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Epidemiological occupational studies in rural areas: methodological challenges

Estudos epidemiológicos ocupacionais em área rural: desafios metodológicos

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Abstract

Introduction: agricultural production in Brazil has grown in recent decades, and rural workers are exposed to many occupational risks. Epidemiological studies on the topic remain limited, especially regarding methodological complexity. **Objectives**: to present the main methodological challenges to carrying out occupational epidemiological studies in rural areas. **Methods**: the considerations presented in this article are based on the literature and on the experience of the authors as researchers of this thematic. **Results**: we approached concepts about target population, living and working place, workers classification, and agricultural production context characterization. We discussed sampling strategies, characterization of economic indicators, including agricultural production and mechanization level, pesticide exposure, such as chemical types, forms, and frequency of exposure, pesticide poisonings, and availability and use of personal protective equipment. We described the necessary care with biological samples and aspects involving interviewers, training, field work, and clinical and logistical issues. **Conclusion**: despite the methodological and logistical challenges, adequate planning enables successful research studies, of great complexity and high scientific level, about the health-work relationship in agricultural activity.

Keywords: agriculture; occupational health; rural population; epidemiological studies; pesticides.

Resumo

Introdução: a produção agrícola no Brasil tem crescido nas últimas décadas e os trabalhadores rurais estão expostos a vários riscos ocupacionais. Estudos epidemiológicos sobre o tema ainda são limitados, especialmente pela complexidade metodológica. **Objetivos**: apresentar os principais desafios metodológicos para a realização de estudos epidemiológicos ocupacionais rurais. **Métodos**: as considerações apresentadas neste artigo têm como base a literatura e a experiência dos autores como pesquisadores desta temática. **Resultados**: foram abordados conceitos sobre população alvo, local de moradia e trabalho, classificação dos trabalhadores e caracterização do contexto da produção agrícola. Foram exploradas as estratégias de amostragem; a caracterização dos indicadores econômicos, incluindo produção agrícola e nível de mecanização; a exposição aos agrotóxicos, como tipos químicos, formas e frequência de exposição; a intoxicação por agrotóxicos; e a disponibilidade e o uso de Equipamentos de Proteção Individual. Foram descritos os cuidados com amostras biológicas, bem como aspectos envolvendo entrevistadores, treinamentos, trabalho de campo, questões climáticas e logísticas. **Conclusão**: apesar dos desafios metodológicos e logísticos, com o planejamento adequado é possível realizar com êxito pesquisas de grande complexidade e de alto nível científico sobre a relação saúde-trabalho na atividade agropecuária.

Palavras-chave: agricultura; saúde do trabalhador; população rural; estudos epidemiológicos; agrotóxicos.

Introduction

Agricultural production in Brazil has shown expressive growth in recent decades. Based on data from the last Agricultural Censuses between 2006 and 2017, the gross value of agricultural production had an average annual growth of 4.1%[1] despite an 8.8% reduction in the workforce[2]. Examining the period from 1995 to 2019, while the total Gross Domestic Product (GDP) grew by 70%, the GDP of Agriculture increased by 129%[2].

However, despite the economic and technological growth, agricultural activity is still considered one of the most hazardous in Brazil and the world. According to the International Labor Organization (ILO), agricultural workers are three times more likely to face the risk of death compared with workers in other activities, in addition to being exposed to various physical, chemical, biological, mechanical, and ergonomic risks[3].

Few Brazilian epidemiological studies focus on agricultural work, and many of them have methodological limitations, such as small and/or non-representative samples, poorly defined production contexts, research without an appropriate comparison group and without controlling for confounding factors, among others. Additionally, knowledge production regarding gender issues in agricultural work is limited, underestimating women's participation[4]. While the number and quality of studies in this area have increased, considerable gaps remain, particularly concerning the effects of chronic exposure to pesticides[5]. Furthermore, official health information systems present high underreporting of work-related accidents and diseases, limiting their potential as surveillance tools, especially in agricultural activities[5,6].

Even authors with extensive experience in urban epidemiological studies have acknowledged methodological and logistical difficulties in conducting studies in rural areas with primary data[7]. Studies on rural themes using secondary data, such as ecological studies[8], also face limitations regarding the access to and the quality of data, among other challenges. This article aims to present concepts and key challenges for conducting population-based occupational studies in rural areas and share successful experiences from epidemiological studies conducted by the authors[9-14].

Methods

The reflections presented in this article are based on the authors' experience throughout all phases of conducting epidemiological studies in rural areas. With various research projects, especially within the context of family farming, the authors found it necessary to seek alternative methodologies to assess different aspects of rural workers' health. Additionally, the concepts and methodologies discussed are informed by scientific literature, participation in the discussion of other researchers' work—particularly in committees and events—and institutional reports, such as those from the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* – IBGE), Department of Informatics of the Unified Health System (*Departamento de Informática do Sistema Único de Saúde* – DATASUS), and Institute of Applied Economic Research (*Instituto de Pesquisa Econômica Aplicada* – IPEA), among others.

Table 1 shows some of the main studies that support the approaches discussed in this article.

Table 1 Methodological aspects of rural population studies

Local/Study	Authors/ Year	Study Focus	Target Population/ Sample	Design	Methodological Aspects
São Lourenço do Sul – state of Rio Grande do Sul/Tobacco farming study	Faria, NMX et al/2023[6]	Acute pesticide poisonings in tobacco farming	492 Pesticide applicators in tobacco farming from two districts/1rst & 2nd stages (June-July/October-November)	Cross-sectional. Bivariate analysis between chemical types and pesticide-related symptoms. Poisson regression and sensitivity/ specificity analysis	Compared different criteria for pesticide poisoning: symptom questionnaire, standardized medical examination, and toxicological evaluation. Used evaluation of plasma cholinesterase levels and photo cards to assess pesticide exposure.
	Faria, NMX et al/2014[13]	Occupational exposure to pesticides, nicotine, and psychiatric disorders	2,400 Tobacco farmers aged 18 or older/3rd stage (harvest season)	Cross-sectional. Poisson regression	Evaluated the prevalence and occupational factors associated with minor psychiatric disorders, with emphasis on chemical exposures to pesticides and nicotine. Developed sampling and logistic strategies for fieldwork.
	Fassa, AG et al/2014[11]	Factors associated with Green Tobacco Sickness (GTS)	2,469 Tobacco farmers aged 18 or older/3rd stage	Cross-sectional. Stratified analysis by sex. Poisson regression	Characterized GTS with a standardized questionnaire, utilizing various timeframes, and identified risk factors for GTS. Developed sampling and logistic strategies for fieldwork.
	Meucci, R et al/2015[14]	Chronic low back pain (LBP)	2,469 tobacco farmers aged 18 or older/3rd stage	Cross-sectional. Poisson regression	Described tasks performed in tobacco farming. Characterized low back pain among farmers with a standardized questionnaire and examined the association between occupational exposures and LBP.
	Meucci, R et al/2014[27]	Work limitation due to chronic low back pain (LBP), LBP in the last month (LBP-LM), and acute low back pain (LBP-A)	2,469 tobacco farmers aged 18 or older/3rd stage	Cross-sectional. Poisson regression	Presented an inventory of tasks that farmers with low back pain had to stop doing or do with some limitation.
	Fiori, NS/2015[12]	Wheezing/asthma symptoms	2,469 tobacco farmers aged 18 or older/3rd stage	Cross-sectional. Stratified analysis by sex. Poisson regression	Described exposure to dust in tobacco farming. Evaluated prevalence and occupational factors associated with wheezing (asthma symptom) in the last year.
	Cruzeiro Szortyka, ALS et al/2021[30]	Suicidal ideation and suicide attempts	2,469 tobacco farmers, 18 years or older/3rd stage	Cross-sectional. Poisson regression analysis	Investigated prevalence of suicidal ideation (multivariate) and suicide attempts, as well as factors associated with suicidal ideation.
	Fassa, AG et al/2021[21]	Child labor in tobacco farming	99 young tobacco farmers, under 18 years/3rd stage	Cross-sectional, including urinary cotinine	Characterized child labor in tobacco farming and the prevalence of GTS, wheezing, LBP, among other outcomes.

(Continues)

Table 1 Continuation...

Local/Study	Authors/ Year	Study Focus	Target Population/ Sample	Design	Methodological Aspects
São Lourenço do Sul – state of Rio Grande do Sul / Tobacco farming study	Fassa, AG et al/2018[45]	Urinary cotinine among tobacco farming workers	582 Pesticide applicators in tobacco farming + GTS symptomatic/2nd and 3rd stage	Cross-sectional. Urine collection in selected individuals. Stratified analysis by sex. Poisson regression	Evaluated nicotine exposure by urinary cotinine. Identified that occupational transdermal nicotine exposure increases urinary cotinine levels. Examined the duration of elevated urinary cotinine levels. Suggested that urinary cotinine shouldn't be used as a biomarker for GTS.
Bento Gonçalves-RS/Fruit farming study	Faria, NMXF et al/2009[10]	Acute pesticide poisonings in fruit farming	290 agricultural pesticide applicators	Sample: all peach producers from two districts. Descriptive. Bivariate analysis. Cholinesterase measurement in low/high exposure	Investigated the prevalence of acute pesticide poisonings. Used a questionnaire on pesticide-related symptoms.
Antonio Prado and Ipê-RS/ Study among rural workers in Serra Gaúcha	Faria, NMX et al/2000[9]	Characterization of activities in family farming in Serra Gaúcha	1,479 rural workers	Random sampling. Cross-sectional descriptive. Bivariate analysis	Developed strategies to assess the economic level of properties, created a questionnaire to describe agricultural tasks, occupational exposures, including forms and intensity of pesticide exposure. Developed sampling and logistic strategies for fieldwork.
	Faria, NMX et al/1999[42]	Minor Psychiatric Disorders in family farming in Serra Gaúcha	1,200 rural workers	Random sampling. Cross-sectional. Logistic regression analysis	Characterized the prevalence and occupational factors associated with mental health in family farming. Identified the association between pesticide poisonings and minor psychiatric disorders.
	Faria, NMX et al/2006[20]	Dust and respiratory symptoms in family farming in Serra Gaúcha	1,379 rural workers	Random sampling. Cross-sectional. Logistic regression analysis	Developed a list of organic and mineral dust in family farming. Examined the association between dust and respiratory symptoms.
Vacaria/ Rural Production Units study	Stedile, NRL et al/2022[22]	Use of pesticides in Rural Production Units (RPU)	428 Rural Production Units in the Family Health Strategy (ESF) coverage area	Cross-sectional descriptive. Bivariate analysis	Characterized rural production units and how pesticides were managed in the RPU, according to the number of fiscal modules. Examined differences in the management of products used in agriculture and veterinary products.

Results and discussion

The quality of scientific production on the health of rural workers depends on an adequate methodological design, with statistical power to investigate planned associations and capable of minimizing biases, especially selection and information biases. Additionally, to improve comparability between studies, specifying the concepts used is necessary. Considering the diverse context of Brazilian agricultural activity and the lack of reliable information for understanding the reality, we recommend the observation of the methodological aspects discussed in this article. This will allow for the generation of high-quality knowledge to support public health policies for rural workers.

Selection of the target population and study location

Defining the target population and study location are fundamental aspects. The Brazilian Institute of Geography and Statistics (IBGE) considers the rural population based on an administrative criterion (municipal public decree), which is adopted in most studies. However, there are other criteria, such as that of the Organization for Economic Cooperation and Development (OECD), primarily based on population density, considering areas with less than 150 inhabitants/km^2 as rural. In the 2000 Demographic Census, the proportion of the Brazilian rural population was 19%, but using OECD criteria, it would be much higher, reaching 30%[16]. In the 2010 Census, the IBGE identified 15.6% of the population as rural, but by OECD criteria, this proportion would be 24%[17]. A new classification proposal, which depicts a less urban Brazil, is being prepared for the 2022 Census.

The term "rural" mainly refers to someone's workplace or place of residence. Some people may live in urban areas and work in agricultural activities, while others may live in rural areas and engage in non-agricultural activities. Therefore, depending on the research question, defining whether the target population should consist of rural residents or agricultural workers is necessary.

The selection of the study location needs to consider its theme. For example, to study Green Tobacco Sickness (GTS), selecting an area where tobacco cultivation is prevalent was essential[11]. For evaluating cholinesterase levels among pesticide applicators in a fruit farming area, establishments cultivating peaches, where organophosphate application was frequent, were chosen[10]. In other situations, such as studying mental health[13] or musculoskeletal problems[14], the options for types of crops are broader. In any case, for research planning, awareness of the predominant agricultural crops and animal production is needed. To investigate pesticide exposure, identifying the phases of the agricultural cycle where usage is more or less intense, adjusting the fieldwork period to the aspects to be evaluated, is crucial.

Rural or agricultural worker

The term rural worker is still the most used, as evidenced by the name of the labor union: Rural Workers Union. The NR31 (Regulatory Standard for Occupational Health and Safety in Agricultural Activities), published in 2005 and updated in 2020, maintained the name "rural work"[18]. However, there are controversies regarding the definition of what is considered rural[16,19]. In general, the primary, but not the only, productive activity in rural areas is agriculture, which includes tasks related to the primary production of food and fibers (farming, animal production, horticulture, forestry, etc.).

Most studies consider agricultural worker as someone who works in these activities for 15 or more hours per week[9,13,20,21]. This criterion selects individuals who are indeed exposed to the risks of agricultural work, avoiding the risk being "diluted" among those who do not perform or only perform these activities to a lesser extent. On the other hand, it may fail to capture people who are less exposed to certain risks, such as pesticides. Additionally, since working with pesticides and in tobacco farming is prohibited for individuals under 18 years of age and older adults, some families do not report when people in these age groups are regular workers, leading to a selection bias[22].

Some studies that assess chemical exposure target pesticide applicators, investigating those who were applicators in the last year or the last crop season to capture the most exposed individuals[10]. In this approach, the

main challenge is defining a comparison group. Workers from other activities often live in a different social context and may not be comparable. On the other hand, comparing agricultural workers who do not use pesticides may be influenced by the healthy worker effect, as they may avoid exposure due to existing health issues such as asthma or cancer. The most appropriate option seems to be interviewing all workers, observing their levels of exposure, and comparing those with higher exposure to those with lower exposure. Some workers may be additionally exposed in other work environments, and capturing this information is important for subsequent analysis. Observing cases where individuals report not participating in pesticide application but may have been exposed due to other simultaneous activities or tasks performed nearby during the application is also necessary.

Work location: rural property, rural/agricultural establishment, agricultural production unit*

The term rural property refers to a land area registered in the name of an owner and their family or an agricultural company, which may or may not have agricultural production. In Brazil, the more appropriate term for an area with agricultural production is agricultural/rural establishment.

The workplace location can also be characterized as an agricultural production unit[23] when individuals from the same family or company produce and market their production jointly, occupying areas that belong to multiple owners or partners but with unified management. In most studies, the concept of Agricultural Production Unit (PU) has been used since in family farming, land ownership is commonly divided among family members.

The PU should be characterized according to the total area, including areas used for agriculture, animal production, native forest, and others. Although it is often measured in hectares, other units of measurement can be used. For example, the classification of the National Institute for Colonization and Agrarian Reform (*Instituto Nacional de Colonização e Reforma Agrária* – INCRA) can be used, which considers the number of fiscal modules. The size of the fiscal modules varies among states and even municipalities, ranging from 5 to 110 hectares[24]. The INCRA classifies rural properties by area as follows: properties inferior to one fiscal module; properties between one and four fiscal modules; medium-sized properties, superior to four and up to 15 fiscal modules; and large properties, superior to 15 fiscal modules[24]. This classification has been used to describe the characteristics of PUs and the practices used in pesticide management[23].

The characterization of the production process varies according to the study objectives. Considering that not all workers have the necessary knowledge to provide information about the characteristics of PUs, this information can be collected in a specific questionnaire applied to the main operator of the establishment to ensure more consistent information and avoid missing data. Subsequently, the database with PU characteristics will be unified with the one containing individual information from each worker on those PUs. Rigorous checking of questionnaire numbers for the establishment and individual questionnaires is essential to enable linking between databases. The correct linkage is fundamental, especially in studies analyzing the effect of the context on one or more outcomes in a specific group of individuals.

Production context: family farming or commercial/enterprise farming

Family farming, which in 2006 accounted for about three-quarters of the people working in agricultural activities, experienced a 17% reduction in the number of workers in 2017[25]. Brazilian legislation (Law No. 11.326/2006) defined family farming as that developed in an area equal to or smaller than four fiscal modules, with a predominance of family labor and income from agricultural sources, and with the farming unit directed by the farmer or a family member[26]. These requirements are essential for accessing financing lines, such as the National Program for Strengthening Family Agriculture (*Programa Nacional de Fortalecimento da Agricultura Familiar* – PRONAF). However, epidemiological studies may choose to use the legal criteria partially or even other criteria to define family farming.

* Editorial note: the terms used here are those commonly adopted in Brazil.

In addition to family farming, there is also patronal and/or enterprise farming, in which the predominant labor force is made up of employees. Brazil has about 5 million agricultural establishments of different sizes and technological levels[27]. Large establishments, due to legal requirements (NR-31 and others)[18], must have data on chemical, physical, and biological risks, as well as results of complementary health exams. Information on risks related to ergonomic aspects is still very limited in agricultural work. Conducting research in large establishments involves negotiating with managers and/or owners, which may be supported by other agencies[23], such as the Municipal Health Council and the Labor Public Prosecutor's Office. In any case, in addition to the authorization of the establishment's management, the consent of each respondent must be obtained, expressed by signing of the informed consent form, both in business and family units.

Definition of interviewees: owner family and/or employees

The studies may include interviews with all residents or only those who are agricultural workers. Regarding the characterization of the owner family, there may be doubts about who is a relative, especially when individuals with more distant ties—such as uncles, spouses, children, brothers-in-law, sisters-in-law, among others—live on the PU. In general, all individuals with family ties who are not employees are considered part of the owner family. However, restricting the concept to those who share part of the income derived from production is also possible. The tenant, despite not having ownership of the land, act as responsible for the direction of the agricultural establishment with their family.

Agricultural work has both permanent and temporary employees, with formal and informal relationships. Additionally, there are numerous arrangements between neighbors, with exchanges of different tasks (for example, one helps to load chickens, and another plows the land with a tractor or assists with pesticide application).

In large-scale patronal/entrepreneurial agriculture, employees are generally permanent and/or hired for a specific period of work (such as during harvest season), but informal employees also exist. Between 2006 and 2017, third-party hiring increased 143% in this segment, as showed by Agricultural Census[25].

Interviewing temporary employees, such as seasonal workers, presents difficulties. Many of them used to work in more than one establishment during the same period, are not available every day of the week, or do not reside in rural areas. Additionally, employers who pay by the hour or day of work are often reluctant to release these workers for an interview. This hinders locating and contacting them, making fieldwork logistics more challenging. Furthermore, when they work in multiple establishments, characterizing their work location becomes more complex. Legal restrictions on child labor also hinder identifying and conducting interviews with agricultural workers under the age of 18. When this is a group of interest, it is recommended to include all residents of the establishment and assess their participation in agricultural activities during the interview[22]. In studies on family farming, reconciling the economic characterization is also challenging. While agricultural economic indicators of the establishment are used for the owner family, in the case of employees, the payment method can vary, predominantly being a monetary value paid to the individual. In these studies, it may be easier to exclude temporary employees. If this group is the focus of a study, the difficulties outlined in the design and planning of the fieldwork need to be considered.

Sample selection

Sample selection in rural epidemiological studies can be challenging due to the need for a representative sample of the population. Depending on the study objectives and the municipality structure, different approaches can be used. If available, the list of residents in rural areas covered by the Family Health Strategy (*Estratégia de Saúde da Família* – ESF) can be used[14,15,23]. However, not all municipalities have good ESF coverage in rural areas. Lists of producers from the Institute of Technical Assistance and Rural Extension (*Institutos de Assistência Técnica e Extensão Rural* – EMATER) can also be utilized, but they may be unavailable. For studies focusing on agriculture families, a common approach is to use a random sample of establishments drawn from the list of rural producers (model 15) available at the City Hall.

Once the establishments are selected by random sampling, support from key informants such as ESF teams, EMATER staff, and others is essential to locate these establishments or production units (PUs). The number of establishments or PUs to be selected needs to be determined based on census estimates of the number of people employed per establishment. For example, the 2017 Agricultural Census found an average of 2.98 people employed per establishment[28], while, in a study of tobacco farming, this number was 2.88, requiring the selection of an additional supplementary sample[12].

Ensuring an adequate sample size is essential to achieve the necessary statistical power to perform multivariable analysis capable of detecting moderate risks, such as those found in associations between pesticides and various health outcomes. Moreover, minimum sample sizes should be defined for specific population categories or strata if the intention is to analyze subgroups in the study, such as by gender or age group, or to compare workers performing different activities.

To increase participation and reduce losses and refusals, it is recommended to conduct extensive publicity campaigns in all communication channels that have an impact on the specific target population, including radio programs, participation in local events, religious services, and pre-study publicity with family health teams and community health agents.

Economic Indicators

The characterization of economic indicators in rural areas is similar to that in urban areas. When evaluating employees with formal employment, monthly income is obtained. However, in family agriculture, seeking alternatives is necessary since, in general, work relationships are not formalized, and remuneration can take various forms (temporary work, partnership, leasing, integrated systems). Therefore, other indicators can be used to characterize the economic and technological profile of the family PU. For example, gross income has been estimated based on the annual volume of the main agricultural products and/or the size of the herds marketed in the last twelve months[9,13,14].

The level of mechanization is also a good indicator, characterized by the availability of agricultural machinery. The 2017 Agricultural Census assessed tractors (< 100 horsepower or ≥ 100 horsepower engine power), seeders or planters, harvesters, fertilizer spreaders or lime distributors, and agricultural aircraft[27,33]. However, to evaluate the effects of pesticides, differentiating tractors not by horsepower but by the presence of an enclosed cabin, chemical filter, and air conditioning may be more important[23]. This information allows us to build a synthetic indicator of the level of mechanization based on the sum of available machinery. The synthetic indicator can also use weighting to consider whether the machinery is owned or rented, its power, and/or time of use. A specific indicator for tobacco farming is the availability of electric curing barns, since, although they increase electricity consumption, they facilitate the work of tobacco farmers.

Assessing the ownership of vehicles, such as passenger cars, motorcycles, or vehicles for transportation of production (trucks, vans, and other utilities) is also important. Despite having less economic impact, the presence of motorcycles in rural areas has grown, and while they are important for facilitating the movement of the rural population, they are also linked to an increase in accidents[34].

The technological level, including access to technical assistance, has been more closely related to increased productivity and income than the size of the establishment[35]. Access to rural credit, irrigation technologies, electricity, and solar power can also influence the productivity and income of the establishment[33]. The availability of cold storage or integration into a production chain can facilitate the marketing of produce and increase income[36]. On the other hand, farmers often take out loans to finance production and eventually end up in debt. Evaluating this aspect is essential since studies indicate that difficulty in repaying debts[13,30], as well as a decline in agricultural production[37]—or other indicators of poorer economic conditions—were an important risk factor for adverse mental health outcomes.

Pluriactivity, or part-time farming, has grown since income sources from non-agricultural activities can increase income and quality of life, contributing to the retention of these workers in agricultural activities. Compared to 2006, the 2017 Agricultural Census identified a growing percentage of pluriactivity, especially in family agriculture[27].

However, depending on the type of non-agricultural activity, workers may be exposed to other important occupational risks. Since this is a historical trend (in Brazil and other countries), characterizing and quantifying these activities in studies on rural workers is recommended.

The pesticides question

The evaluation of pesticide exposure is limited; many of the chemical types available in Brazil have no biomarkers, or they are only available in large centers, or they are costly. The current legislation (NR-7, in its updated version of 2022)[38] makes it mandatory to monitor occupational exposure to arsenic, rarely used, and cholinesterase-inhibiting insecticides, by cholinesterase—plasma or erythrocyte. This biomarker is also used in epidemiological studies but has several limitations: it is specific to cholinesterase inhibitors; its evaluation time is quite restricted in the case of carbamates, since they cause temporary inhibition; it requires a reference measurement (non exposed period) that is not always available; it involves blood collection; and it may show interference by various health issues[39]. In other countries, several biomarkers of pesticide exposure can be measured in urinary metabolites or hair. Assessing pesticide exposure also becomes more complex due to multichemical exposure, both from the use of products that combine various chemical types and the use of different products.

To obtain information on pesticide exposure, the first challenge is to identify the main chemical products used. A successful experience was used in the tobacco farming study[6,13]. With the support of key informants (EMATER, Rural Workers Union, agricultural technicians, agricultural stores, and others), a list was created with about 70 trade names of the most used pesticides. Laminated cards were prepared, with 12 products on each page, containing photos and the respective names of the chemical products. These cards were used by the interviewers to help the respondents identify the products used on the farm. For analysis, commercial products were unified according to their active ingredients and chemical groups[6,40].

For the study on acute pesticide poisoning in tobacco farming[6,13], the applicators were asked to identify the products used in the last 30 days and the date of the last day of contact. This system may be limited in assessing past exposures but was quite useful in evaluating recent exposure to pesticides[6]. Nevertheless, some doubts persisted regarding differences in the formulation or concentration of some products.

Pesticide exposure should be assessed by temporal criteria, such as the average time of use, such as hours/day, days/week, days/month, or days/year. The latter was used in the US[41] as one of the indicators of cumulative exposure, weighing according to the type of PPE used, in addition to other criteria. Other studies used years of exposure as the main criterion for cumulative exposure[13]. Based on this data, a synthetic indicator of exposure intensity can be constructed.

Exposure forms can be described by the activity performed, such as applying, preparing the solution, assisting in application, cleaning equipment, filling the spraying tank, washing contaminated clothing, transporting, storing, veterinary use, and re-entering the crop/orchard after application[6,13,42]. Moreover, some situations may indicate higher exposure, such as applying in more than one agricultural production unit or spilling the product on clothing while performing these or other activities, which is one of the criteria for characterizing events of high exposure[6,43].

The assessment of acute pesticide poisoning is important not only due to its own relevance but also for its association with various chronic health problems[13,14]. For this evaluation, the information provided by the worker, the medical diagnosis, or the application of a questionnaire on symptoms related to pesticides following the methodology proposed by the World Health Organization (WHO) for classifying acute pesticide poisonings can be used[6,44].

Biological Samples

Depending on the study objectives, the collection and processing of biological samples such as blood, urine, and others may be necessary. The tobacco farming study was successful in this aspect[6,45], relying on experienced nursing techniques to collect blood, reducing problems of hemolysis in the samples. Since plasma cholinesterase

is an enzyme sensitive to temperature variations, the samples were labeled and stored in thermal boxes with strict temperature control immediately after blood collection. At the end of the day, in the laboratory, they were centrifuged and prepared for shipment to the toxicology laboratory. In the fruit farming study[10], an occupational examination laboratory was dispatched to rural districts with mobile units equipped with human resources and the necessary materials for blood collection and processing, including centrifuges. In both cases, the collection was performed shortly after the interviews, and the maximum time until delivery to the toxicological laboratory was no more than two days[10], respecting the optimal processing time to ensure result quality.

In both studies, blood collection occurred at two moments: during the winter period when insecticides were not used (reference test), and at the peak of pesticide application. To define the reference measurement, at least one month without exposure to cholinesterase-inhibiting insecticides is recommended[38]. For subsequent analysis of laboratory results, recording the last day of exposure is important.

In tobacco farming, during the tobacco harvest period, urinary cotinine was also evaluated[45]; the vial was given to the worker who met the criteria, and the urine was collected at their own residence. The samples were stored in rented freezers distributed in the districts where the study was being conducted. Periodically, the frozen samples were sent to the toxicology laboratory.

Recently, new perspectives have emerged for evaluating exposure to various types of pesticides, such as organophosphates, pyrethroids, neonicotinoids, dithiocarbamates, glyphosate, and others. In international studies, urinary metabolites and other types of biological samples—such as hair strands, feces, and saliva—have been used[39].

Personal Protective Equipment – PPE

Studies have evaluated the use of personal protective equipment (PPE), such as hats, protective clothing, masks, gloves, and closed footwear/boots. However, this form of assessment presents limitations since it does not distinguish the purpose of use (chemical protection for pesticides), what constitutes "protective clothing" according to the worker's perception, and what is certified PPE. For a more accurate evaluation, it is important characterizing the use of waterproof overalls or pants and water repellent fabric coats, high waterproof boots, waterproof aprons, well-fitted respirators or masks with chemical filters, face shields or facial masks for face and eye protection, chemical-resistant gloves (nitrile or neoprene), and caps with neck protection flap.

Additionally, the frequency of use and whether it is used in all tasks with contamination risks should be examined. This includes washing contaminated clothing, reentering areas after application, and cleaning equipment used in application. The proper cleaning and decontamination of PPE before reuse should also be verified. Some workers report reusing certain equipment without prior decontamination, which can turn what should be protective into a source of contamination.

Interviewers

Interviewers, preferably with completed high school education, need to conduct interviews, accurately fill out questionnaires, and frequently use devices such as tablets, PDAs (palm-top), or mobile applications. Therefore, they must have the ability to correctly record information on these devices.

In the tobacco farming study, selected interviewers were former community health agents (*Agente Comunitário de Saúde* – ACS) from rural ESF units[12,14,15]. In the third stage, when increasing the number of interviewers was necessary, additional IBGE enumerators were hired[12]. In other studies, rural area teachers, high school students (from urban areas)[9], other public servants, or rural union workers conducted interviews[10,23].

Due to geographical proximity and trust within the community, ACSs were able to ensure greater adherence to the research in tobacco farming. On the other hand, in sensitive topics such as mental health issues, being acquainted

with the interviewers could lead to underreporting of symptoms, underestimating the magnitude of the mental health problem (information bias)[13,30,42].

Another important aspect is the need to remunerate interviewers, since voluntary workers may not always have the commitment to the task, especially regarding meeting targets to complete fieldwork on schedule. The number of interviewers needed will depend on the sample size, study logistics, and instrument complexity.

Training and pilot study

Training and pilot studies are essential to assess candidates for interviewers and refine the study planning. These activities allow candidates to experience questionnaire administration and fieldwork logistics, enabling adjustments and clarification of any doubts.

In the tobacco farming study[11-14], three training sessions were conducted. The first, lasting two days, aimed to introduce the study, and train questionnaire completion and interview techniques. The second training included a preliminary version of digital instruments, allowing candidates to familiarize themselves with the devices used. Any programming failures and issues with the questionnaires were addressed. Additionally, a pilot study was conducted in non-sampled establishments to evaluate candidates' performance and questionnaire adequacy. After adjusting the instruments, a third training was held to present the final version of the questionnaires, train interviews, and finalize details.

Creating an instruction manual, defining and standardizing responses to doubtful questions, is essential. The manual should be used during training to familiarize interviewers with the material. It should include the interviewer's stance, aspects related to sample selection such as inclusion/exclusion criteria, and substitution rules. It should also clarify issues such as the classification of education level. This is an aspect that has changed over time, so the manual can include a table (digital or laminated card) with the equivalence between existing classifications and years of approved study. Interviewers should bring any doubts not covered in training and the manual for discussion with supervision.

Fieldwork period

Occupational risks vary depending on the predominant phase of the agricultural cycle in the region. Fieldwork beginning during one phase and extending to other phases of the agricultural cycle should be avoided, since this can lead to a change in the pattern of exposure, especially in chemical risk.

In the tobacco farming study, to assess green tobacco sickness[11] (and other health issues[12-14]), 2,570 tobacco farmers were interviewed during the harvest months (January and February). To meet this challenge, 36 well-trained interviewers were hired[12,14], with the necessary support, especially a good transportation logistics, to ensure efficient and suitable fieldwork. In the same study, similar to what was done in fruit farming[10], around 500 tobacco farmers who applied pesticides were assessed in two stages, low and intense pesticide exposure, over 2-4 weeks[6].

Fieldwork in rural areas involves considerable physical and operational wear, in addition to high costs, especially due to travel. Planning return visits to interviewees who were not available during the first visit is necessary, in addition to addressing any health issues involving research team members. Therefore, the study planning should allocate resources and logistics to enable efficient fieldwork to take place during the same phase of the agricultural cycle.

Climatic issues

Climatic interference is common in rural fieldwork. Excessive rainfall can complicate travel, causing problems with vehicles on poorly maintained roads. Some places may even become inaccessible. On the other hand, people are

more likely to be at home on rainy days. The planning should consider these difficulties, considering the comfort of interviewers as well.

Additionally, climatic issues can impact agricultural production. Different studies have observed problems such as storms, hail, out-of-season frosts, or drought. In other words, rural workers are at the mercy of the weather. Thus, the study planning should consider the potential agricultural impacts of climatic issues and gather information for subsequent analysis.

A less-evaluated aspect, but that should also be considered, is the impact of prolonged heat exposure, which can produce thermal stress and, in some cases, chronic effects, such as nephropathies[46].

Travel and other logistics

This is one of the critical points of rural fieldwork, since rural roads are often in poor condition, damaging or getting vehicles stuck. In most cases, support from institutions such as Health Departments or other municipal entities, Occupational Health Reference Centers (*Centro de Referência em Saúde do Trabalhador* – CEREST), among others, is needed. In the tobacco farming study[6,11], several official vehicles (from the Federal University of Pelotas and the Municipal Health Department) were made available, in addition to the researchers' cars. However, they were insufficient for all the needs. A good solution was to hire interviewers with their own vehicles (car/motorcycle), increasing remuneration to cover fuel costs. However, this limits the options for interviewers and increases fieldwork costs, which can be much higher than estimated (about 140 km/day/vehicle). Allocating additional resources for this budget item is recommended.

Regarding team meals, considering the scarcity of options in rural areas, multiple locations were pre-contracted for the group's meals, with easy access (family home/bar), covering the entire study area.

Other methodological aspects

In occupational epidemiological studies, analyzing risk factors for specific health issues is common. However, studying the impact of morbidity on productive capacity, i.e., limitations for work resulting from these pathologies, is also possible. This approach was used to examine limitations in agricultural tasks in tobacco production due to lower back pain[15].

Although not an exclusive aspect of rural studies, highlights the importance of using validated instruments, which can vary depending on the study focus; for example, respiratory problems, musculoskeletal issues, mental health, or substance use/abuse.

Final considerations

The Brazilian agricultural production, of increasing social and economic importance, presents diverse productive characteristics that can impact working conditions and workers' health. Although the number of epidemiological studies on agricultural work has increased over time, they are still relatively scarce, possibly due to various methodological challenges in design, analysis, logistical aspects, and approaches to various occupational risks. However, with adequate planning, it is possible to successfully conduct highly complex and scientifically advanced research on agricultural activity and rural populations.

Given its complexity, this article does not cover all the challenges that may arise in rural epidemiological studies but provides important reflections and practical suggestions based on the experience of conducting this type of research and the lessons learned by researchers. Therefore, it presents relevant inputs to support future studies that can contribute to building knowledge in the field of rural worker's health.

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