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Pesticide exposure and association with physical and hearing symptoms of rural workers

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Abstract

The chronic and combined exposure to pesticides can cause damage to the health of the rural worker, including hearing. The purpose of the study was to characterize rural workers in terms of sociodemographic aspects and exposure to pesticides, as well as to analyze the relationship between this exposure and the occurrence of physical and auditory symptoms. This was a quantitative study, with a descriptive and explanatory scope, using a cross-sectional design, carried out with 71 rural workers, males, exposed to pesticides. Data collection was performed in two ways: (i) a collection instrument for characterizing contact with pesticides, physical and auditory symptoms (ii) auditory screening for the investigation of aerial hearing thresholds. Data analysis was performed through descriptive statistics and through the Wilcoxon test and Spearman's correlation. The level of significance was set at 5% for statistical tests. Among the physical symptoms associated with the use of pesticides, headaches prevailed (31.0%). As for the result of auditory screenings, 31 (43.7%) rural workers failed in both ears, 28 (39.4%) obtained the results of "passing" and 12 (16.9%) failed in only one ear. When analyzing the association between the results of auditory screenings and variables regarding exposure to pesticides, exposure time was the only variable that showed a significant association. The findings clarify that the professional activity of farmers poses a risk to hearing, however, it is necessary to consider that other factors, such as noise and vibration, can aggravate hearing loss in this population.

Keywords: Pesticide. Farmer. Occupational health. Hearing

INTRODUCTION

Risks to human health due to chronic exposure to pesticides have been the object of great scientific interest[1,2]. There is even a hypothesis that exposure and/or poisoning by pesticides is related to increased suicide rates and the prevalence of attention deficit hyperactivity disorder (ADHD) in children[3,4]. However, there are still important gaps about the exact effect on the health of individuals in relation to the combined exposure of pesticides[5].

Pesticide poisoning can be measured based on various parameters, such as recent symptoms reported by the worker, assessment of occupational history, knowledge of the location and organization of work, among others. Protocols for assessing chronic poisoning by pesticides suggest that occupational and environmental exposure be assessed, as well as clinical assessment, which includes general physical examination, laboratory tests, mental health assessment and even an audiological assessment[6,7].

In this sense, it is relevant to understand the physical symptoms associated with the

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use of pesticides, since different symptoms are associated with different types of pesticides and often workers see them as natural processes resulting from their management; that is, there is a depreciated perspective between the use of pesticides and possible physical symptoms[8].

As for hearing, studies have observed changes in the auditory system due to exposure to pesticides[9,10,11,12] which shows the importance of rural workers to perform audiological evaluations, with pure tone audiometry being the most used evaluation method and considered the starting point for the audiological diagnosis. However, only workers with intense noise exposure are legally supported for audiological control. That is, there is no specific recommendation to assess the hearing of workers exposed to chemical agents, such as pesticides, when not exposed to excessive noise[13].

Thus, the purpose of the study was to characterize rural workers in terms of sociodemographic aspects and exposure to pesticides, as well as to analyze the relationship between this exposure and the occurrence of physical and auditory symptoms.

MATERIALS AND MEHODS

This was a quantitative study, using a descriptive and explanatory scope, with a cross-sectional design, carried out with rural workers exposed to pesticides residing in a municipality in the northwestern region of Rio Grande do Sul, RS. All participants had the same Basic Health Unit (UBS), of the Unified Health System (SUS), located in rural areas as their reference points.

First, the survey of the total number of rural workers in this UBS was carried out through the analysis of medical records, totaling 293 subjects. For sample selection, those aged 18 years or older, male, using pesticides on his rural property and working at least 15 hours a week in agricultural activities (criterion to be considered rural worker, according to IBGE) were considered as inclusion criteria in the study. Rural workers who showed changes in visual inspection of the external auditory canal or who already had a hearing loss of diagnosed non-occupational origin were excluded, as well as women, due to possible hormonal influences in laboratory tests performed, but not discussed in the present study.

To define the sample, the probabilistic method was used, considering a stratified sample proportional to the size of the age group, with a 95% level of confidence, an error of 7% and a proportion of 30%, resulting in 96 rural workers. The selected participants were contacted via telephone, received explanations about the study and were invited to go to the UBS on a defined date and time. If the individual selected for some reason did not answer the phone or refused to participate, the next participant in a reserve sample was used.

Considering the above, even with the use of the reserve sample, 96 rural workers, 82 attended the BHU; however, of these, 11 were excluded (nine did not meet any inclusion criteria, one did not want to perform auditory screening because he had performed ear surgery and another refused to perform the auditory examination), totaling a sample of 71 rural workers.

Data collection was performed in two ways: (i) collection instrument for characterizing contact with pesticides, previous history of the rural workers, physical and hearing symptoms; (ii) auditory screening for the investigation of aerial hearing thresholds. The collection instrument was adapted from the Protocol for the Evaluation of Chronic Intoxications by Pesticides prepared by the State Department of Health of Paraná6 and completed by the speech therapist based on an interview with the worker. In the first part of the instrument, questions were asked about their general data (age, education, race) and information on the use of pesticides (time of use, place of purchase, type of pesticide used and use of personal protective equipment - PPE) was requested. In a second step, information was collected on the general health of rural workers, on the recent physical symptoms associated

with the use of pesticides and also on hearing health (otorrhea, tinnitus, history of tympanic perforation, ear surgery and use of ear protection) .

In auditory screening, the Interacoustics AD229 audiometer was used in a quiet room at the UBS. The aerial auditory thresholds of the frequencies of 250Hz, 500Hz, 1000Hz, 2000Hz, 3000Hz, 4000Hz, 6000Hz and 8000Hz were investigated. All frequencies were investigated due to the importance of analyzing the audiometric configuration of the findings. As a "pass" criterion in auditory screening, normality was considered in the inspection of the external auditory canal and the average between the frequency thresholds of 500Hz, 1000Hz, 2000Hz and 4000Hz up to 25dB, in both ears, according to the classification of the World Health Organization Health (1997). All participants who had "failed" the auditory screening were referred for audiological diagnosis at a center specialized in SUS auditory rehabilitation. Afterwards, analyses were also performed only with low frequencies (500, 1000 and 2000Hz) and high frequencies (3000, 4000 and 6000Hz) due to the potential for worsening of high frequencies due to exposure to pesticides.

The study respected the ethical procedures established by Resolution No. 466/2012 of the National Health Council (CNS), which regulates research involving human beings and was approved by the Ethics Committee on Research with Human Beings of the Federal University of the Fronteira Sul through Opinion No. 1.848.706. All participants involved in the study signed the Informed Consent Form.

Data analysis was done through descriptive statistics, through the verification of the percentages of qualitative variables and descriptive measures of position and variability of quantitative variables. Also, statistical analysis of the data was performed, and the Wilcoxon test was used to compare two samples, meanwhile Spearman's correlation was used to verify the relationship between two variables. The level of significance was set at 5% for all statistical tests. The data were stored on a LibreOffice Calc spreadsheet. To perform the statistical tests, the software R v.2.15.3 was used.

RESULTS

As for the sociodemographic aspects, of the 71 rural workers participating in the study, 62 (87.3%) declared themselves white, 56 (78.9%) had an incomplete primary education, age ranged from 32 years to 76 years, with an average age of 55±10.5 (mean ± standard deviation) years and a predominant the age group being 50 to 59 years old (36.6%).

The average time of use of pesticides by these workers was 27.6±13 (mean ± standard deviation) years, four years was the minimum time mentioned of exposure and the maximum was 66 years.

Regarding the use of pesticides, it was observed that 39 (54.9%) of rural workers bought the products in unions. When asked about the use of personal protective equipment (PPE) during the application of pesticides, such as gloves, mask, face shield, water repellent jumpsuit, Arabic cap, waterproof apron and boots, 31 (43.7%) reported that they used "Sometimes", 22 (31%) workers "never" used it and only 18 (25.3%) mentioned that they "always" used it.

The act of bathing after the application of the pesticide was mentioned by 38 (53.5%) participants and the continuous care in washing EPI clothes contaminated by pesticides was mentioned by 25 (36.6%) of them.

Regarding the type of pesticides, rural workers were asked about the commercial name of the products they used, both concurrently as well as sporadically, and 50 different products were mentioned in total. Pesticides belonging to the glycine chemical group are the most used; 88.7% of the participants use them (Table 1).

Table 1– Quantity of pesticides used by rural workers according to the chemical group, UBS Bela União, Santa Rosa, RS, 2017

Chemical group	No. of pesticides			Total@
	1	2	3	n (%)
Glycine	57	4	2	63 (88.7)
Strobirulin&	13	11	10	34 (47.9)
Bipyridyl	10	-	-	10 (14.1)
Aryloxyalanoic acid&	9	1	-	10 (14.1)
Neonicotinoid&	8	2	-	10 (14.1)
Organophosphate&	8	-	-	8 (11.3)
Sulphonylurea	7	-	-	7 (9.9)
Benzoylurea	7	-	-	7 (9.9)
Pyrethroid&	7	-	-	7 (9.9)
Others#	18	-	1	19 (26.8)

Source: Prepared by the authors. Note: @percentage of referral; &classification carried out by the author, there may be an association with other products; #triazole, pyraclostrobin and epoxiconazole, carboxanilide and dimethyldithiocarbamate, triazine, dipyridyl, pyridinecarboxylic acid and pyridyloxyalkanoic acid, primidinadione, dinitroaniline, inorganic pyrazol, phosphine, fluorine and sulfonamide precursor.

Regarding the toxicological class of pesticides, still according to the classification valid until August 2019, Class I (red label) which are extremely toxic products, 22 workers used only one product, 14 use two products of this class, two workers reported using three products and two reported using four products.

Table 2– Pesticides used by rural workers according to the toxicological class&, UBS Bela União, Santa Rosa, RS, 2017

Toxicological class	No. of pesticides					Total@
	1	2	3	4	5	n (%)
I	22	14	2	2	-	40 (56.3)
II	25	9	1	-	1	36 (50.7)
III	36	17	7	-	1	61 (85.9)
IV	6	1	-	-	-	7 (9.9)

Source: Prepared by the authors. Note: &Used classification valid until August 2019 #percentage of referral.

Concerning the recent symptoms associated with the use of pesticides reported by rural workers, headaches prevail (31.0%), followed by nausea (18.3%), vomiting (12.7%), dizziness (11.3%) and others.

Table 3– Symptoms reported by rural workers associated with the use of pesticides, UBS Bela União, Santa Rosa, RS, 2017

Symptoms	n	%
Headache	22	31.0
Nausea	13	18.3
Vomiting	9	12.7
Dizziness	8	11.3
Diarrhea	7	9.8
Eye irritation	6	8.4
Dryness of the mouth	4	5.6
Blurred vision	3	4.2
Skin lesions	3	4.2
Mental confusion	3	4.2
Abdominal pain	3	4.2
Cramps	3	4.2
Others	6	8.4

Source: Prepared by the authors. Others: tingling in the limbs, excessive sweating, coughing, fever and memory difficulties.

As for the result of auditory screening, it was observed that 31 (43.7%) rural workers presented "failures" in both ears, with hearing thresholds compatible with hearing loss of varying degrees from mild to moderate, 28 (39.4%) obtained the result "passing" and, therefore, normal hearing and 12 (16.9%) displayed "failures" in the screening in only one ear, suggestive of unilateral hearing loss.

In Table 4, it is possible to see the difference between the average of the low frequency thresholds (500Hz, 1000Hz and 2000Hz) and the high frequencies (3000Hz, 4000Hz and 6000Hz) in each ear.

Table 4– Comparison of air thresholds for low and high frequencies of rural workers, UBS Bela União, Santa Rosa, RS, 2017

Frequency	Ear	Mean ± SD	Median / Interquartile range	Average ranking	p&
500, 1000 e 2000Hz	RE[A]	24.23±12.3	20/10	107	0.359
	LE[a]	24.58±11.3	25/15	107	
3000, 4000 and 6000Hz	RE[B]	38.76±20.3	35/35	107	0.182
	LE[b]	41.71±21.6	40/35	107	
		p#<0.001 p$<0.001			

Source: Prepared by the authors. Note: RE: right ear; LE: left ear; p#: relative to the comparison between low and high frequencies of the right ear; p$: relative to the comparison between low and high frequencies of the left ear; p&: relative to the comparison between right and left ears; p: for the Wilcoxon test.

There was a significant difference (p<0.001) between the distribution of low frequencies and high frequencies in both ears, which demonstrates a greater impairment of acute thresholds in the auditory screening of rural workers in this study.

When analyzing the association between the results of auditory screening and variables regarding exposure to pesticides, exposure time was the only variable that showed a significant association (Table 5).

Table 5– Average air thresholds for frequencies of 500Hz, 1000Hz, 2000Hz and 4000Hz and the time of exposure to pesticides, UBS Bela União, Santa Rosa, RS, 2017

Exposure time (years)	RE (dB) Mean Median	LE (dB) Mean Median
Less than 10	27.5 20.0	28.0 23.8
10 to 19	24.4 21.3	24.8 22.5
20 to 29	25.3 23.8	27.7 28.8
30 to 39	27.8 23.8	30.7 26.9
40 to 49	33.1 34.4	33.9 35.6
50 or more	43.1 38.8	40.6 35.6
r (p)	0.34 (p=0.004)	0.35 (p=0.003)

Source: Elaborated by the author. Note: RE: right ear; LE: left ear, r: for Spearman correlation.

There is an increase in the average of the auditory aerial thresholds as the years of exposure to pesticides increase, this increase occurs both in the right and left ears, and this relationship is significant, although low, with a correlation coefficient of 0.34 (p=0.004) and 0.35 (p=0.003) respectively for the right and left ear.

Regarding the result of auditory screening and the association with other variables of exposure to pesticides, such as the use of PPE in the preparation of pesticides, use of PPE in the application of pesticides, history of past intoxication and use of pesticides from the organophosphate chemical group, no there was no significant association.

DISCUSSION

In this study there was a predominance of white rural workers, aged 50 to 59 years old and with an incomplete elementary education. Regarding education, this profile is consistent with other studies[14,15,16,17] and reflects the low level of education demonstrated by rural workers, which may justify greater exposure to pesticides, due to a lack of understanding of the risks involved[16]. Low schooling may also be related to the fact that these subjects were raised at a time when education was not a priority, which reflects, therefore, in the low level of education of these people[18].

Regarding the use of PPEs, it was observed that the vast majority of rural workers do not effectively use the indicated protection, as the

most frequent answer was "sometimes" followed by "never", which shows the lack of care with workplace safety. This finding agrees with the literature, as studies[8,19] point to the inadequate or even lack of PPE use.

Monquero, Inácio and Silva[19] point out that one of the possible explanations for the lack of effective use of PPE is in the understanding, by rural workers, that oral toxicity is the most risky factor, but it is known that intoxications are related to contact of the product or syrup with the skin. Still, according to Fonseca *et al.*[8], the equipment, in general, is described by farmers as uncomfortable and unsuitable for the hot climate, interfering with their acceptance of its use.

There is, however, a controversy regarding the perception of health risk and exposure to pesticides, as 38 (53.5%) rural workers reported always taking a bath after application and 26 (36.6%) always being careful in washing the clothes used in the spraying, which is different from the lack of care with the use of PPE in the application. According to Fonseca *et al.*[8], the disbelief in the effectiveness of PPE is one of the first elements that emerge from this dichotomous relationship, because among farmers there is no conviction that the equipment really protects.

In the present study, glycine-type pesticides were the most mentioned (Table 1), 88.7% of workers reported using it. Other studies also indicated this type of pesticide as the most used[17,20,21]. Barreto, Herman and Gariboti[22] state that glyphosate and its salts are the most widely used pesticides in Brazil and also in Rio Grande do Sul, as they are a non-selective systemic herbicide and can be used in different cultures, thus spreading their use.

Regarding the toxicological class (Table 2), according to the classification adopted in Brazil until August 2019, Class III (considered moderately toxic) was mentioned by 42.4% of rural workers in this study, corroborating with the literature[19,23]. In Brazil, in August 2019, The National Health Surveillance Agency (Anvisa) published a toxicological reclassification of pesticides and they were divided into five categories: Category 1 - Extremely Toxic Product (red band); Category 2 - Highly Toxic Product (red band); Category 3 - Moderately Toxic Product (yellow band); Category 4 - Low Toxic Product (blue band) and Category 5 - Product Unlikely to Cause Acute Damage (blue band)[24].

In the study by Araújo *et al.*[23], the most used substances were those with the highest level of toxicity, even when products with the same active ingredient and less toxicity were available. According to the authors, this fact is due to the myth created by farmers that when applying several products simultaneously there is less risk of loss of the harvest. Also, another factor that contributes to this attitude is the pressure exerted by the sellers of pesticides.

Still, Murakami *et al.*[14] warn that toxicity studies only evaluate exposure to an active ingredient isolated in laboratory animals, with a single route of exposure. However, in the reality of agricultural work, as observed in this study, combined exposures occur and therefore there are many gaps concerning the exact effects influencing the health of individuals[5].

Thus, it is relevant to understand the symptoms associated with the use of pesticides. In the present study, as shown in Table 3, as well as in the research by Murakami *et al.*[14] and by Delgado and Paumgartten[25], headache and nausea stand out as the most referred to symptoms. Fonseca *et al.*[8] observed that many workers see headache and stomach problems as natural processes resulting from their management.

Another symptom frequently related to the use of pesticides is dizziness, which was the fourth most mentioned symptom in this study. Several studies report this as a subjective symptom to exposure to pesticides[11,20]. According to Hoshino *et al.*[11], dizziness must be properly investigated by the health teams responsible for the care of workers, considering that this symptom can harm

the quality of life, and may even incapacitate them from working.

The average time of exposure to pesticides in this study was 27.6±13 (mean ± standard deviation) years. This average is high when compared to other studies carried out in Rio Grande do Sul, such as that of Faria, Rosa and Facchini17 in which the average time of chemical exposure was 19.4±10.5 (mean ± standard deviation) years and the by Ristow26 with a mean of 21±9 (mean ± standard deviation) years.

This may be explained, in part, by the fact that the beginning of agricultural activities occurs very early in Brazilian rural communities, they begin as a child and continue into old age[23], which was observed in the present study, considering that the age of the participants extended to 76 years. However, in Brazilian labor legislation, according to Regulatory Norm N°. 31 (NR31), it is prohibited to work with pesticides for minors under 18 and those over 60 years old. However, this is a complex issue within family farming where, in general, adolescent participation is encouraged and the work of the elderly is essential. For this reason, farmers over 60 years of age were not excluded from the study, as it is a striking feature of the region that men, even if retired and over 60, still work.

Considering one of the objectives of the study, when analyzing the result of auditory screening, 31 (43.7%) rural workers presented "failures" and hearing thresholds compatible with hearing loss, mainly of a mild degree, were even referred for audiological diagnosis. When adding the number of workers who failed in one ear, the percentage rises to 60.6%; that is, 43 rural workers had hearing impairments. There was a higher prevalence of hearing problems compared to other studies[14,20], but many studies, although with a lower incidence, also observed changes in hearing after auditory screening of rural workers exposed to pesticides[9,27,28,29,30,31].

In relation to the further lowering of the high frequencies, as observed in Table 4, other studies[9,14,20,28,31] also showed this result in the auditory assessments of farmers. According to Murakami *et al.*[14], hearing disorders caused by pesticides are more accentuated at high frequencies, especially between 3000Hz and 6000Hz, corroborating the findings of the present study. In fact, in the study by Foltz, Soares and Reichembach[32] there was also a significant difference when comparing the averages of the low with the averages of the high frequencies, agreeing with the findings of the present study.

When analyzing the results of auditory screening and variables regarding exposure to pesticides, there was a significant correlation between the exposure time and the average air thresholds of the frequencies of 500Hz, 1000Hz, 2000Hz and 4000Hz, in both ears (Table 5). This shows that over the years of exposure, there was a worsening in the average hearing thresholds of the airways of these rural workers.

This fact can be explained due to the greater exposure to the risk factor. Haeffner *et al.*[33] point out that pesticides with a high degree of toxicity, have ototoxic effects and induce harmful changes to hearing, especially when prolonged exposure of the worker to this risk factor occurs.

In the study by Bazilo *et al.*[10], carried out with farmers, the worst performances were observed in central auditory processing tests as the exposure to pesticides increased. The authors created an exposure index that, among several factors, considered the years of exposure.

No other variable was associated with auditory screening. One reason may be related to the low use of pesticides from the organophosphate chemical group by these rural workers (Table 1). This may be because this type of pesticide is part of a group of chemical agents that can lead to hearing loss[34]. The research by Körbes *et al.*[34] confirms the ototoxicity of the organophosphate pesticide after observing the presence of anatomical changes in the structures of the vestibulocochlear system of guinea pigs

that received doses of pesticides from this chemical group.

Foltz, Soares and Reichembach[32] also found no significant relationship in the comparisons of the variables, use of PPE and contact with pesticides and inferred that the attenuation of PPE may not be sufficient, considering that hearing losses were nevertheless observed in the studied sample.

In contrast, in the study by Sena, Vargas and Oliveira[27], there was an association between the toxicological class of pesticides and the classification of the degree of hearing loss. Farmers who used pesticides with higher toxicity were those who most experienced hearing loss.

Thus, even though the bivariate analyses did not show a significant association between auditory screening and variables related to exposure to pesticides, the number of rural workers with hearing disorders was high. Thus, it is necessary to consider other agents in this process.

Hearing problems can result from occupational exposures to other agents, such as noise, vibration and dust[34]. For Cunha, Duarte and Souza[35], in general, the sound level values emitted by tractors, even those with higher technology, are greater than 85 dB, which is the maximum exposure allowed for an eight-hour workday. That is, the noise levels emitted are agents for hearing damage.

Still, Delecrode *et al.*[28] and Fernandes and Souza36 report that the audiometric configuration caused by chemical substances, such as pesticides, can be very similar to that related to noise. Therefore, it is another confounding element in the definition of the etiology of hearing loss in rural workers.

However, the literature is increasingly studying the interaction between noise and chemicals in workers' hearing. Even Fernandes and Souza36, Mello and Waismann[37] and Teixeira, Augusto and Morata[12] report that this interaction can generate hearing loss of greater severity, than that resulting only from exposure to noise or chemical. This fact can be exemplified through the study by Guida, Morini and Cardoso[29] in which audiometric examinations of two groups of workers aged between 31 and 45 years were compared; one group exposed to pesticides and noise and another group exposed only to noise. The results showed that the group exposed to pesticides and noise had worse audiometric thresholds when compared with the group exposed only to noise.

Thus, there is evidence that exposure to pesticides can contribute to hearing damage and that noise when interacting with pesticides, potentiate their ototoxic effects[12].

Therefore, the occurrence of changes in the auditory system of rural workers cannot be attributed only to exposure to pesticides, because this working class is exposed to several factors that attack the auditory system, such as noise and vibration, which together with the years of exposure generate this multifactorial process[27,38].

Further investigation is needed to confirm the level of influence of each factor on the hearing loss of rural workers[38]. Also, studies with a larger number of participants or with a different research design, could contribute to find greater correlations between the variables regarding hearing loss and exposure to pesticides[9].

CONCLUSION

In the present study, there was a predominance of rural workers who declared themselves as white, aged between 50 and 59 years old and with an incomplete elementary education. The most mentioned physical symptoms were headache and nausea. Regarding auditory screening, 31 (43.7%) rural workers presented "failures" in both

ears, with hearing thresholds compatible with hearing loss of varying degrees from mild to moderate, requiring referral to audiological analysis. The result of auditory screening and the exposure time variable was the only one that showed a significant association.

The findings, in fact, clarify that this professional activity poses a risk to hearing, however, it is necessary to consider that hearing loss may result from factors, such as the ototoxicity of pesticides and noise, including that it is believed that the interaction between the pesticides and noise enhance hearing damage.

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