap labor supply in urban areas increased. About 170 million Chinese adults of rural origin were working in cities in 2014 (National Bureau Statistics of China, 2014). This huge migration has profoundly changed traditional family life in rural China. For instance, an estimated 28.3% of rural children and 37% of rural older adults were left behind by migrating workers (He et al., 2015; Jia & Tian, 2010). High risks of mental health problems among the left-behind (He et al., 2015; Wang et al., 2015) as well as problems resulting from population loss can contribute positively to suicide rates in rural communities as suggested by a Japanese study (Otsu, Araki, Sakai, Yokoyama & Voorhees, 2004).

At the same time, China's rural communities are themselves more likely to harbor migrants now than in the past. Loosening of residential restriction and rapid development of the economy have not only enabled the large scale of rural-to-urban migration, but also made other types of migration, such as rural-to-rural and urban-to-rural, possible. In most rural communities, inhabitants had known each other over multiple generations. Now, having migrants mixed into the population may disturb the tightly-knit social networks and traditional lives in rural villages, and may lead to less cohesive communities (Neal & Neal, 2014).

In addition to migration-related social changes, ethnic diversity is a longstanding yet often overlooked factor that may affect community cohesion in China. Although over 90% of the Chinese population belong to the largest ethnic group, Han, officially China recognizes 55 ethnic minority groups. Rural China is home to many of these groups, to whom special political, economic and social policies apply (Gustafsson & Ding, 2009). In recent years, ethnic minority tensions have increased across China, due partly to discrimination and disadvantages experienced by ethnic minorities in the new market economy (Hasmath, 2014). Furthermore, Western studies have shown that ethnic heterogeneity is negatively associated with trust in others (Putnam, 2007).

Socioeconomic deprivation and suicide

Area socioeconomic conditions have been studied extensively with regard to suicide. In their review of the literature, Rehkopf and Buka (2006) concluded that studies overall support an inverse association between area socioeconomic conditions and suicide, especially when smaller geographic units and area poverty or deprivation measures are used. Recent studies in some Asian and Western nations also support a strong association between area socioeconomic conditions and suicide (Chang et al., 2011; Denney et al., 2015).

In China, geographic disparities in socioeconomic conditions have been widening since the economic reform (Xie & Zhou, 2014). However, research on social stratification in China tends to focus on the rural-urban divide or regional disparity, thereby inappropriately ignoring substantial inequalities within the rural stratum. In rural China, three characteristics—physical infrastructure, education and transportation—are reasonable indicators of area socioeconomic conditions.

Basic physical infrastructure, such as running water and sewage systems, is essential to maintain a basic standard of living. In rural China, local-level infrastructure is primarily the responsibility of local communities (Lin, Tao, & Liu, 2006), so poor villages are likely to lack basic infrastructure, making rural existence very challenging. Moreover, given China's remarkable economic growth in recent decades, living in villages with deficient infrastructure may increase sense of relative deprivation and risks of depression (Li, Liu, Zhang & Xu, 2015).

As the market economy steadily matures and returns on human capital continue to grow, education has become the most important means to move up the social ladder in China (Meng, Shen & Xue, 2013). Limited educational opportunities, as reflected by high rates of illiteracy, reduce the chance for upward mobility of individuals and inhibit social and economic development of the area.

Without easy access to public transportation, it becomes harder for residents to access health and social services which not only delays treatment but also increases levels of stress of those with physical and mental health problems. Difficulty accessing public transportation also increases risks of social isolation and depression. While public transit accessibility is conceived as an indicator of socioeconomic deprivation, geographic remoteness has the potential to operate as an independent risk factor of suicide as well (Cheung, Spittal, Pirkis & Yip, 2012).

Defining geographic areas

In this study, we used statutory villages in China to define rural areas. Villages are the smallest scale in the Chinese administrative hierarchy, and are the basic production and social units in rural China. They have well-defined geographic, economic and administrative boundaries. Each village has a village committee with designated officials, such as village head and accountant (Oi & Rozelle, 2000). Village committee is the organization of self-government in the countryside of China. Under the rules and regulations set by the Organic Law of the Villagers Committees, villagers may self-govern their own affairs, serve their own needs, and conduct election (China.org.cn).

It should be noted that defining rural and urban has been a confusing matter in China (Chan, 2009). Not only that different agencies use different definitions, China's economic development and rapid urbanization have expanded the urban boundary in a fast pace (Kamal-Chaoui, Leman, & Zhang, 2009). Our definition of rural could have included villages that are transitioning to become urban as defined by the National Bureau of Statistics of China (NBS).

Hypotheses

We hypothesize that villages with higher levels of out-migration and migrant inflows, and that are ethnically diverse, will have higher rates of suicide. We also expect that villages with higher levels of infrastructure deficiency and illiteracy, and lower levels of public transit accessibility, will have higher suicide rates.

Methods

Data source

Data for this study were from a community survey that was part of the 2011 baseline national survey of the China Health and Retirement Longitudinal Study (CHARLS). The CHARLS was a survey of the middle-age and older population of China, and the sample was obtained through multistage probability sampling. Detailed sampling procedure has been described elsewhere (Zhao et al., 2013).

Our sample included 307 rural villages[1] across 27 of China's 31 provinces. As mentioned, village committees and leaders are responsible for governing their villages, including managing the land and collective enterprises, maintaining public security, and mediating disputes among villagers (Levy, 2010). The community survey collected data on the social, economic, and policy environments of the villages from face-to-face interviews with members of the village committee. Those who were most familiar with information in a topic area were requested to answer questions pertaining to that area, and they were asked to look up relevant statistics at the time they completed the survey.

Variables and measures

Suicide

The dependent variable was the total number of suicide deaths in the village in the previous three years (2008–2010). This number was based on village leaders' reports. In rural China, over 80% of all deaths occur at home (Yang et al., 2005) and village doctors (health workers with basic medical training) sign most of the death certificates (Hendin et al., 2008). In most villages, village doctors have a close relationship with the village committee and are likely to inform the leaders in the case of suicide. In addition, rural villages in China are tight-knit communities where news spread quickly through informal networks. Village leaders have an interest to keep tab of what is happening in the village and should be knowledgeable about local suicides.

China does not have complete mortality registration system. Currently two death registration systems—the Ministry of Health–Vital Registration (MOH-VR) and the Disease Surveillance Points (DSP)—are in operation (Yang et al., 2005). But neither covers the whole population: MOH-VR covers 8% of the Chinese population and the sites are located mostly in eastern and central regions; the DSP consists of 145 points which were selected to represent the overall Chinese population and covers about 1% of the population. In areas where MOH-VR or DSP system is operating, family reports the death to the nearby township hospital to get a death certificate. Both systems rely on information obtained from family members to determine cause of death (Hendin et al., 2008), and there is no medical examination for unnatural or accidental deaths (Phillips et al., 2002). In places not covered by either the MOH-VR or DSP system, suicides are not necessarily reported to entities outside the village.

Social fragmentation

Out-migration

The CHARLS community survey included a question asking the total number of village inhabitants who worked outside the village for more than three months in the prior year, and another question about the number of village residents 16 years old or older. Assuming most or all of the migrant workers had reached 16 years of age, we multiplied by 100 the ratio of the responses to these two questions, and used it as a measure of village-level out-migration. Because of a skewed distribution, the out-migration variable was divided into quintiles.

In-migration

The community survey asked about the total number of people who lived in the village for 6 months or longer in the year prior (used to indicate population size in this study) as well as the number who did *not* have local household registration (*hukou*). We divided the number lacking *hukou* by the total, and used a 4-category variable to indicate levels of migrant inflow. Most villages had no migrants. These were coded 1. The rest were tertiled, representing low (2), moderate (3) and high (4) proportions of inmigrants.

Ethnic diversity

The community survey asked about the number of households belonging to ethnic minority groups in the village. We created a 3-category variable to represent ethnic diversity: villages with Han people only, villages with both Han people and ethnic minorities, and villages with ethnic minorities only.

Socioeconomic deprivation

Infrastructure deficiency

We constructed an infrastructure deficiency index by applying principle component analysis (PCA) to seven indicators: road type (paved=0, not paved=1), days road not passable in a year (0 days=1, < 1 month=2, > 1 month=3), sewer system (had sewer system=0, no sewer system=1), waste management (waste moved away by trucks=1, waste buried/burned/put into river locally=2, no waste management=3), toilet (flushable=1, not flushable=2, open-air=3), drinking water (all households used tap water=1, some households did=2, no households did=3) and fuel source (no household used hay=1, some households did=2, all households did=3). Scores of the first component, which accounted for 54.7% of the variance, were divided into quintiles to indicate deficiency in physical infrastructure.

Public transit accessibility

The community survey asked about the distance, in kilometers, from the village office to the closest public transportation (train station or bus stop). We converted the metric measure to walking distance, using conventional standard of 80 m to a one-min walk. Because of a skewed distribution, we categorized the walking distance into four groups to denote levels of accessibility to public transportation: excellent (a less-than-5-min walk), good (a walk of 5 to less than 30 min), poor (a 30- to 60-min walk), and very poor (a walk of more than 60 min).

Illiteracy rates

This refers to the percentage of the adult population that was illiterate. In the community survey, the village leaders either gave a percentage or indicated it in a 20% interval range (e.g., 0–20%, 20–40%). The interval-type response (*n*=12) was converted to a number using the mid-point.

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[1] Six neighborhoods in the CHARLS had both village and community (urban) committees. These six were regarded as rural villages for the purposes of our study.

Population composition

It is important to control for composition effects in the analysis. Given reports of variation in suicide rates across age groups (Liu et al., 2015) and gender (Phillips et al., 2002) in rural China, we controlled for age and sex compositions of the villages using the two variables below.

Older adult percentage

We divided the total number of village inhabitants aged 65 or older by the total population and multiplied by 100 to obtain this measure.

Sex ratio

This was calculated as the ratio of males to females among village inhabitants aged 16 and older.

Data analysis

We used negative binomial regression to analyze the data, as the likelihood ratio test of the dispersion parameter alpha indicated that the dependent variable was overdispersed ($\chi^2 = 380$, $p < .001$). We had fitted a zero-inflated negative binomial regression model and that was not significantly different from a standard negative binomial regression model ($z = .91$, $p = .18$). The population size (natural logarithm) of the villages was included as an exposure in all negative binomial regression models, thereby suicide rates were analyzed.

Considering that the village characteristics we examined were likely to be intercorrelated, we took several steps to understand the association of each with suicide. First, we examined the bivariate relationship between the village-level characteristics and suicide. Then we examined how social fragmentation was associated with suicide by entering the three indicators (i.e., out-migration, in-migration and ethnic diversity) in a block to the model. We did the same for socioeconomic deprivation (infrastructure deficiency, illiteracy rates and public transit accessibility). Finally, we included all indicators of social fragmentation and socioeconomic deprivation—as well as the percentage of older adults and the sex ratio—into a full model for suicide.

The amount of missing values was modest, the highest percentage (4.2%) being for older adults (see Table 1). Two cases were recoded "missing" in population size and another two were recoded "missing" in in-migration, due to unreasonable values in the variables. We conducted multiple imputation (Little & Schenker, 1995). The results reported below were based on analysis of ten imputed datasets. Because some villages were located in the same province, we used robust standard errors to account for a possible within-province correlation in the outcomes. All analyses were carried out using Stata 13 (StataCorp, 2013). All coefficients were exponentiated to interpret the results as incidence rate ratios (IRRs). A significance level of $< .05$ was used.

Results

Descriptive findings

Table 1 presents the summaries of suicides and characteristics of the villages in the sample. In total, 155 suicides occurred in the sampled villages over the three years (2008–2010). The number of suicides across the villages ranged from 0 to 18, with 99% of villages reporting suicide deaths between 0 and 7. Two villages are outliers; one reported 16 and another 18 suicides. A sensitivity check regarding these two outliers is presented later.

With population size defined as the total number of people living in the village for more than 6 months during calendar year

Table 1
Summary statistics for number of suicides and village characteristics in the sample.

Variables	Medium	Mean	SD	%	Range	Valid *n*
Number of suicides	0	.5	1.7		0–18	300
0				81.0		243
1				8.3		25
2				5.0		15
3+				5.7		17
Population size	1764	2503	2783		100–30000	305
Out-migration (%)	25	31.0	24.6		0–100	296
1st quintile (lowest proportion)	3.8	3.8	2.5		0–8	59
2nd quintile	13.6	13.6	3.3		8.3–19	59
3rd quintile	25	25.5	4		19.1–32.3	59
4th quintile	41.7	41.9	5.8		32.4–50.7	59
5th quintile (highest proportion)	64.5	69.5	16.5		51–100	60
In-migration[a] (%)	0	5.2	13.9		0–92.7	303
1 (none)	0	0	0	50.2	0	152
2 (low)	.5	.6	.4	16.5	.1–1.4	50
3 (moderate)	2.3	2.7	1	16.5	1.5–5.2	50
4 (high proportion)	16.7	27.4	23.4	16.8	5.4–92.7	51
Ethnic diversity						307
Han only				57.0		175
Han+ethnic minority				39.1		120
ethnic minority only				3.9		12
Infrastructure deficiency scores	2.8	2.7	1.1		.2–4.6	297
1st quintile (least deficient)	1	.9	.4		.2–1.5	59
2nd quintile	2.3	2.2	.3		1.6–2.6	58
3rd quintile	2.8	2.9	.1		2.6–3.2	60
4th quintile	3.4	3.4	.2		3.2–3.6	60
5th quintile (most deficient)	4.0	4.1	.2		3.6–4.6	60
Illiteracy (%)	10.0	13.5	13.6		0-90	300
Public transit access						303
excellent (< 5 min walk)				44.2		134
good (5–< 30 min walk)				26.1		79
poor (30–60 min walk)				12.2		37
very poor (> 60 min walk)				17.5		53
Older adults (%)	13.3	16.1	11.5		1.5-93.3	294
Sex ratio (male to female)	1.09	1.18	.43		.6-6.2	295

a=for in-migration, 1=no in-migrants, 2–4 were obtained from dividing villages with in-migrants into tertiles.

2010, the sampled villages had a mean population of 2503. Almost all villages (98%) had some of their adult population out-migrated for work. About half of the villages (50.2%) had no in-migrants. Most villages (57%) had Han people only; about 39% of villages had mixtures of Han and ethnic minorities and 4% had ethnic minorities only.

Adult illiteracy rates were about 13.5% on average. In terms of public transit accessibility, about 44% of the villages were considered excellent (a less than 5-minute walk), 26% were good (a 5 to less than 30 minutes walk), 12% were poor (a 30- to 60-minute walk), and 17.5% were very poor (a more than 60-minute walk). On average, the sampled villages had populations consisting of 16% older adults, and had more adult males than females.

Bivariate association of village characteristics and suicide

Table 2 shows the estimate of each independent variable in a separate negative binomial regression model for suicide. Without

Table 2
Bivariate (unadjusted) associations between village characteristics and suicide in Chinese rural villages ($N=307$).

	IRR (SE)	95% CI
Social fragmentation		
Out-migration (ref=1st quintile; lowest proportion)	1	
2nd quintile	3.12 (2.81)	.53, 18.22
3rd quintile	4.09 (2.44)[*]	1.27, 13.16
4th quintile	3.10 (1.76)[*]	1.02, 9.44
5th quintile (highest proportion)	9.57 (6.04)[***]	2.78, 32.97
In-migration (ref=1; no in-migrant)	1	
2 (low)	3.57 (1.54)[**]	1.53, 8.34
3 (moderate)	2.69 (2.42)	.46, 15.62
4 (high proportion of migrants)	1.06 (.60)	.34, 3.29
Ethnic diversity (ref=Han only)	1	
Han + ethnic minority	.89 (.41)	.36, 2.18
ethnic minority only	.13 (.10)[*]	.03, .62
Socioeconomic deprivation		
Infrastructure deficiency (ref=1st quintile; least deficient)	1	
2nd quintile	7.47 (8.26)	.85, 65.68
3rd quintile	1.21 (.99)	.24, 6.18
4th quintile	8.35 (4.71)[***]	2.76, 25.28
5th quintile (most deficient)	12.51 (8.33)[***]	3.36, 46.62
Public transit access (ref=excellent)	1	
good	2.38 (1.80)	.54, 10.45
poor	4.04 (2.07)[**]	1.48, 11.02
very poor	1.43 (.78)	.49, 4.17
Illiteracy percentage	1.03 (.02)[*]	1.00, 1.07
Population composition		
Older adult percentage	1.07 (.02)[**]	1.02, 1.12
Sex ratio	2.90 (3.15)	.34, 24.36

Each independent variable was estimated in a separate negative binomial regression model for suicide. Incidence rate ratios (IRRs), robust standard errors with clusters in province (SE), and 95% confidence interval (CI) are presented.

[*] $p < .05.$
[**] $p < .01.$
[***] $p < .001.$

adjustment, all independent variables except sex ratio were significantly associated with suicide rates. The estimates suggest that higher proportions of out-migration, low in-migration (vs. none), Han-only villages (vs. minority-only), higher degrees of infrastructure deficiency, poor public transit accessibility (vs. excellent), higher illiteracy rates and higher percentages of older adults were all associated with higher suicide rates.

Multivariable negative binomial regression results

When all three indicators of social fragmentation were simultaneously entered into the model (Model A, Table 3), the results show that villages in the highest and second highest quintiles of out-migration had significantly higher incidence rates of suicide than villages in the lowest quintile. The association between in-migration and suicide was not a linear trend. While significantly higher suicide rates were observed in villages with low proportions of in-migrants than those without any migrants, the difference between those with moderate or high proportions of in-migrants and those with no in-migrants was not significantly different. No statistically significant association was found between ethnic diversity and suicide in Model A.

In Model B (Table 3), all three indicators of socioeconomic deprivation were simultaneously estimated. The results indicate that villages in the fourth and fifth quintile of infrastructure deficiency (i.e., the two most deficient categories) had significantly higher suicide incidence rates compared to those that were the least deficient. The association between public transit accessibility and suicide rates did not follow a linear trend. Compared to villages with excellent access to public transportation, villages that had

poor accessibility, but not those with very poor or good accessibility, had significantly higher incidence rates of suicide. Illiteracy rates were not significantly associated with suicide.

The Full Model (Table 3) includes all indicators of social fragmentation and socioeconomic deprivation—as well as percentages of older adults and sex ratios—as predictors. The estimates for out-migration were smaller than those in Model A (Table 3), but the pattern remained. Villages with the highest proportion of out-migration had more than five times the incidence rates of suicide than those with the lowest proportion of out-migration had. The estimates for in-migration were larger than those in Model B, and they suggest that villages with any degree of migrant inflow had significantly higher rates of suicide than villages with no in-migration. Specifically, compared to the rate for villages with no in-migrants, the incidence rates of suicide for villages with low, moderate, and high proportions of in-migration were a factor of 6.3, 3.3 and 3.5, respectively. The incidence rates of suicide in mixed Han-minority villages was almost twice that of the rate in Han-only villages, and the difference was statistically significant.

The estimates for infrastructure deficiency in the Full Model indicate that the incidence rates of suicide in villages that were most and second-most deficient in infrastructure were more than nine times and six times, respectively, the rate for the least deficient villages. Regarding public transit accessibility, the estimates show that villages with poor access to public transit had a suicide incidence rate 2.6 times of that of villages that had excellent access, but no significant differences in suicide rates were observed between the latter and those with good or very poor public transit accessibility. Older adult percentages were positively and significantly associated with suicide in the Full Model.

Sensitivity check

We estimated all models without the two outliers of suicide (which reported 16 and 18 suicides, respectively). The pattern of results is similar to those reported above, although the magnitude of estimates changes. For example, the contrast between villages with excellent and poor access to public transportation became statistically not significant (IRR=2.06, 95% CI=.95, 4.49, $p=.07$).

Discussion

Based on village-level data collected from a national survey in China, we conducted an ecological study of suicide and found that both social fragmentation—indicated by out-migration, in-migration, and ethnic diversity; and socioeconomic deprivation—indicated by infrastructure deficiency and public transit accessibility, are positively associated with suicide rates in Chinese rural villages. The percentage of older adults is also positively associated with suicide rates. Some studies in the West have suggested that social fragmentation is more strongly associated with area suicide rates than socioeconomic deprivation (see Gunnell, 2005). But our findings show that the effects of socioeconomic deprivation remained strong after controlling for social fragmentation indicators whereas the effects of out-migration (a social fragmentation indicator) were greatly reduced after controlling for socioeconomic deprivation indicators. This suggests that socioeconomic deprivation is a strong and robust correlate of suicide in Chinese rural villages. Such findings are consistent with studies conducted in other Asian regions (Chang et al., 2011; Hong & Knapp, 2013; Hsu, Chang, Lee & Yip, 2015). Below we highlight the association between some village characteristics and suicide.

Table 3
Social fragmentation, socioeconomic deprivation and suicide in Chinese rural villages (N=307).

	Model A		Model B		Full Model	
	IRR (SE)	95% CI	IRR (SE)	95% CI	IRR (SE)	95% CI
Social fragmentation						
Out-migration (ref: lowest proportion)	1				1	
2nd quintile	2.25 (1.68)	.52, 9.69			1.70 (1.16)	.44, 6.51
3rd quintile	2.62 (1.69)	.73, 9.31			1.41 (.91)	.39, 5.03
4th quintile	3.34 (1.62)[*]	1.30, 8.63			1.33 (.85)	.38, 4.64
5th quintile (highest proportion)	13.37 (8.48)[***]	3.86, 46.34			5.70 (3.68)[**]	1.61, 20.24
In-migration (ref: no in-migrant)	1				1	
2 (low)	6.11 (3.19)[**]	2.19,17.02			6.31 (3.02)[***]	2.46,16.20
3 (moderate)	1.81 (1.10)	.55, 5.93			3.29 (1.86)[*]	1.08, 9.99
4 (high proportion)	1.74 (.74)	.75, 4.02			3.53 (1.80)[*]	1.29, 9.69
Ethnic diversity (ref: Han only)	1				1	
Han+ethnic minority	1.93 (.72)	.93, 4.02			1.90 (.57)[*]	1.05, 3.44
ethnic minority only	.34 (.27)	.07, 1.59			.52 (.41)	.11, 2.44
Socioeconomic deprivation						
Infrastructure deficiency (ref: least deficient)			1		1	
2nd quintile			4.90 (4.59)	.78, 30.81	3.14 (2.19)	.80, 12.31
3rd quintile			1.03 (.86)	.20, 5.36	1.49 (.93)	.44, 5.07
4th quintile			7.28 (5.30)[**]	1.74, 30.42	6.32 (4.26)[**]	1.69, 23.73
5th quintile (most deficient)			8.67 (6.49)[**]	1.98, 37.89	9.22 (6.20)[**]	2.46, 34.56
Public transit access (ref: excellent)			1		1	
good			2.33 (1.59)	.61, 8.87	1.56 (.84)	.54, 4.51
poor			2.41 (1.03)[*]	1.05, 5.56	2.64 (.90)[**]	1.36, 5.15
very poor			1.09 (.54)	.42, 2.86	.79 (.35)	.32, 1.91
Illiteracy percentage			1.01 (.01)	.99, 1.03	1.01 (.01)	1.00, 1.03
Population composition						
Older adult percentage					1.03 (.01)[**]	1.01, 1.06
Sex ratio					1.75 (1.52)	.32, 9.56
Log pseudolikelihood	− 246		− 244		− 223	

Negative binomial regression models for suicide were estimated. Model A included only the three indicators of social fragmentation and Model B included only the three indicators of socioeconomic deprivation in the model. The Full Model included both sets of indicators as well as older adult percentage and sex ratio. Incidence rate ratios (IRRs), robust standard errors with clusters in province (SE), and 95% confidence interval (CI) are presented.

[*] *p < .05.*
[**] *p < .01.*
[***] *p < .001.*

Out- and in-flow of migrants

We found that villages that had the highest proportion of adults out-migrated, compared to villages with lower proportions of out-migration, had significantly higher suicide rates (differences between the 5th quintile and other categories of out-migration, except the 2nd quintile (p=.054), were significant at p < .05, in the Full Model in Table 3). But no significant differences were found among other villages (i.e., those ranked in the 1st to 4th quintile of out-migration) after controlling for socioeconomic deprivation, which may be attributable to certain protective effects of out-migration. Out-migration may, for example, provide a way for the at-risk population, such as rural young women, to escape from an oppressive environment of domestic violence, arranged marriages and family conflicts (Wang et al., 2014). In addition, remittances sent home by migrant workers may help relieve poverty-related stress of the receiving families (Ping & Shaohua, 2008). But our results suggest that, when out-migration reaches a very high level, its negative effects, especially when it comes to incidences of suicide in the villages, outweigh whatever positive effects it may have. In our sample, the most out-migrated villages had more than half of their adult population out-migrated for work.

We also found that villages with any in-migrants in their population had significantly higher rates of suicide than villages with no in-migrants, controlling for village-level socioeconomic conditions. Inflow of migrants is a relatively new phenomenon in rural villages of China. In-migration might create disturbances to institutional continuity and to existing social networks, thus reducing social cohesion and increasing suicide risks (Sampson, Morenoff & Gannon-Rowley, 2002). Our findings suggest that the negative impact of in-migration may be worse for villages with a low percentage of migrants than those with more. Possibly, the former are in the early phase of receiving migrants and are adjusting to the transition, whereas villages with high proportions of migrants may have adapted to the new reality.

The association between population mobility and suicide has been established in many prior studies (Hooghe & Vanhoutte, 2011; Middleton et al., 2004). Our findings reinforce this linkage in the context of rural China. Out-migration has many consequences to the place of origin, including disrupting traditional family life which Durkheim (1897) regarded as the most protective mechanism against self-destructive behavior. Inflow of migrants might also destabilize traditional lives in rural communities.

Ethnic diversity

We found that mixed Han-minority villages had higher incidence rates of suicide than villages with Han people only, all else being equal. Establishing trust and social capital may be more challenging in villages with ethnic diversity, due to language and cultural differences (Sampson et al., 2002). In the case of China, the degree of social fragmentation can be compounded in ethnically diverse areas, because of negative repercussions from differential policy benefits perceived or received by Han and ethnic minorities, and persistent socioeconomic disadvantages of ethnic minorities in the Chinese society (Hasmath, 2014).

Infrastructure deficiency

Our findings that villages with higher degrees of infrastructure deficiency had higher incidence rates of suicide are consistent with findings in other countries (Chang et al., 2011; Denney et al., 2015; Hong & Knapp, 2013). Most prior studies have used demographic attributes (e.g., unemployment rates, percent below poverty) to indicate neighborhood socioeconomic disadvantages. We used a contextual measure of socioeconomic deprivation which is less subject to the confounding of compositional effects. Basic infrastructure is needed for a community to function properly. Poor infrastructure may increase residents' stress levels, sense of hopelessness, and depressive symptoms (Li et al., 2015).

Access to public transportation

The analysis shows that villages with poor access to public transit, but not those that had very poor accessibility, had significantly higher incidence rates of suicide than villages with excellent access. One reason may be that villages with poor public transit accessibility are in the transitioning state. Their residents, aware of higher standards of living in more developed villages, may be frustrated with and depressed by their poor access to public transportation. In contrast, villages with very poor public transit accessibility may be quite isolated and remote. The remoteness and isolation may provide impetus to inhabitants to be interdependent, which helps strengthen social ties and protect against suicide.

Contributions and limitations

This is one of the first studies to examine the association between neighborhood contexts and suicide in China. Unlike most prior ecological studies of suicide, which employed administrative data on a large level of aggregation, our unit of analysis is the rural village, which is more homogenous than larger areas when it comes to socioeconomic conditions and cultural process. Thus, the rural village is less susceptible to the ecological bias associated with heterogeneity in the exposure area (Middleton et al., 2004). Our analysis has included a range of factors at the village level that were purported to influence suicide rates. By considering these factors together, we were able to test the independent effects of each on suicide and thus reduce confounding and suppressor problems.

It should be emphasized that the associations we observed at the village level do not necessarily imply that such factors are associated with an individual's risk of suicide. The village-level effects included both compositional (i.e. individuals residing in the villages) and contextual (i.e., neighborhood) effects. We were unable to unpack these two components due to the lack of individual-level data. We emphasize that, as an ecological study, this study presents and interprets findings at the village level only. Nevertheless, it is important to examine area-level correlates of suicide so as to avoid the 'atomistic fallacy' in understanding such an important issue as suicide.

Our study has several limitations. First, the dependent variable, suicide, was based on village leaders' reports, and degrees of both accuracy and bias are unclear. In particular, stigma associated with suicide may cause their under-reporting. To assess the degree of bias in the leaders' reports of suicides, we calculated the annual rate of suicide in our sampled villages which was 6.9 per 100,000 individuals (dividing the total number of suicide deaths by 3, and then divided the result by total population). This figure is lower than the estimates based on data from the MOH-VR (9.1/100,000) (Wang et al., 2014) and DSP (15.5/100,000) (Liu et al., 2015) in the same period, suggesting potential under-reporting of suicides by the village leaders. If under-reporting is more likely to occur in socially and economically more disrupted villages, we may have under-estimated the effects of socioeconomic deprivation and social fragmentation factors on suicide rates. Another reason for the discrepancy between our and the 'official' figures may be that migrants who died by suicide in the city were counted as rural death in the MOH-VR and DSP, whereas village leaders likely excluded these migrants when reporting suicides in their villages.

The CHARLS has implemented some measures to reduce reporting errors in the community survey, such as asking the most knowledgeable person to answer specific sections of the instrument. In our sample of 307 villages, about 41% had two or more respondents. In addition, respondents were asked to look up relevant statistics as they were completing the survey (Zhao et al., 2013). However, we are constrained in verifying the village leaders' reports, due partly to not knowing the location of the villages.

A second limitation of our study relates to the general rarity of suicides. There may be a high level of variability of suicide rates, especially in areas as small as those in rural villages. We used suicides over three years, which may provide a more accurate picture of the geographical distribution of suicide than would be seen over a shorter period.

A third limitation is that we modeled overall suicide rates, and the data do not allow us to examine age- and gender-specific effects of village-level risk factors. Some prior studies have suggested that male and female suicide rates have different area-level correlates (Otsu et al., 2004).

Finally, the data related to village-level characteristics were collected in 2010 whereas suicides was evaluated in 2008–2010. So the temporal order of their measurement does not follow the conceptualization. We assumed that the village-level characteristics were relatively stable in that three year period, as rural environment usually does not change quickly.

In spite of the limitations, our study suggests that further investigation of neighborhood effects on suicide in rural China is warranted. Our findings need to be replicated, preferably with adjustment of individual-level data and differentiation of gender- and age-specific suicide rates. An important area for further research is mechanisms linking neighborhood contexts and individual's suicidal behavior, that is, asking how village-level factors influence individual's intention and decision to commit suicide. Additionally, the outcome of suicide attempts is likely to depend on environmental factors such as accessibility to means (e.g., pesticides) and availability of trained professionals to handle suicide. Research to understand village-level factors that can reduce the lethality of suicide attempts would be a worthwhile effort.

Our findings have important implications for suicide prevention in rural China. They suggest that neighborhood-level interventions have the potential to reduce suicide risks for a large number of people, and villages with high levels of out-migration, inflow of migrants, mixes of Han and ethnic minority residents, poor infrastructure, poor access to public transportation, and high percentages of older adults should be considered as priority targets for intervention.

Acknowledgments

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