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Research paper

# Suicide by pesticide poisoning remains a priority for suicide prevention in China: Analysis of national mortality trends 2006–2013

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ABSTRACT

*Background:* Despite recent declines, suicide remains a priority for China. Ease of availability of high-lethality suicide methods, such as pesticides and firearms, contributes to the overall incidence and is an important target for suicide prevention. This study investigates whether changes in the distribution of methods of suicide have contributed to the recent reduction in suicide in China.

*Method:* Suicide rates (2006–2013) were calculated using the Chinese Disease Surveillance Points system, stratified by gender, age group, and urban-rural residence, to investigate trends in suicide over the study period. Multilevel negative binomial regression models were used to investigate associations between socio-demographic factors and method-specific suicide.

*Results:* The most common method of suicide in China for both males and females was pesticide poisoning, followed by hanging. All methods declined over the study period, with the exception of suicide by jumping in males. Suicide rates for pesticide poisoning and for hanging increased exponentially with age in those aged over ≥45 years in both sexes. Pesticide poisoning declined from 55% to 49% of all suicides, while hanging increased from 27% to 31%.

*Limitations:* This was an ecological study of a time series of suicide rates, with risk factor adjustment being limited to population-level point estimates derived from a single census.

*Conclusions:* Suicide by pesticide poisoning and hanging remain the leading methods of suicide in China. Changes to the safe use of pesticides and targeted prevention initiatives to restrict access, along with socio-economic development and urbanisation, are likely contributors to declines in suicide by pesticide poisoning

## 1. Introduction

Suicide remains a major public-health problem for China, despite recent studies showing decreasing trends over the most recent period (Liu et al., 2015; Zhang et al., 2014). Suicide in China accounts for approximately 20% of all suicides globally (Qin and Mortensen, 2001; Yang et al., 2013) and is the eighth most common cause of years of life lost and second most common external cause of death in China (Yang et al., 2013).

Recent studies of China have shown changes in the epidemiology of suicide in the context of declining national suicide rates (Liu et al., 2015; Zhang et al., 2014), with a higher incidence in males than in females, declines in younger age cohorts, and significant geographic differences (Liu et al., 2015), including differences in area-based markers of socio-economic status such as education level (Liu et al., 2015), unemployment (Li et al., 2012) and the proportion of the population involved in agricultural production (Li et al., 2012). Previously, female suicide rates were higher than male rates in rural areas, and higher suicide rates in young adults aged 20–34 years were also evident (as well as in older age cohorts) (Phillips et al., 2002). However, the most recent trends suggest that male to female ratios in suicide rates are more consistent with Western developed contexts, with higher rates in males than in females. Previous age-specific analyses which showed higher rates in young adults compared to other age groups (Phillips et al., 2002), now show a more conventional age-specific trend in suicide rates, with rising rates with increasing age, and little evidence of elevated suicide rates in young adults (Liu et al., 2015).

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Understanding the key methods contributing to national and international suicide rates is also important, as this can inform suicide prevention initiatives and target those methods that are more amenable to prevention (such as suicide by pesticide poisoning (Gunnell and Eddleston, 2003; Gunnell et al., 2007) and suicide by jumping (Pirkis et al., 2013)). Pesticide suicide has previously been shown to be a key priority for suicide prevention in China (Phillips et al., 2002; Zhang et al., 2008), including focussed interventions, of varying success, that have targeted suicide by poisoning by providing 'lock boxes' to agricultural producers in some counties (World Health Organization, 2016). Studies of emerging methods, such as from carbon monoxide poisoning from burning barbecue charcoal reported in other South East Asian contexts (Chang et al., 2014; Chen et al., 2013, 2015), have been limited and, in some cases, restricted to suicides enumerated via newspaper reports (Cheng et al., 2015). Restricting access to means of suicide is a key principle of effective suicide prevention (Gunnell and Frankel, 1994; Mann et al., 2005), with the strongest evidence of population-impact to reduce suicide relating to restriction of access to means, including for barbiturates (Oliver and Hetzel, 1972), carbon monoxide poisoning (following catalytic converters for car exhaust fumes) (Amos et al., 2001; Spittal et al., 2012), and firearms (Miller et al., 2002). Understanding the distribution of suicides in terms of method provides important evidence to inform any potential suicide prevention program or initiative.

Accordingly this study examines recent temporal trends in method-specific suicide among people aged 15 years and older in mainland China between 2006 and 2013 to (i) identify whether changes in patterns of methods used for suicide have contributed to the recent reduction in suicide, and (ii) identify potential socio-demographic determinants of suicide methods.

## 2. Method

### 2.1. Data sources

Total suicide counts (ICD-10 codes X60-X84, Y10-Y34, Y87.0) from 2006 to 2013 (with corresponding population denominators) 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). Following preliminary analysis of the proportional distribution of suicide and undetermined deaths that showed a similar distribution by sex and age, suicide methods were categorised as pesticide poisoning (ICD-10 codes X68, X48 and Y18), hanging (X70, Y20, and W75-W76), drowning (X71 and Y21), jumping from a high place (X80 and Y30), and other gases and vapours (including carbon monoxide and motor vehicle exhaust gas) (X67 and Y17). These categories of suicide methods accounted for approximately 90% of all suicide in China. The most common methods were pesticides (approximately 51%) and hanging (approximately 29%), and are the focus of the present study.

Cause of death in the DSPs is attributed by trained coders in hospitals and local Centre for Disease Control and Prevention (CDC) staff for all deaths in each surveillance point, and also from household surveys for non-hospital deaths, and data exchange with police stations, the civil affairs department, and maternal and child departments (Liu et al., 2016; Yang et al., 2005; Zhou et al., 2010). Decedents are counted as local residents if they have lived in the county or district for more than six months, otherwise they are coded to their previous county or district of residence. Corresponding population counts cross-classified by 5-year age group and gender for each county or district of DSPs were extracted from the National Bureau of Statistics.

Population catchments for each DSP surveillance point were divided into urban and rural areas, based on the National Bureau of Statistics of China classification for urban areas ('Qu' or districts) and rural areas ('Xian' or county). In total there were 64 urban points and 97 rural points across the DSPs (Supplementary Table 1). This urban-rural classification has been used previously in China (e.g. Yin et al., 2011), and differs slightly from the National Bureau of Statistics standard and uses county as the unit of classification given incomplete address information in the DSP in some instances at the village level. Potential socio-demographic 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) based on associations shown previously in China (Liu et al., 2015). Given the focus on method specific suicide in the present study, and the likely prominence of pesticide poisoning as a method of suicide (Phillips et al., 2002; Zhang et al., 2008), the proportion employed in agriculture within each county or district was also defined as a proxy measure of exposure to means (Chang et al., 2012). Each of these variables were divided into tertiles representing 'low', 'moderate', and 'high' groups.

### 2.2. Analysis

Age-standardized rates (using the 2010 census population as the standard) were calculated for each suicide method (pesticide poisoning, hanging, drowning, jumping, and other gases and vapours), and also stratified by gender, age group, and urban-rural residence, to investigate trends and differentials in suicide over the study period (2006–2013). A series of multilevel negative binomial regression models (based on counts of suicide stratified by county, gender, age-group and urban-rural residence, and offset by the natural logarithm of the population) were also specified to investigate associations between socio-demographic factors and method-specific suicide. These models were restricted to suicide by pesticides and hanging, as these methods were the two most common methods of suicide. Multilevel models were employed given the hierarchical structure of the DSPs data (samples of individuals within counties). Models investigated the association between each suicide method and mean years of education and the proportion of the population employed in agriculture, adjusted for sex, age (in 5 year age-groups ≥15 years), and period (details in Supplementary Table 2). The interaction between urban-rural area and (i) tertile of population employed in agriculture and (ii) tertile of mean years of education was investigated to assess whether relative differences between lowest and highest tertiles differed by urban and rural areas, with the interaction term assessed in a Type III test of heterogeneity for fixed effects. Model estimates were exponentiated and expressed as rate ratios (RR) with 95% confidence intervals (CI). Analyses were conducted using PROC GLIMMIX in SAS 9.3.

## 3. Results

The most common method of suicide in China over the study period (2006–2013) for both males and females was pesticide poisoning (declining from 9.0 per 100,000 to 4.9 per 100,000 in males and from 8.5 per 100,000 to 4.2 per 100,000 in women), followed by hanging (5.2 to 3.3 per 100,000 in men and 3.2 to 1.9 per 100,000 in women) (Fig. 1).

Suicide rates for pesticide poisoning and for hanging increased exponentially with age for both males and females in those aged over ≥45 years, with the highest rates in those aged ≥65 years (Fig. 2). Suicide rates declined for all suicide methods, with the sharpest decline evident for suicide by pesticide poisoning (Fig. 1). The exception was for suicide by jumping, which increased slightly in males peaking at 1.3 per 100,000 in 2011, and remained at approximately 1.2 per 100,000 to 2013.

As a proportion of all suicides, pesticide poisoning declined from 55% to 49% over the study period, while hanging increased from 27% to 31%, jumping increased from 5% to 11%, and drowning did not

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