Association between working conditions and occupational exposure in rural agricultural workers in Montería, Colombia

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SUMMARY
The objective of this research was to analyze the relationship between working conditions and risk exposure derived from agricultural activity in rural workers in Montería, Colombia, through a correlational, descriptive, analytical study developed with 233 workers during the year 2025. The study subjects were selected by simple random sampling per household, with a confidence level of 95% and 5% error. The data were obtained through a survey and analyzed with the chi-square test, for the integral measurement of the associations between variables, a multiple correspondence analysis was used and the workers were grouped through a cluster analysis. The results showed three clusters and/or typologies of agricultural workers as follows: 1) workers with precarious working conditions who use low-toxicity agrochemicals 2) workers with better material conditions (access to water, rest place, PPE), low economic income, greater occupational burden and handling of highly toxic substances, and 3) minority group of workers with greater labor formality and access to social protection (health, pension and ARL) with the management of moderately toxic agrochemicals.The findings revealed that working conditions and risk exposure in the agricultural sector are not homogeneous, but respond to differentiated work configurations**,** associated with the interaction between labor informality, type of activity, working conditions, and social security. In conclusion, the need to strengthen public policies and intersectoral interventions with contextualized differentiating perspectives that promote dignified, safe and equitable jobs is externalized.
KEYWORDS: occupational health, agricultural workers, working conditions, occupational exposure, rural population

INTRODUCTION

The agricultural sector plays a strategic role in the world's food security, managing the fruitful potential of the land and sustaining the production of essential foods that guarantee the survival, well-being and development of individuals, families and communities. According to the Food and Agriculture Organization of the United

Nations (FAO)[1], agriculture has been a priority activity for development because it has sustained civilizations for more than 12,000 years, not only because of its contribution to food, but also because of its ability to generate employment and livelihoods for large sectors of the population. However, this relevance contrasts with the circumstances and realities in which agricultural work is carried out, since the underlying dynamics of this activity imply a series of factors that put pressure not only on land and water systems, but can also affect the health and safety of those who carry out these tasks[2], depending on the working conditions and the territorial contexts where these activities are carried out[3].

Globally, by 2022, the agricultural sector employed approximately 892 million people, equivalent to 26.2% of total employment; a figure that reveals the social magnitude of agricultural work. This overview makes it possible to configure the multiplicity of options offered by agriculture for human and social development by providing job opportunities and livelihoods, but it also requires a critical examination and analysis of the profound inequalities that exist in the working conditions of the world's population, especially in developing countries, because these are not always guaranteed optimal levels of occupational health and safety[4]. In this scenario, the use of pesticides, fertilizers and organic waste is a factor of special consideration, due to the impact on human health[5].

For several decades, scientific evidence has extensively documented the adverse effects on people's health from the use of pesticides and agrochemicals used in agriculture. Rural workers exposed to pesticides have a higher risk of adverse health outcomes, including neurological disorders, respiratory symptoms, dermatological conditions, kidney impairment and other chronic health effects associated with occupational exposure to hazardous chemicals[6–8]. These effects not only compromise the individual health of the worker, but also impact their quality of life, their productive capacity and the well-being of their family.

The worrying situation of the safety and health of agricultural workers shows a constant in vulnerable populations in developing countries, but especially in those territories where poverty, the deficiency of public services, the lack of support for the peasantry and the weak articulation of public policies reduce health conditions, as is the case of many rural areas of the Colombian Caribbean region[9]. This complex articulation of social determinants deepens the vulnerability of agricultural workers, making it necessary to take other investigative perspectives that reinforce the debate between the link: working conditions and exposure to risk, where the particularities and inequalities existing between groups of workers in the rural sector are investigated, in order to envision possible interventions by the State according to the needs and singularities of the population and territories.

In this order of ideas, a large part of the rural population in Córdoba (Colombia) lives and works in conditions of high social vulnerability. Agricultural workers do not have stable jobs, have incomes below the current legal minimum wage, and do not have effective access to social security systems. Likewise, they do not provide or have personal protective equipment (PPE) at the time of carrying out their work and declare the existence of felt morbidity and a history of occupational accidents, which shows a significant gap, a disarticulation between existing public policies and the daily realities of agricultural workers[10].

This specific situation leaves unanswered many questions that question the effectiveness of programs and projects aimed at favoring the rural population, in territories with an agricultural vocation, as is the case of the context where this research was developed. In addition to questioning whether working conditions are the same for all workers or whether there is heterogeneity among the same agricultural workers; differences that can be analyzed by expanding the debate on this matter. In response to these questions, the present research aimed to analyze the relationship between working conditions and risk exposure derived from agricultural activity in rural workers in Montería, Colombia.

METHODOLOGY

Type of study

Acorrelational, descriptive/analytical study was carried out, framed in the quantitative approach with agricultural workers in the rural sector of the city of Montería.

Population, Sample and Sampling

According to the National Administrative Department of Statistics (DANE)[11], the peasant employment rate in Colombia is 56.3%, which is equivalent to an employed population of approximately 9,829 people of working age. This population includes collectors, fumigators, macheteros, day laborers, plagueros and administrators, who perform essential functions for the agricultural economy of the region. Specifically in the rural areas of Montería, adjacent to the village of Aguas Negras and the township of Sabanal, scenarios where the study was developed, there is a total population of 17,458 people distributed in 5,374 homes.

To characterize this population and ensure the representativeness of the data, a simple random sampling was applied per household, ensuring that all potential participants had the same probability of being selected. The sample design was established with a confidence level of 95% and considering maximum margins of error of 0.05, resulting in a sample of 233 agricultural workers, supporting the statistical quality of the study.

The formula used for the calculation of the sample was based on the methods described by Martínez[12] and Myers[13], which are widely recognized for their methodological rigor. Additionally, according to information from the Ministry of Agriculture[14] and DANE[15], approximately 17% of the workforce in Colombia was employed in agricultural activities during the reference period. This data contextualizes the weight of the peasant population and reinforces the social and economic relevance of this population.

The methodology implemented ensures representative and useful results to understand the labor dynamics in this rural area.

$$n = \frac{N * Z_{\alpha}^{2} * p * q}{\varepsilon^{2} * (N-1) + Z_{\alpha}^{2} * p * q}$$

Where,

N: Size of the population of interest, 9829.

$1 - \alpha$: Confidence level, 95%.

Z_{α}: Value in the standard normal that has an area to the right of .α

ε: Maximum error to tolerate.

Q: Probability that you will work in the field
q: Probability that you will not work in the field
n: Sample Size

Procedure

The information was collected through a structured questionnaire administered under the modality of a survey, prepared by the research group and validated through a pilot with 30 people through the calculationof Cronbach's Alpha index. The instrument included the following variables of interest: a. Sociodemographic and occupational characteristics, b. Perception of occupational risks (occupational diseases and/or accidents), c. Perception of exposure to hazards (referred to in other international geographical contexts as risk factors); d. Pesticide management; and e. Health conditions. Prior to the collection of information, training was carried out for the survey team in order to ensure the correct application of the form and compliance with good practices during the process. Subsequently,peasant organizations were contacted whose databases served as support for the selection of families and the surveyed worker. Among the inclusion criteria were: 1) being over 18 years old, 2) working in agricultural activities in any modality, 3) having more than 10 years exercising the activity.

Each of the selected participants was visited at their place of work, where they were clearly informed of the objective of the study, their willingness and availability to participate in the research was verified.The informed consent was read, which was signed voluntarily by each participant. The survey was applied only when it was certain that the rural worker understood the research purposes and the scope of his or her participation.

Data analysis

The first statistical process carried out corresponded to a confirmatory factor analysis to validate the survey questionnaire. To this end, the collected information was organized, filtered and tabulated in a database for statistical treatment using Excel (Microsoft 365), R version 4.4.2 and SPSS v25 programs. With the information collected, a multiple correspondence analysis (MCA)[16] was performed, which facilitated the analysis and summary of the relationship between the variables established in the research.

Cronbach's alpha for internal dimensions is greater than 0.700 in most cases, making them acceptable for study reliability. In this way, it was possible to determine that there is a strong relationship between the questions, that the instrument has a good level of reliability and internal consistency, which means that it is considered an excellent instrument for implementation by the participants. On the other hand, Bartlett's sphericity test presented a p-value of less than 0.05 for all cases, which indicates that the data matrix is valid for the factor analysis process. In addition, KMO in all cases is greater than 0.500.

Ethical aspects

The ethical and legal considerations that were taken into account in this research are covered by *Resolution 8430 of 1993* of the Ministry of Health of Colombia, which establishes the behavioral and legal bases of health research, in accordance with Article 5, which stipulates that in all research related to human beings, the protection of their

rights must prevail; likewise, Article 11 defines the classification of risk, which is classified as having minimal risk.

RESULTS

The survey questionnaire was applied to a total of 233 agricultural workers working in rural areas of Montería, Córdoba, Colombia. Of this group, the majority were male (91.8%), adult (49.8%), with incomplete high school (26.6%) and in common-law unions (60.5%).

Working conditions and exposure to toxic substances

Table 1 identifies that for the first dimension the most important variables are the value of the day of work or day, the frequency of payment, having an adequate place to rest during the working day, the type of payment, having a supply of drinking water for consumption, the form of employment and whether or not they are provided with personal protection elements with given r squares by 0.7460, 0.6636, 0.5851, 0.6118, 0.5670, 0.5574 and 0.5321 respectively.

On the other hand, for dimension 2, the most important variables are: if the worker is affiliated, who pays him the ARL?, who pays him pension?, type of payment, health affiliation, type of link to the sector and frequency of payment with r squares of 0.6264, 0.6233, 0.5206, 0.4470, 0.3715 and 0.3327 respectively.

Together, these two dimensions make it possible to differentiate labor profiles associated, on the one hand, with daily working conditions (salary, frequency of payment, water supply, PPE, place to rest, to wash, jobs performed, type of employment relationship) and, on the other, to access to social protection (health, pension and ARL), evidencing the coexistence of heterogeneous labor realities among rural workers in the agricultural sector.

Table 1. Levels of correlation of variables with dimensions

Variable	Dimension 1		Dimension 2	
	R^2	P-value	R^2	P-value
Value of the day of work or daily wage	0,7460	1.69E-65	0,1595	1.72E-07
Payment frequency	0,6636	9.92E-51	0,3327	1.06E-17
Suitable place to rest during the day	0,5851	5.14E-46	0,0227	2.14E-02
Payment Type	0,6118	1.02E-45	0,5206	2,41E-35
They supply drinking water for consumption	0,5670	7,25E-44		
Form of linkage	0,5574	9,00E-43	0,1133	1.40E-07
They provide you with personal protection elements	0,5321	5,74E-40	0,0293	8,85E-03
Space to wash, bathe, and/or change clothes	0,4250	1.41E-29	0,0670	6.41E-05
Job stability	0,3968	3.61E-27		
Toxicological category	0,2985	9,74E-17	0,1081	2.88E-05

Personal protection items provided	0,2772	4.67E-16	0,0617	2.18E-03
Personal protection elements used	0,2681	1.93E-15	0,0681	1.04E-03
Number of jobs performed	0,2628	4,34E-15	0,1463	6,51E-08
It has a toilet for use at work	0,1617	1.81E-10	0,2078	2.34E-13
If you are affiliated, who pays your pension?	0,0654	1.41E-03	0,6233	2,72E-48
Type of relationship in the sector	0,0408	1.94E-03	0,3715	4,35E-25
If you are affiliated, who pays you the ARL?	0,0571	3.69E-03	0,6264	1.05E-48
Health Affiliation	0,0565	3.96E-03	0,4470	2.82E-29

Source: Own construction

In the same way, the importance of the categories of the variables is studied, developing the same hypothesis as above. Table 2, for example, shows the 15 main categories for dimensions 1 and 2, for the first dimension it is observed that these main categories are the categories of not applicable in the value of the payment or day, having or not having an adequate place to rest during the working day, the frequency of payment for harvesting and having or not having access to drinking water for consumption. among other categories.

While, for dimension 2, those with the highest participation are the categories of the employer who makes the payment of ARL and pension, not being affiliated to ARL and pension, having contributory health paid by the worker, the type of payment per period and the types of formal and informal relationship, The third dimension is related to the organization of work and the type of occupational exposure. particularly with the number of trades performed and the toxicological category of the products used. Overall, it is evident that occupational exposure in the agricultural sector is not homogeneous, but responds to differentiated configurations of working conditions. These findings reinforce that risk exposure in rural agricultural work, in addition to being closely linked to the level of toxicity or hazardousness of the substances used, is also determined by working conditions, social security coverage, contractual and organizational factors, as well as access to PPE and basic services in the work environment.

Table 2. Participation of the categories of the variables in the conformation of the dimension

Dimension 1		**Dimension 2**	
Variable	$\boldsymbol{Cos^2}$	**Variable**	$\boldsymbol{Cos^2}$
Value of the day or day: Not applicable	0,6067	ARL Payment: The Employer	0,5198
Rest Space: Yes	0,5851	Pension payment: The employer	0,5198
Rest area: No	0,5851	ARL Payment: Not affiliated	0,4468
Payment Frequency: Per Harvest	0,5733	Health affiliation: Contributory - Worker	0,4387

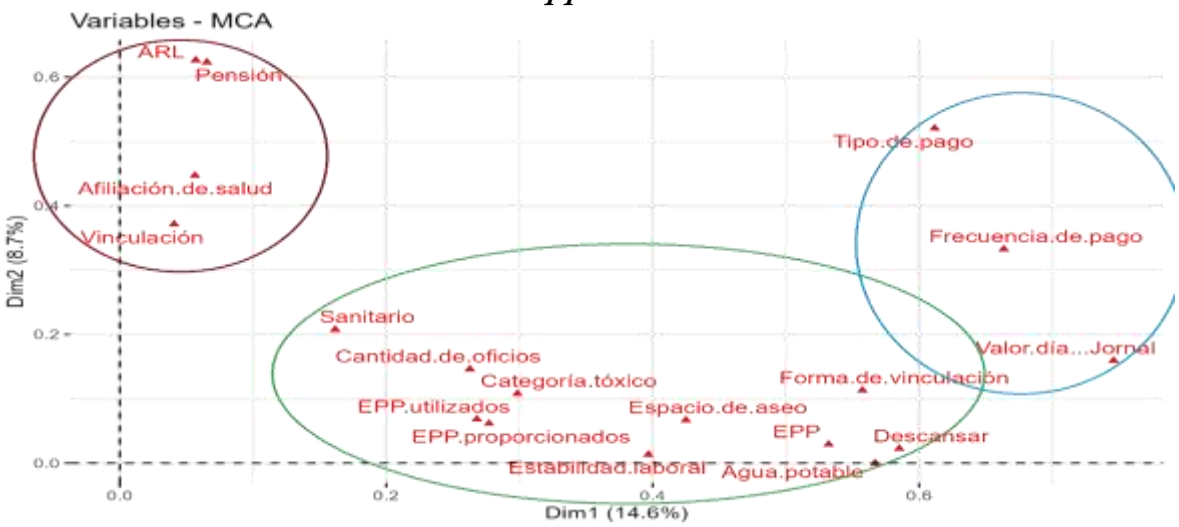
Drinking water supply: Yes	0,5670	Type of payment: Work period	0,4248
Drinking water supply: No	0,5670	Pension payment: Not affiliated	0,4212
Payment Type: Harvest Profits	0,5586	Type of bonding: Formal	0,3715
Form of linkage: Owner	0,5575	Type of link: Informal	0,3715
Form of employment: Worker	0,5575	Health Affiliation: Subsidized	0,2382
You are provided with PPE: Yes	0,5321	Toilet available: Yes	0,2078
You are provided with PPE: No	0,5321	It has a toilet: No	0,2078
Toilet Space: No	0,4250	Payment Frequency: Monthly	0,1567
Toilet Space: Yes	0,4250	Payment Type: Harvest Profits	0,1337
Job stability: Temporary	0,3968	Payment Frequency: Per Harvest	0,1294
Job stability: Permanent	0,3968	Form of employment: Worker	0,1133

Source: Own construction

Correlations between the variables and the factors created

Graph 1 shows the association between each of the variables in the study and the dimensions or factors. In it, you can visually identify the variables that are most correlated with each of the dimensions or factors created.

Figure 1. Correlation between variables and dimensions of the questionnaire applied

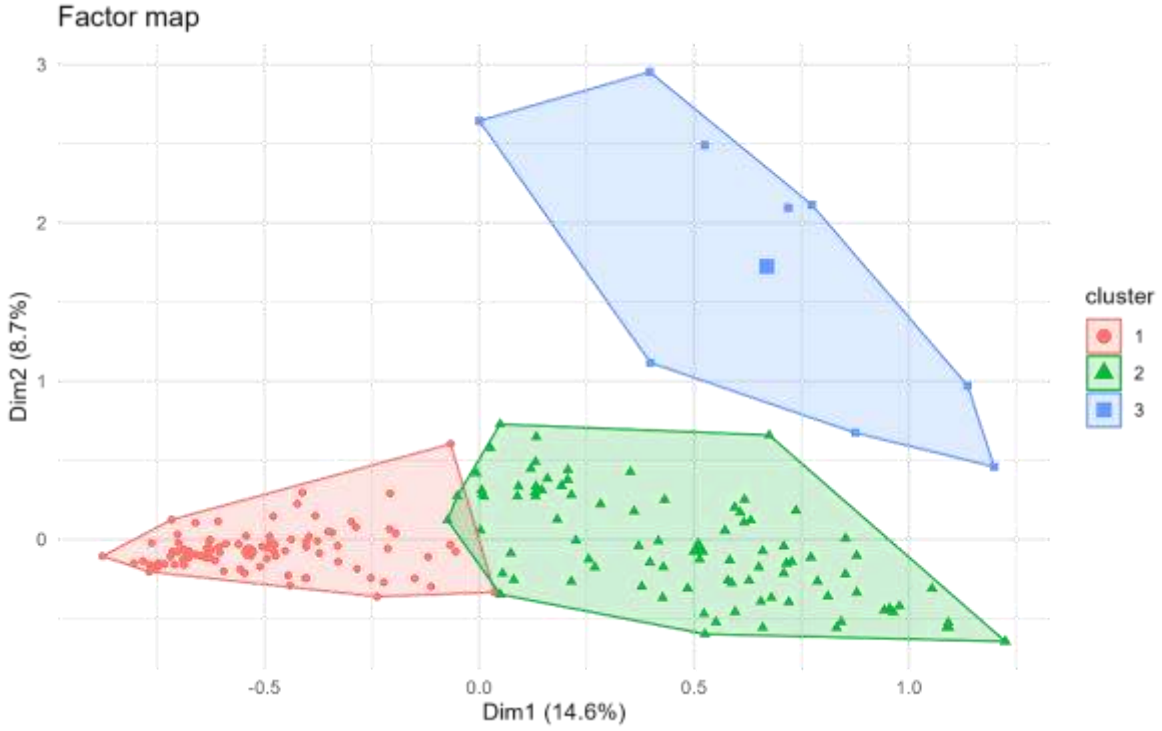


The variables that are best explained in dimension 2 are the payment of the ARL and pension, as well as the affiliation to health and the type of link to the labor sector. On the other hand, in dimension 1 it is explained or related much better to the variables of value of the day, frequency of payment, adequate space to rest, having drinking water, PPE and form of attachment. This distribution confirms that the constructed factors coherently group variables related to social protection and, in parallel, to the material conditions of agricultural work, validating the structure of the questionnaire applied.
In general, the results of the multiple correspondence analysis show that working conditions (form of employment, salary, social security protection, provision of PPE, access to drinking water, space for rest), perception and occupational exposure are articulated generating differentiated risk profiles, which reflects the heterogeneity of rural work and the structural inequalities that permeate and impact it.

Cluster Analysis

The analysis of hierarchical clusters was carried out in order to identify homogeneous groups of workers according to their occupational exposure profile. This technique allowed the participants to be classified into three clearly differentiated groups, which group the workers according to similarities in their working and protective conditions.
As can be seen in Figure 2, the first cluster groups 49.3% (n=115) of agricultural workers, the second 46.8% (n=109) and the third 3.9% (n=9). This distribution reveals that the majority of workers are concentrated in profiles characterized by unequal working conditions, while only a minority group has better levels of formality and social protection, which shows a marked heterogeneity in working conditions within the rural agricultural sector.

Figure 2. Distribution of individuals in the conformation of clusters



The first cluster is mainly associated with the categories of absence of rest spaces, lack of personal protection elements, non-existence of areas for personal hygiene, lack of drinking water supply and informal labor linkage, with a predominant daily payment between $20,000 and $29,999, and in some cases between $30,000 and $49,000 per day or per day worked. This group is made up of workers whose employment relationship is characterized by daily payments linked to the performance of specific activities, which reflects limited and temporary job stability.

Likewise, these workers usually carry out between two and four different activities, without having a space to rest or wash themselves in their workplace and lack the provision of personal protection elements. Although this cluster is mostly associated with those workers who generally do not use toxic substances, the fragility of working conditions added to the limited or absent use of protective measures, configure a scenario of high occupational fragility.

The second cluster involves the categories of: availability of rest space, access to drinking water supply, existence of toilet, personal hygiene area, provision and use of PPE, employment as an owner and daily income between $15,000 and $19,999 with a payment frequency associated with the harvest cycles. This cluster brings together workers who, although they receive relatively low incomes, have greater permanent job stability, given that their remuneration is obtained at the end of each productive period. As for the material working conditions, the work environment has basic spaces for rest and personal hygiene, access to drinking and sanitary water, in addition to an approximate endowment of seven to nine personal protection elements, which they report using regularly during the working day. However, the members of this cluster usually carry out more than eight different work activities, which shows a high diversification of tasks and, consequently, a potential expansion of exposure to different risks and dangers (the term danger is called in some international contexts as a risk factor or agent).

Particularly relevantly, this group is associated with workers who use substances classified as highly toxic, which introduces a highly dangerous component into their occupational exposure profile. From an analytical perspective, this cluster reflects a significant occupational paradox, in which relatively favorable structural conditions and higher levels of protection coexist with greater exposure to substances with a high degree of hazard. This finding shows that, although the availability of basic infrastructure and the use of PPE are protective factors, they are insufficient to effectively eliminate or mitigate occupational risks derived from the handling of highly toxic substances. Consequently, there is a need to implement differentiated preventive strategies, strengthen self-care practices and develop occupational surveillance (monitoring, supervision, risk control and health follow-up); all adjusted to the particularities of the various agricultural tasks, the uniqueness of each worker and the territorial context in which the productive activity is carried out.

The third cluster is related to the categories of affiliation to the contributory social security regime, with coverage in health, pension and occupational risks, assumed by the employer or independently. It is also characterized by a formal employment relationship, with periodic payments, on a monthly or biweekly basis, and a predominantly permanent

Job stability, although there are also some temporary modalities. This cluster identifies a minority proportion of workers in the agricultural sector who have a higher level of labor formality, reflected not only by their affiliation to the social protection system, but also by having more structured organizational conditions in the work environment.

In terms of occupational dynamics, these workers tend to perform a single type of activity, which suggests a lower diversification of tasks, and therefore a reduction in multiple exposures to different hazards and risks caused by agricultural work. From the statistical analysis, it is observed that this group has personal protection elements and access to basic sanitation services in the work context. However, the use and handling of substances classified as moderately toxic makes it clear that, even under relatively favourable working conditions, chemical risk management remains a priority for the preservation of worker health.

DISCUSSION

The results of the research show that the population of agricultural workers in the city of Montería, Colombia, presents differentiated profiles of occupational exposure, which emerge from the multivariate interaction between working conditions, such as form of labor linkage, characteristics and number of tasks performed, provision and use of personal protection elements, exposure to different hazards, risks and levels of toxicity, as well as access to social protection mechanisms.

However, despite the fact that there is a marked heterogeneity, it is observed that most of the respondents are in a situation of informality, without formal labor protection and with insufficient income to cover their basic needs; persistent factors that significantly limit progress towards decent work in rural agriculture. These findings coincide with what has been reported in studies on decent work and labor informality in the agricultural sector, which warn of the existence of structural gaps in social protection, income level and precarious working conditions that continue to be configured as barriers that are difficult to overcome so that this population has access to decent work with social protection, fair income and job security, in line with the principles of equity, freedom and human dignity established in the Declaration of Philadelphia[17] and promoted by the International Labour Organization[16,18] and the United Nations[19].

From a comparative international perspective, in Europe and North America, agricultural production depends largely on temporary foreign workers, configuring a labor market strongly supported by seasonal and precarious employment. This scenario expresses a paradox: although the food security of the population depends on the work of rural agricultural workers, this same group often experiences food insecurity and poverty. In this context, the evidence reported in Canada and the United States shows that migrant agricultural workers, both seasonal and temporary, are among the groups with the greatest social and labor vulnerability and register high levels of food insecurity[20,21]. Their living and employment conditions are marked by precarious working environments that include unfavourable regulations, low incomes, long and physically demanding hours, as well as limited access to rights such as health care, legal support and social protection programmes.

Both studies consistently point out that the instability inherent in day and seasonal work, characterized by low wages and uncertainty about the continuity of employment, is a key

factor in explaining the relationship between temporary agricultural work and food deprivation or hunger. Overall, these international findings indicate that, rather than being isolated conditions, a common pattern of risk is observed that combines job insecurity, restrictions of rights and economic fragility, which allows us to establish a framework of contrast with the results obtained in our study.

In Latin America, the findings of this study are consistent with studies carried out with agricultural day laborers in other contexts such as Mexico and Ecuador, reported by Cuevas et al.[22] and Valdiviezo et al.[23]; the working conditions described by these authors are comparable to those observed in this research, particularly with regard to insufficient wages to meet basic needs, absence of affiliation to social security and persistent scenarios of vulnerability and job insecurity, which directly impact the quality of life and well-being of those who sustain agricultural activity.

In relation to the structural context of regional rurality, a relevant aspect in this discussion is the living conditions of the rural population in Latin America and the Caribbean, where paradoxically food insecurity, hunger and poverty affect rural populations more intensely than urban populations, generating a high dependence on low-productivity employment, deficit access to basic services and low social protection coverage. These problems remain partially unexplained, given that public policy efforts in Brazil, Mexico, and other Latin American countries have shown improvements in reducing wage disparities between urban and rural workers; however, greater efforts are still required to progressively close the existing gaps[24].

In addition, comparative evidence for Colombia and Latin America shows that the income gap between rural and urban areas remains deep and structural. Traditional agricultural sectors have significantly lower remunerations than industrial and service activities in cities. In several analyses, rural agricultural wages are barely about half or less of urban manufacturing wages. This wage gap is combined with less availability of formal employment, greater job instability, and less social protection in the countryside, which limits the economic mobility of rural households and reinforces migration dynamics to urban areas[24].

As a result, these wage inequalities are directly reflected in poverty indicators: although Colombia has reduced poverty overall, the incidence in rural areas is still approximately two to three times higher than in urban areas. International trends also confirm the pattern, as ILO estimates indicate that, on average, rural workers earn significantly lower incomes than urban workers. Overall, the literature indicates that the combination of lower wages, fewer opportunities, and greater labor vulnerability explains the persistence of territorial welfare gaps, a framework that is pertinent to interpret the results obtained in Montería[24].

CONCLUSION

Given the variability of the existing working conditions in Montería, Córdoba, occupational exposure in the agricultural sector is not homogeneous. The study identified three types of workers with differentiated characteristics, observing that the workers with the highest risk of exposure to toxins are those who receive lower incomes, even though the number of agricultural activities is higher compared to the other two groups. Likewise, it was identified that the workers with the most deficient working conditions

are those who are engaged in activities other than fumigation, which is why they do not register direct exposure to toxins, but they do concentrate other forms of job insecurity. In the rural area of Montería, Córdoba, agricultural workers are mostly made up of male and adult labor force, within which low educational levels and non-formalized family ties prevail. Working conditions are characterized by high informality, precariousness and job instability, given that the largest proportion corresponds to salaried peasants who work in temporary jobs with a high physical load and exposure to occupational risks, mainly represented by collectors, planters and fumigators.

Exposure from pesticide use is significantly related to poisoning and the use of personal protection elements, which makes it possible to measure the existing vulnerability in terms of occupational safety and health for the rural population. However, the variables occupational accidents and affiliation to the health system do not show a clear statistical association, evidencing that the effects of chemical exposure on health could be mediated by contexts of labor informality and limitations in social insurance. For these reasons, the results suggest the need to strengthen and focus public policies aimed at prevention, protection and effective insurance of agricultural workers in the department, through intersectoral strategies that integrate occupational health, social protection and improvement of rural working conditions.

Conflict of interest: The authors declare no conflict of interest.

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