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Association between pesticide exposure and suicide rates in Brazil

Neice Muller Xavier Faria *, Anaclaudia Gastal Fassa, Rodrigo Dalke Meucci

Postgraduate Program in Epidemiology, Social Medicine Department, Pelotas Federal University, RS, Brazil

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ABSTRACT

Introduction: The association between pesticide use and an increased suicide risk is a controversial issue. Previous studies have shown higher rates of suicide among agricultural workers and people living in small municipalities, but have not identified the causes of these results.
Objective: To investigate the association between pesticide exposure and suicide rates.
Methods: Crude suicide rates of a 15-year time series (1996–2010) were examined, followed by an ecological study using age-standardized suicide rates for the period 2006–2010. The unit of analysis was all 558 Brazilian micro-regions. Pesticide exposure was evaluated according to the proportion of farms that used pesticides and had reported cases of pesticide poisonings. The statistics were analysed using Pearson's correlation and multiple linear regression adjusted for socioeconomic, demographic and cultural factors.
Results: Among the age group that was analysed, the mean suicide rate was 6.4 cases/100,000 per year in the 2006–2010 period, with a male/female ratio of 4.2. The times series showed that there were higher suicide rates among people aged 35–64 years and among men aged 15–34 years. The ecological analysis showed that the suicide rates were higher in micro-regions with a higher proportion of farms run by 35–64 year olds, female workers and on farms with better economic indicators (higher farming income, level of mechanization and farm area). There was a positive association between the Catholic religion and suicide rates. Micro-regions with a greater use of pesticides, and with a high proportion of pesticide poisoning had the highest suicide rates for all three groups analysed: both genders, men, and women (p ranging from 0.01 to $p < 0.001$).
Conclusion: This study reinforces the hypothesis that pesticide use and pesticide poisoning increase the suicide rates. However, due to the limitations of the study's ecological design, such as ecological fallacy, further appropriately designed studies are needed to confirm the causal relationships.

1. Introduction

The estimated global suicide rate is 16/100,000 inhabitants (WHO/SUPRE, 2013), and therefore suicide is an important public health problem. Although the overall Brazilian rate is relatively low (4.6/100,000 for the entire population in 2005) (Brasil, 2008), it is higher in certain regions, such as the south, which has reported the highest Brazilian suicide rates in recent decades (Brasil, 2008). Studies have shown that suicide rates are higher in small municipalities (<50,000 inhabitants) (Brasil, 2008; Marin-Leon et al., 2012), although there is not much information about the factors that are associated with increased suicides in this context.

In Brazil, studies have found higher rates of suicide and suicide attempts in two areas where pesticides are intensively used: the Dourados region of the state of Mato Grosso do Sul (Pires-a et al., 2005) and the mountainous region (Serrana) of Rio de Janeiro state (Meyer et al., 2010). In Rio Grande do Sul state, one study analysed the temporal trends of suicide rates in the period between 1979 and 1998 and found a higher rate among primary sector workers, especially agricultural workers (Meneghel et al., 2004). However, the association between pesticide exposure and suicide (Faria et al., 2006) could not be verified due to limited data at that time.

Studies among farm workers have shown an association between pesticide poisoning and psychiatric problems, particularly depressive disorders (Stallones and Beseler, 2002; Beseler et al., 2006, 2008; London et al., 2012; Faria et al., 1999; Wesseling et al., 2010; Weisskopf et al., 2013; Beseler and Stallones, 2008; Beard et al., 2011). However, this association is not so clear when analysing pesticide exposure – without poisoning – and the occurrence of psychiatric problems (London et al., 2005, 2012; Freire and Koifman, 2013).

* Corresponding author at: 80 Republica St, Apt 1401, 95700 000 Bento Gonçalves, RS, Brazil. Tel.: +55 54 34512215; fax: +55 54 91298413.
E-mail addresses: neice@clinicagianisella.com.br, neicef@yahoo.com.br (N.M.X. Faria).

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Several pesticides, especially organophosphates, are neurotoxic and have been associated with increased psychiatric problems, particularly depression (Stallones and Beseler, 2002; Beseler et al., 2006; London et al., 2005, 2012; Wesseling et al., 2010; Beseler and Stallones, 2008; Freire and Koifman, 2013; Lima et al., 2011; Keifer and Firestone, 2007). These problems could contribute to the occurrence of suicide among exposed workers (London et al., 2005, 2012; Stallones, 2006). Furthermore, in several parts of the world intentional pesticide poisoning has been the main method of suicide (London et al., 2005), although this is not the case in Brazil (Brasil, 2008; Marin-Leon et al., 2012).

Parallel to the growing pesticides consumption worldwide, is the increasing concern about their effects on mental health. While the world's pesticide market grew by 93% during the last 10 years, the Brazilian market increased by 190% (ANVISA, 2012) and since 2008 it has been the world's largest pesticide market. Intensive use of these products exposes the majority of the Brazilian population to their effects through food residues, environmental contamination, occupational poisoning or accidental cases. A huge number of Brazilian farm workers are exposed to pesticides at work in a frequent and prolonged manner, often without any protection.

Considering this context of intense pesticide exposure and also the improvement in the quality of secondary data in Brazil, this study examined the association between pesticide exposure and suicide rates in Brazil.

2. Methods

The crude suicide rates during a 15-year period (1996–2010) were analysed. A time series was plotted to examine the proportion of suicides according to the method of death (direct cause), and suicide rates according to gender and age groups (in groups of 10 years from 15 years to 75 years or over). In addition, an ecological study was carried out, where the unit of analysis was all 558 of the Brazilian geographic micro-regions as defined by the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística – IBGE).

Suicide was defined as death resulting from an intentionally self-inflicted injury/poisoning and registered as the principal cause of death on death certificates. The data on deaths were obtained from the Ministry of Health's Mortality Information System (Sistema de Informações em Mortalidade – SIM/DATASUS-MS) (Estatísticas Vitais, 2010), and the International Classification of Diseases ICD-10 codes X60 to X84 were considered to be deaths from suicide. All suicides were included regardless of the method used. The analyses were restricted to people aged 15 or over because the suicide rate in people younger than 15 accounted for approximately only 1.2% of the total and because of the interest in examining the effects of occupational exposure. Suicides where the age was unknown were also excluded.

The number of suicides for each micro-region was used to build crude suicide rates. Afterwards, suicide rates per micro-region were age-standardized through the direct method, using the World Health Organization standard population (WHO, 2001) as a reference (Ahmed et al., 2000). The standardized rates were calculated according to age groups (15–24; 25–34; 35–44; 45–54; 55–64; 65–74; 75 years or more) per annum, for the entire population (both genders) and stratified according to gender (male suicides and female suicides). The mean standardized rates for a five-year period (2006–2010) were calculated and these results were used in the multivariate analyses.

Multivariate analysis through multiple linear regression was carried out to examine the associations between pesticides (pesticide exposure and pesticide poisonings) and suicide rates (for entire population and stratified by gender). The confounding factors taken into consideration were demographic and sociocultural factors (age and schooling of main farm operator, female rural workforce, skin colour, marital status, religion), the Human Development Index – HDI, and economic indicators (farm size, gross income from farming production, level of mechanization, farmworker density). The HDI varies from 0 (worst index) to 1 (best index) and this data was built using information from the Brazilian Demographic Census 2000 (PNUD, 2003).

The main form of exposure was defined by two variables: the proportion of farms using pesticides and the proportion of farms reporting cases of pesticide poisoning. Although they both indicate exposure to pesticides, they reflect a different intensity of exposure. Thus, their effects are not independent and they cannot be included in the same model. Considering the epidemiological controversy about the relationship between pesticide exposure (without poisoning) and rates of suicide, as well as pesticide poisoning as an important indicator of intense exposure, two models were developed, one for each main exposure variable.

All of the above mentioned variables were identified in the official databases that record agricultural work and production, as were the socio-economic and demographic aspects. According to the literature, these aspects might be associated with suicide and were available for the micro-region's aggregation level.

To examine qualitative variables (as religion, skin colour and marital status) and to include them as continuous variable in multiple linear regression, it was necessary a dummy variable, examining if a characteristic was present or not. Only one variable was selected to represent each indicator. Priority was given to the measure with strongest correlation with suicide rates out of all the possible measures for that variable. Therefore, the dummy variable used for religion was '% of Catholics', and the indicator of skin colour was '% of white-skinned people' (Szklo and Nieto, 2012). For marital status, the indicator was 'the rate of divorces and other legal separations/100,000 inhabitants' following the literature (Faria et al., 2006).

For the quantitative variables, several different cut-off points were tested using the Pearson's correlation test and those with strongest correlation were selected. For example, the cut-off point of the farm size (10 ha and over) corresponds to around half of Brazilian farms (47%) and this size had the strongest correlation.

The main exposure was examined in two ways: pesticide exposure and pesticide poisoning (% of farms using pesticides in 2006 and % of farms reporting cases of pesticide poisoning in 2006). The adjustment factors included in the multivariate analysis was: age group (% of farms run by people aged 35–64 years), low schooling (% of farms run by people up to 1 year of schooling), female rural workforce (% of women among people working at farms), skin colour (% of white-skinned people), religion (% of people of Catholic faith), divorce rate (number of people divorced + legally separated/100,000 inhabitants), HDI (mean per micro-region of Human Development Index), farm size (% of farms having an area equal to or greater than 10 ha – around 24.7 acres), farming income (mean value of farming production/farm area in hectare groups), level of mechanization (% of farms with agricultural machinery and implements), farm worker density(- number of workers – farmers and farm workers – aged 14 and over, working at each farm).

Data on exposures were obtained from official records: from the Brazilian Institute of Geography and Statistics – IBGE (2006 Agricultural Census (Censo Agropecuário, 2006), the 2000 Demographic Census (Censo Demográfico, 2000), and the 2006 Civil Register (Estatísticas do Registro Civil, 2006)) and from the Brazilian Unified Health System's Database – DATASUS (Estatísticas Vitais, 2010). The HDI was extracted from the 2003 UNDP Atlas (United Nations Development Programme) (PNUD, 2003).

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