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Short report

A test of the substitution hypothesis: An analysis of urban and rural trends in solid/liquid poisoning suicides in Taiwan

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ABSTRACT

Taiwan experienced both a significant decrease and a significant increase in the suicide rate during the period 1986–1999, which provides a unique opportunity to examine the substitution hypothesis in suicide research: that is, whether a reduction in the use of a certain method of suicide would be offset by a parallel increase in the use of other methods. We also explored whether such method substitution, if it existed, differed across urban and rural settings. Data on age-, sex-, method-, and urban-/rural-specific suicide rates for the period 1986–1999 in Taiwan were obtained and the year of 1993 is found to be the inflection point. We analyzed using Poisson regression to estimate the average annual percentage change (AAPC) for periods of decline (1986–1993) and increase (1993–1999) in suicides. The rapid decline in suicide by solid/liquid poisoning (mostly using pesticides) during a period of accelerated economic development (1986–1999) in Taiwan was found to be associated with the increased use of alternative methods. An interaction model found a marked decrease in solid/liquid poisoning suicide in both urban and rural Taiwan over the period of decline (1986–1993). The extent of the decrease was greater in rural areas but was accompanied by a rise in the use of several other suicide methods. However, the net effect was still a marked reduction in the suicide rate. A general increase in suicide among all age groups, for all methods, in both rural and urban settings, and for both sexes was found during the period when the suicide rate increased (1993–1999). We conclude that restricting access to the means of pesticide suicides reduces not only the method-specific suicide rate but also the overall suicide rate; nonetheless, suicide method substitution is not an all-or-nothing phenomenon. Stratified analyses by geographical (i.e. urban/rural) area can help to disentangle the patterns in each subgroup, which will improve our understanding of the phenomenon and make suicide prevention efforts more focused and effective.

Introduction

Suicide by pesticide poisoning is a leading method of suicide in many developing Asian countries and in some developed ones, such as Japan, South Korea, and Taiwan, where its use is common in rural areas (Chen, Wu, Yousuf, & Yip, 2012). The World Health Organization (WHO) reports that pesticide ingestion is now the most common method of suicide worldwide (Bertolote, Fleischmann, Butchart, & Besbelli, 2006). Restricting access to lethal pesticides is of paramount importance for reducing the burden of suicide (Yip et al., 2012). However, to the best of our knowledge, no studies have examined the relative changes in suicide method by gender, age, and setting (urban and rural areas) and tested stratified substitution effect analytically after the access to pesticide being restricted. Here, we explore how the substitution of other suicide methods following the decline in the solid/liquid poisoning suicide rate (mostly pesticides in rural areas) can vary geographically. With this knowledge, more focused and effective suicide prevention efforts can be developed, and this would have a significant policy impact in terms of restriction of means in many parts of the world.

Taiwan (population 23 million) experienced a rapid decline in solid/liquid poisoning suicides (mostly pesticide suicides in rural areas) along with a decrease in the overall suicide rate during the

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1980s; however, an increase in the suicide rate occurred after the 1990s (Fig. 1). Our aim was to explore any urban or rural differences in the change in suicide rate in Taiwan over the period 1986–1999 according to age, sex, and method. We hypothesized that during the period when the overall rate was declining (1986–1993), this decrease would mainly be attributable to the decline in solid/liquid poisoning suicides (60% using pesticides in rural areas). We also examined whether a time lag in substitution occurred during the period 1993–1999, when the suicide rate rose again, by estimating changes in suicide rates for different subgroups of the population (according to age, sex, method, and urban/rural setting). In fact, the increase and decline of suicide rates in 1986–1999 synchronized with the up and down of the unemployment rate in Taiwan (Fig. 2). The year 1993 can be viewed as a watershed that indicates different stages of economic development and suicide patterning in Taiwan.

Methods

Data descriptions

Official suicide mortality data from Taiwan for the period 1986–1999 were made available by the Department of Health. Cause of death was categorized based on the International Classification of Diseases, 9th revision (ICD-9). Deaths coded under E950-959 (intentional self-harm) and E980-989 (undetermined intent) were included in the analysis as one previous study has indicated that suicide statistics in Taiwan have usually been underestimated and the category most commonly misclassified is "undetermined death" (Chang, Sterne, Lu, & Gunnell, 2010). Suicide methods were grouped into four categories: poisoning with solids/liquids (E950 and E980), hanging (E953 and E983), jumping from a height (E957 and E987), and other methods.

Only 3-digit ICD-9 codes were available from the official death records in Taiwan during the study period; hence, the detailed information provided by the 4th digit code was not available. The Taiwan Department of Health retrospectively recoded the underlying cause of death using ICD-10 but only for selected years. Using the recoded data available during the study period (1987, 1992, 1997), solid/liquid poisoning deaths could be further classified into those involving pesticides (X68 and Y18), medications (X60-X64 and Y10-Y14), and other substances (X65, X66, X69 and Y15, Y16, Y19). We compared the proportion of pesticide suicides in 1987, 1992, and 1997 where this more detailed coding was available. We found that the proportion of suicides involving pesticides accounted for 60% [95% confidence interval (CI) = (57%, 63%)], 54% [95% CI = (50%, 59%)], and 60% [95% CI = (58%, 64%)] of solid/liquid poisoning suicides in each of the three time periods, respectively. When stratified by urban/rural areas, the proportions of suicides involving pesticide use in the solid/liquid poisonings category were as follows: 51% (95% CI [42%, 60%]), 31% (95% CI [21%, 42%]), and 45% (95% CI [36%, 54%]) in urban areas and 69% (95% CI [66%, 72%]), 65% (95% CI [60%, 70%]), and 70% (95% CI [66%, 73%]) in rural areas in 1987, 1992, and 1997 respectively. Pesticides were the most common agents used in solid/liquid poisoning suicides in rural areas throughout the study period; in urban areas, however, pesticides accounted for less than half of the solid/liquid poisoning suicides in 1992 and 1999.

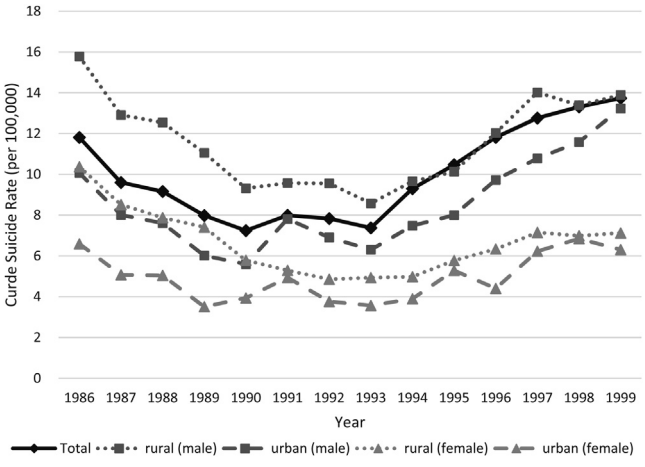

Fig. 1. Gender-specific suicide rates in urban and rural Taiwan, 1986–1999.

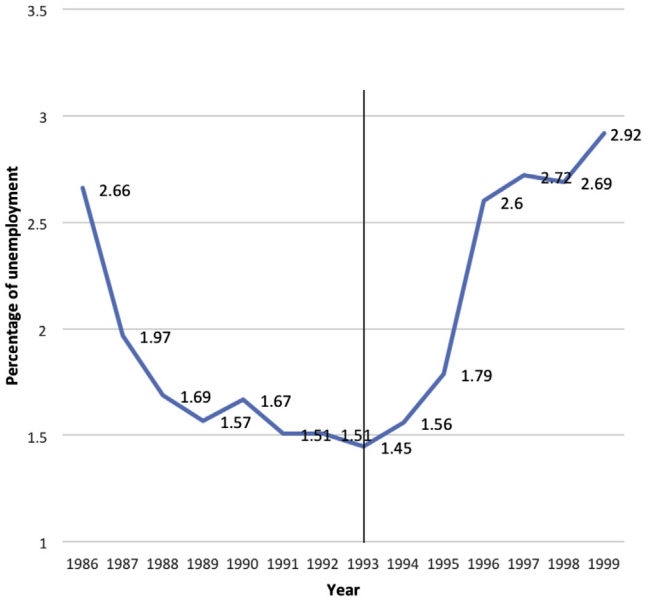

Fig. 2. Trend of unemployment rate in Taiwan, 1986–1999.

We categorized two metropolitan cities (Taipei City and Kaohsiung City) and five big cities (Keelung, Hsinchu, Taichung, Tainan, and Chiayi) as urban locations; their population densities were over 3000 person/km^2 throughout the study period. All other areas were classified as rural locations. In the period 1980–2002, the annual migration rates were around 9–13% and the annual proportions of within-city migration were higher than those of cross-city/county migration (Hsueh, Tseng, & Hsieh, 2007). Therefore, as the population size in both urban and rural areas did not change much, we inferred that the phenomenon of mildly dynamic population composition did not invalidate these two categories' contextual differences.

Analytical strategies: Quasi-Poisson regression analysis

To assess the overall trend, Poisson regression modeling was first performed separately for each of the periods 1986–1993 and 1993–1999. Over-dispersion was detected, and therefore, as recommended by Ver Hoef and Boveng (2007), a quasi-Poisson model was used instead of a negative binomial model. Compared to a quasi-Poisson, a negative binomial regression gives small numbers more weight. We avoided the issue of giving excess weight to the small suicide numbers in some categories as we were assessing the impact of the changes in these categories. The dispersion parameter was estimated as the Pearson Chi-Square over its degree of freedom (McCullagh & Nelder, 1989). By fitting the annual number of suicide cases with the corresponding year (1986 and 1993 were both treated as base year 0), the estimated slope coefficient (β)