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# Pesticide exposure: a population-based study in a rural area in southern Brazil

*Exposição a agrotóxicos: estudo de base populacional em zona rural do sul do Brasil*

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**ABSTRACT:** ***Objective:*** To estimate the prevalence of pesticide exposure and associated factors among rural residents. ***Methods:*** A population-based, cross-sectional study conducted with 1,518 individuals in 2016. We randomly selected 24 census tracts from the eight rural districts of the city of Pelotas, RS. All individuals aged 18 years or older, living in the randomly selected households were eligible. A descriptive analysis was performed and the prevalence of contact with pesticides was presented. The association between outcome and independent variables was analyzed using Poisson regression according to the hierarchical model. The variables were all adjusted to the same level, including those at the previous level and those with p<0.20 were kept in the model. ***Results:*** The prevalence of contact with pesticides in the past year was 23.7% and among the participants, 5.9% reported having pesticide poisoning at some time in their lives. The probability of contact with pesticides in the past year was higher among men (PR=2,00; 95%CI 1.56 – 2.56), among those aged 40–49 years (PR = 2.00; 95%CI 1.12 – 1.80), among individuals with lower levels of education (PR = 2.06; 95%CI 1.39 – 3.10), in those who performed rural work (PR = 2.87; 95%CI 1.39 – 3.10) and in those who had lived in rural areas all their lives (PR = 1.28 95%CI 1.00 – 1.66). ***Conclusions:*** Approximately one in four adults in rural Pelotas had come into contact with pesticides in the year before the study. The findings show the existence of social inequalities related to exposure to pesticides and provide information for action aimed at reducing exposure and poisoning from these products.

***Keywords:*** Pesticides. Epidemiology. Cross-sectional studies. Risk factors. Rural population.

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**RESUMO:** ***Objetivo:*** Estimar a prevalência de exposição a agrotóxicos e fatores associados entre moradores de zona rural. ***Métodos:*** Estudo transversal de base populacional realizado com 1.518 indivíduos, em 2016. Foram aleatoriamente selecionados 24 setores censitários de oito distritos rurais de Pelotas, RS. Indivíduos ≥ 18 anos residentes nos domicílios aleatoriamente selecionados eram elegíveis. Foi realizada análise descritiva e apresentada prevalência de contato com os agrotóxicos. A associação entre desfecho e variáveis independentes deu-se por regressão de Poisson, conforme modelo hierárquico. As variáveis foram ajustadas para todas do mesmo nível, além daquelas que foram mantidas no modelo do nível anterior e das com valor p < 0,20. ***Resultados:*** A prevalência de contato com agrotóxicos no último ano foi de 23,7%, e, entre esses participantes, 5,9% relataram intoxicação por agrotóxicos alguma vez na vida. A probabilidade de contato com agrotóxicos no último ano foi maior entre os homens (razão de prevalência — RP = 2,00; intervalo de confiança de 95% — IC95% 1,56 – 2,56); entre aqueles com idades entre 40 e 49 anos (RP = 1,44; IC95% 1,12 – 1,80); entre os menos escolarizados (RP = 2,06; IC95% 1,39 – 3,10); os que exerciam trabalho rural (RP = 2,87; IC95% 2,05 – 4,01); e aqueles que moraram na zona rural a vida inteira (RP = 1,28; IC95% 1,00 – 1,66). ***Conclusões:*** Aproximadamente um em cada quatro adultos da zona rural de Pelotas entrou em contato com agrotóxicos no ano anterior ao estudo. Os achados evidenciam a existência de desigualdades sociais relacionadas à exposição aos agrotóxicos e fornecem informações para ações visando à redução da exposição e intoxicação por esses produtos.

***Palavras-chave:*** Agrotóxicos. Epidemiologia. Estudos transversais. Fatores de risco. População rural.

# INTRODUCTION

High population growth in recent decades has called for the need to increase food production. As a result of the so-called green revolution, which focused on increasing agricultural productivity around the world, it was necessary to use large quantities of synthetic chemical fertilizers and pesticides[1]. As such, Brazil's economy is based mainly on the export of agricultural commodities[2]. According to current Brazilian legislation, Law No. 7,802, of July 11, 1989, pesticides and the like are considered products and agents of physical, chemical or biological processes that are intended for use in the production, storage and product processing sectors.

In 2008, Brazil became the largest world market for pesticides, moving around US $7.3 billion[3]. The country represented 19% of the world pesticide market, surpassing even the United States, which was responsible for 17% of the world market[4]. According to the latest data from the Brazilian Institute of the Environment and Renewable Natural Resources (*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis* - Ibama)[5], in 2018, Brazilian agriculture used 549,280.44 tons of active ingredients, with an increase of 1.72 % in domestic sales compared to the previous year[5]. Developing countries are the ones that most consume these products, through irregular and excessive use in agricultural cultivation[6], and each Brazilian consumes, on average, seven liters of pesticides per year[7].

When used indiscriminately, pesticides can cause everything from mild symptoms, such as dermatitis, to chronic non-communicable diseases, premature birth, male infertility, some types of cancer, Parkinson's and Alzheimer's disease, in addition to environmental damage[8-13]. According to a study carried out using data from the Notifiable Diseases Information System (*Sistema de Informação de Agravos de Notificação* - SINAN), the use of pesticides and poisonings because of their use increased in Brazil from 2007 to 2016, becoming second most occurring among all exogenous poisonings and the first in terms of lethality. Among the group of pesticides, agricultural products were the agents that most caused acute poisoning in Brazil, with approximately 36 thousand cases in that period[14].

Approximately 15 million people work in agricultural establishments in the country, making up the group with the highest risk for exposure and poisoning from pesticides[15]. Rural workers are exposed and contaminated from pesticides throughout their daily workday. As such, the use of personal protective equipment (PPE) aims to reduce or eliminate health risks, as long as it is used properly, since just using it does not guarantee that the risk will be eliminated[16].

Despite the intense use of pesticides, the rural population still has limited access to information on the use of these products and their health risks through contact[17]. In order to prevent the occurrence of future diseases linked to pesticide use, the knowledge about the damage from exposure to such substances among individuals is important, especially among those who perform work in rural areas. Thus, the aim of the present study was to estimate the prevalence of exposure to pesticides and related factors with contact with these products in an adult population living in a rural area in southern Brazil.

## METHODS

A cross-sectional population-based study carried out between January and June 2016, belonging to a larger study, entitled: *Health assessment of adults living in the rural area of the municipality of Pelotas, RS*. A representative sample of the adult population (over 18 years old), residing in a rural area of the municipality of Pelotas, was evaluated. This region is made up of eight districts and 50 census sectors, making up 7% of the municipality's population[15]. According to Gonçalves et al., approximately one sixth of the activities carried out in the rural area of the municipality are related to planting[18] and, according to the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* - IBGE), in 2018, orange and peach trees were among the main crops[19].

Multistage cluster sampling was used. In total, 24 census sectors were drawn systematically and proportional to the number of permanent households in each district. A visit to 720 households (30 per sector) was stipulated. Considering that there are two adults per household[15], it was defined that 30 houses would be visited in each census sector drawn. Subsequently, Google Earth software, was used to divide these sectors into nuclei. To select the nuclei, first, the location with the most branching out of streets was established, and it was named the center of the nucleus. The distance stipulated for the inclusion of households was a radius of 1 kilometer from the center of the nucleus onwards, defined by the presence of at least five households in this area.

All residents aged 18 or over from the selected households were interviewed. The sample exclusion criteria included individuals who were hospitalized at the time of the research or they had some cognitive disability that made it impossible for them to answer the questionnaire. More details can be obtained in the methodological article[18].

Direct contact with pesticides was assessed using the question: "Since <month> of last year, have you had direct contact with pesticides?", considering activities such as helping to apply or even applying the agricultural product to the crop, washing clothes used in the application of the pesticide, entering the field after applying the pesticide, preparing the pesticide syrup, and washing the packaging and equipment in the 12 months prior to the interview. The outcome was classified in a dichotomous manner (no and yes).

The independent variables evaluated were: sex (male, female), skin color (self-reported and dichotomized into white and others), age in completed years (18 to 29, 30 to 39, 40 to 49, 50 to 59 , 60 or more), education in completed years (zero to four, five to eight, nine or more), rural work (yes, no) - measured by the question: "Do you perform any rural work, such as planting, animal husbandry, fishing, among others?" (yes, no) - and time spent in rural areas (100%, 50 to 99%, less than 50% of their life). Pesticide poisoning was measured using the question: "In your lifetime, have you had any pesticide poisoning, that is, have you experienced severe headache, nausea, vomiting, abdominal cramps, diarrhea, dizziness, difficulty breathing, generalized weakness, increased salivation and sweat, or have you entered a coma after contact with pesticides?", classified in a dichotomous way (no and yes).

To assess socioeconomic level, the goods index variable was obtained by analyzing the main components, which contains 22 questions related to the quantity of goods in the individuals' homes at the time of the survey, such as: running water, vacuum cleaner, washing machine/dryer, dishwasher, DVD player, VCR, refrigerator, microwave, computer (laptop or netbook), TV, radio, air conditioner, cable TV and/or internet, car and/or motorcycle . In addition, questions were included about the number of bathrooms, the number of rooms of the house used for sleeping and whether they had a house cleaner. This variable was analyzed in quintiles, ranging from the poorest quintile (1) to the richest (5).

Statistical analyzes were conducted using the Stata version 14.0 program (Stata Corporation, College Station, TX, United States), considering the effect of cluster sampling using the command survey (svy). Also, a weighting was used which took into account the percentage of households sampled with respect to the number of permanent residents in each district, according to data from the IBGE[15]. The sample description was performed by obtaining the proportion of individuals in each category of variables.

Crude and adjusted analyzes were performed using Poisson regression, with robust adjustment for variance, prevalence ratios (PR) and 95% confidence intervals (95%CI). The adjusted analysis was performed using the hierarchical level model, in which the variables were adjusted for all of the same level, in addition to those of the previous level in the model. Those variables with $p < 0.20$ were kept for adjustment, and this method was repeated for the other levels. The first level included the variables sex, age, and skin color. The second level included the goods and education index. Lastly, in the third, rural work and time spent in rural areas were included. Only the skin color variable did not remain in the final model (p = 0.249). Differences were considered statistically significant when the p value was less than 5% for associations between exposure variables and outcomes. Only for the educational variable, the p value of a linear trend was evaluated, because the results appear to be linear.

The study was approved by the Research Ethics Committee of the School of Medicine of the Universidade Federal de Pelotas, according to report 1,363,979. All individuals participating in the study signed a Free and Informed Consent Form.

## RESULTS

Of the 1,697 individuals identified, 1,518 were interviewed, with a percentage of losses and refusals of 10.5%. Most respondents were female (51.7%), over 40 years old (66.0%), reported having white skin (85.1%), and 38.6% had low levels of education ( — zero to four years of study). Approximately three out of four respondents declared that they were rural workers (73.9%), and about 70% reported having lived in the countryside for their entire lives (66.1%). In addition, a quarter (23.7%) had come into contact with pesticides in the past year, and among them, about 5% had reported pesticide poisoning at some time in their lives (Table 1).

Table 2 shows the crude and adjusted analyzes, in which most of the variables remained statistically significant, except skin color and the goods index. The probability of contact with pesticides in the last 12 months was higher among men (PR=2.00; p<0.001), among those aged between 40 and 49 years old (PR = 1.44; p = 0.001) and among less educated people (zero to four full years of study) (PR = 2.06; p = 0.033). Also, groups that were more likely to have contact with pesticides were considered to be those who performed rural work and those who had lived in a rural area their entire lives (PR = 2.87; p <0.001 and PR = 1.28; p = 0.017, respectively).

## DISCUSSION

Approximately a quarter of the sample reported contact with pesticides in the last year and, among these individuals, 6% reported having symptoms such as headaches, nausea, vomiting, abdominal cramps and pain, generalized weakness, among others, related to pesticide poisoning.

For this study, the definition of poison cases was based on information reported by the worker. This method has already been tested and recognized for validity in other studies on pesticides[20-22]. However, Viero et al. showed that rural workers handling agrochemicals and pesticides in general denied the direct association between these products and health problems. On the other hand, these individuals may have had characteristic symptoms of poisoning after direct contact with these products and did not relate this fact to the handling of pesticides[23].

Table 1. Sample description according to socioeconomic, demographic, behavioral and health variables, Pelotas, RS (n = 1,518).

| Characteristics | N (%) | 95%CI |
|---|---|---|
| Sex | | |
| Male | 734 (48.3) | 45.8 – 50.9 |
| Female | 784 (51.7) | 49.1 – 54.2 |
| Age (completed years) | | |
| 18 – 29 | 287 (18.9) | 17.0 – 21.0 |
| 30 – 39 | 228 (15.1) | 13.3 – 16.9 |
| 40 – 49 | 296 (19.7) | 17.6 – 21.6 |
| 50 – 59 | 297 (19.6) | 17.6 – 21.6 |
| 60 or more | 410 (26.7) | 24.8 – 29.3 |
| Skin color | | |
| White | 1.295 (85.1) | 83.4 – 87.0 |
| Others | 223 (14.9) | 13.0 - 16.6 |
| Education level (completed years) | | |
| 0 – 4 | 581 (38.6) | 36.1 – 41.0 |
| 5 – 8 | 558 (36.9) | 34.6 – 39.5 |
| 9 or more | 369 (24.5) | 22.4 – 26.7 |
| NEI (quintiles) | | |
| 1$^{st}$ quintile (poorest) | 303 (20.4) | 18.1 – 22.2 |
| 2$^{nd}$ quintile | 302 (19.8) | 18.1 – 22.2 |
| 3$^{rd}$ quintile | 302 (19.9) | 18.1 – 22.1 |
| 4$^{th}$ quintile | 301 (19.8) | 18.0 – 22.1 |
| 5$^{th}$ quintile (richest) | 300 (19.7) | 18.0 – 22.0 |
| Rural worker | | |
| No | 395 (26.1) | 24.0 – 28.4 |
| Sim | 1.117 (73.9) | 71.6 – 76.0 |
| Time living in a rural area* | | |
| 100% of their life | 1.010 (66.1) | 64.6 – 69.4 |
| 99 – 50% of their life | 211 (14.0) | 12.3 – 15.9 |
| < 50% of their life | 285 (18.9) | 17.0 – 21.0 |
| Contact with pesticides (in the past year) | 364 (23.7) | 21.9 – 26.2 |
| Pesticide poisoning (once in their life) | 89 (5.9) | 4.8 – 7.2 |

95%CI: 95% confidence interval, *variable with the largest number missing n = 1,506; NEI: National Economic Indicator.

Table 2. Crude analysis and adjusted analysis for contact with pesticides according to socioeconomic, demographic, behavioral and health variables in adults in rural Pelotas, RS (n = 1,518).

| Characteristics | Crude PR 95%CI | p | Adjusted PR * 95%CI | p |
|---|---|---|---|---|
| Sex | | | | |
| Male | 2.03 (1.59 – 2.61) | <0.001 | 2.00 (1.56 – 2.56) | <0.001 |
| Female | 1.00 | | 1.00 | |
| Age (completed years) | | | | |
| 18 – 29 | 1.00 | < 0.001 | 1.00 | 0.001 |
| 30 – 39 | 1.27 (0.90 – 1.80) | | 1.29 (0.92 – 1.81) | |
| 40 – 49 | 1.44 (1.15 – 1.80) | | 1.42 (1.12 – 1.80) | |
| 50 – 59 | 0.95 (0.68 – 1.34) | | 0.95 (0.66 – 1.35) | |
| 60 or more | 0.43 (0.26 – 0.71) | | 0.44 (0.27 – 0.72) | |
| Skin color | | | | |
| White | 1.33 (0.73 – 2.40) | 0.327 | 1.39 (0.77 – 2.48) | 0.250 |
| Others | 1.00 | | 1.00 | |
| Education level (completed years) | | | | |
| 0 – 4 | 1.40 (1.03 – 1.91) | 0.033** | 2.06 (1.39 – 3.10) | 0.005** |
| 5 – 8 | 1.60 (1.14 – 2.25) | | 1.72 (1.20 – 2.47) | |
| 9 or more | 1.00 | | 1.00 | |
| NEI (quintiles) | | | | |
| 1st quintile (poorest) | 1.00 | 0.056 | 1.00 | 0.150 |
| 2nd quintile | 1.44 (0.96 – 2.16) | | 1.32 (0.87 – 1.99) | |
| 3rd quintile | 1.68 (1.15 – 2.44) | | 1.49 (0.99 – 2.24) | |
| 4th quintile | 1.86 (1.14 – 3.03) | | 1.77 (1.07 – 2.92) | |
| 5th quintile (richest) | 1.24 (0.74 – 2.04) | | 1.33 (0.84 – 2.11) | |
| Rural worker | | | | |
| No | 1.00 | < 0.001 | 1.00 | < 0.001 |
| Sim | 2.28 (1.61 – 3.22) | | 2.87 (2.05 – 4.01) | |
| Time living in a rural area | | | | |
| 100% of their life | 1.48 (1.09 – 2.01) | 0.009 | 1.28 (1.00 – 1.66) | 0.033 |
| 99 – 50% of their life | 0.76 (0.46 – 1.25) | | 0.81 (0.52 – 1.28) | |
| < 50% of their life | 1.00 | | 1.00 | |

PR: prevalence ratio; 95%CI: 95% confidence interval; *Poisson regression with adjustment for robust variance, **p of linear trend; NEI: National Economic Indicator.

Here, contact with pesticides was associated with rural work and living a long time in the countryside. Additionally, those who performed activities related to planting, animal husbandry and fishing were more likely to become in contact with these products compared to those who did not perform such activities. Rural work causes the greatest direct and indirect contact with pesticides for this population[24]. Although it is expected that the most affected are those individuals who work in direct contact with pesticides, it is important to note that, when used in agriculture and other economic activities, pesticides are intensely dispersed in the air, water and soil, contaminating not only workers, but also individuals who are in some way exposed to the products and/or where they are used[25]. In addition, in places where family farming is very present, as observed in the municipality under study, individuals spend most of their lives in the rural environment, somewhat increasing their exposure to these chemical agents[26].

With regard to age group, our findings show a higher probability of contact with pesticides among those aged between 40 and 49 years, which is similar to the study by Figueiredo et al. (38 years old average)[27]. On the other hand, after this age (40 to 49 years old), the association found here becomes the opposite, and a protective relationship is established. This fact may be linked to the natural process of decreasing time in the workforce with age.

As men are responsible for tasks that have direct contact with pesticides, a recent systematic review showed that they are the groups at greatest risk in terms of exposure to these products[28]. According to the National Toxic-Pharmacological Information System (SINITOX), among the 530 deaths registered by poison control centers in 2003, the main toxic agents involved were pesticides for agricultural use, corresponding to more than 30% of the causes of total deaths[29]. For males, these chemical agents represented approximately 40% of the number of deaths recorded[29]. In the same direction, a study carried out with 370 rural workers treated at the toxicology outpatient clinic of Hospital das Clínicas of the Universidade Estadual de Campinas (UNICAMP), between 2006 and 2007, demonstrated that male individuals were more exposed to pesticides[27], corroborating the findings of the present study.

Although the relationship between skin color and contact with pesticides is very scarce in the literature, this study sought to explore this issue, however no significant associations were found for skin color. The population considered in the present study is represented, for the most part, by white skin, just like in the Southern Region of Brazil, which may explain the non-association observed in this regard.

Education level is considered to be an indicator of social condition that is associated with better health conditions, including having a protective effect against exposure to pesticides[17,30]. In the same sense, it was noted in the present study that individuals with less education (zero to four years) were more likely to have contact with pesticides, which may be related to the type of work activity performed, since individuals with less education may be assigned to the most unhealthy jobs, such as helping with the application of pesticides, or even applying them, washing clothes used for applying pesticides, preparing the pesticide syrup, and washing contaminated packaging and equipment. Thus, they are more susceptible to contact with pesticides. In addition, most studies point to low education levels as a limiting factor. That is, lower levels of education can make it difficult to read safety recommendations, labels (or even agronomic prescriptions) or access information on safety of use[17,28,30].

Most studies on pesticides in Brazil do not take into account the social dimension of the risk represented by exposure to these products, focusing their investigations on technical risk analyzes, based on knowledge of toxicology. However, it is important to note that, in Brazil, the legislation (Regulatory Standard 7: Occupational Health Medical Control Program; Regulatory Standard 15: Unhealthy Activities or Operations; and Regulatory Standard 31: Occupational Health and Safety in Agriculture, Livestock, Silviculture, Forestry and Aquaculture) states that all rural workers must carry out occupational medical examinations, including the assessment of unhealthy working conditions, such as those that expose workers to agents that are likely to cause damage to health during their working life, and the chemical risks related to the use of pesticides. However, it should also be considered that this standardization is established for workers governed by the Consolidation of Labor Laws (*Consolidação das Leis do Trabalho* - CLT), in other words, workers in the labor force. Self-employed professionals, which are common in rural areas, are not covered in this inspection, which may be linked to their greater exposure to situations causing health problems.

Finally, the study has some limitations, such as a possible reverse causality bias, which is characteristic of cross-sectional studies. This restricts some associations, as it does not allow for the observation of temporality in the relationship between exposure and the outcome of the study. Memory bias must also be taken into account, since the outcome question was related to the 12 months prior to the interview. Another limitation is that chronic diseases caused by pesticide poisoning were not included. Still, the study period covered the months of greatest harvest intensity for some crops (February to June), which made it impossible to interview those involved in exhaustive harvest work, and those who could have more exposure to pesticides.

Among the positive aspects of this study, we highlight the fact that it is the first population-based study carried out with adults in the rural area of Pelotas. Furthermore, it had a low percentage of losses and refusals, and quality control was used to verify the repeatability of the responses.

## FINAL CONSIDERATIONS

The findings of the present study reflect the vulnerability found in the rural population regarding contact with pesticides. Thus, it is essential to create health promotion strategies through technical knowledge about diseases related to contact with pesticides. It is worth mentioning the importance of training health professionals about pesticides and the possible contamination/poisoning from these products. With this, it is possible to establish a profile of both the substances and the reactions found, in order to develop health education strategies that minimize the risk of contact with these products.

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