A quantitative analysis of Colombian campesinos' use of pesticides: perceived control and confidence in this use

Un análisis cuantitativo del uso de Plaguicidas en los campesinos colombianos: percepción del control y la confianza en este uso

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Abstract

Objective: this study aims to explore how *campesino* non pesticide users differ in their knowledge, attitudes and beliefs, and perceptions of control and confidence surrounding pesticide use compared to pesticide users. **Methodology:** we collected 79 questionnaires with adult (male and female) rural agricultural *campesinos* in San Cristobal, Antioquia, Colombia. We examined the *campesinos'* perceptions on pesticides' harm for human health and the environment, as well as their beliefs, attitudes, perceived control, and perceived confidence related to pesticide use. **Results**: The findings differed between two *campesino* groups sampled: pesticide users and agroecological adherents. Pesticide users showed lower perceptions of pesticide harm for human health and the environment, lower perceived control about stopping pesticide use (an increase of one unit in control decreases the logit of using pesticides by 74%), and lower confidence about stopping pesticide use than agroecological adherents (an increase of one unit in confidence decreases the logit of using pesticides by 64%). **Discussion**: Several individual factors influence the occupational safety and health of *campesinos*, including perceived control and confidence. We recommend that future public health and educational interventions should improve safety training and confidence so *campesinos* can gain control of the process for implementing behavioral change related to pesticide use reduction.

-----------*Keywords:* pesticides, *campesinos*, risk perception, perceived control.

Resumen

Objetivo: Este estudio pretende explorar como los *campesinos* no usuarios de plaguicidas difieren en su conocimiento, actitudes y creencias y percepciones de control y confianza en torno al uso de plaguicidas comparado con usuarios de plaguicidas. **Metodología**: Colectamos 79 cuestionarios con hombres y mujeres adultas que son *campesinos* agricultores en San Cristóbal, Antioquia, Colombia. Examinamos las percepciones de estos *campesinos* sobre el daño de los plaguicidas sobre la salud humana y el medio ambiente. También se exploraron sus creencias, actitudes, percepciones de control y confianza relacionadas con el uso de los plaguicidas. **Resultados**: Los hallazgos difieren entre los dos grupos de *campesinos* muestreados: usuarios y no usuarios de plaguicidas. Los usuarios de pesticidas experimentaron menores percepciones del daño de los plaguicidas sobre la salud humana y el medio ambiente, menor percepción del control acerca de parar el uso de plaguicidas (el incremento de una unidad en control disminuyó el logit de usar pesticidas en un 74%), y menor confianza acerca de parar el uso de pesticidas comparado con los no usuarios de plaguicidas (el aumento de una unidad en la confianza, disminuyó el logit de usar pesticidas en un 64%). **Discusión**: Varios factores individuales influencian la salud ocupacional y la salud de los *campesinos* incluyendo la percepción del control y la confianza. Recomendamos que futuras intervenciones educativas en salud pública aumenten el entrenamiento sobre prácticas seguras y la confianza. Así los *campesinos* pueden ganar control en el proceso de implementar cambios en su comportamiento relacionado con la reducción del uso de pesticidas.

----------*Palabras clave:* plaguicidas, campesinos, percepción del riesgo, control percibido

Introduction

Pesticides* have constituted an immediate solution to pest problems in crops [1]. However, pesticides have produced adverse effects on humans as well as the environment that make their use unsustainable [2-4]. Pesticides are also responsible for the emergence of increasingly resistant pests/pathogens and the destruction of natural pest enemies [1]. Biodiversity has been strongly altered by synthetic pesticides. Pesticide residues in different ecosystems, soil, water, air, animals, and plants are other deleterious results of conventional agricultural practices [5].

Campesinos in many countries where conventional agrochemical-based agriculture constitutes the predominant form of production in the agricultural sector directly suffer from all of the severe threats to human health and well-being posed by exposure to pesticides [6, 7]. Most of the pesticides that are banned in first-world countries are widely employed in Latin America [8]. In this article, we describe and analyze the individual factors of risk perceptions, knowledge, beliefs, and attitudes associated with pesticide use by *campesinos* employing a quantitative approach.

Many health alterations have been associated with pesticide use [9-12]. A variety of human systems can be affected, including the neurological, immunological, respiratory, and reproductive systems [6, 13-15]. Several potential means of exposure exist [5, 16, 17]. The greatest risk and highest toxicity are linked to skin and mucosa contact with pesticides during preparation, mixing, and application [18].

Effects of exposure range from acute intoxication to chronic conditions including developmental and neurologic alterations [6, 10, 12, 16]. Exposure not only affects the farmworker directly involved in the manipulation of toxic substances but also other household members such as children and pregnant women [11, 14, 19]. Even though a growing concern exists about pesticide exposure of farmworkers and their families, relatively few studies have tried to test directly the association of behavioral factors with pesticide exposure in an agricultural population [20].

Several research studies have explored beliefs, attitudes, knowledge, risk perceptions, perceived confidence, and perceived control surrounding pesticide use [21-25]. Some of these studies have explored the perceptions of control, perceptions of risk, and pesticide knowledge among Latino farmworkers in the United States, finding limited knowledge and low risk perceptions (they do not feel at risk when they mix, prepare, or spray with pesticides). These findings suggest that more research is needed and that different public health interventions are important [21, 23, 26, 27].

A study performed with adolescent Latino farmworkers exploring knowledge and risk perception about pesticides found that use of protective equipment was deficient. A large proportion of these farmworkers (42.2%) reported the belief that they were never exposed to pesticides in their work, and many (40.2%) reported that there were no ways to protect themselves from pesticide exposure. However, the large majority (79.4%) acknowledged that pesticides can cause health problems, and over half of the respondents (54%) indicated they have some concern that they have become sick from being exposed to pesticides [21]. In North Carolina, Latino farm workers varied noticeably in the amount of safety training received and the adoption of safety practices. Perceived lack of control was a relevant factor that decreased workers' use of safety practice [24]. Knowledge is not the only factor controlling the decisions reached by individuals involved in agricultural work as far as the opportune adoption of protective measures and/or in relation to reducing pesticide use. Other individual factors, including beliefs, attitudes, and perceptions, influence protective behavior.

* The term pesticide refers to any synthetic chemical substance intended for preventing, destroying, repelling, or mitigating pests. Pests can be insects, other animals, weeds, fungi, or microorganisms that cause damage to crops or animals. The term includes insecticides, herbicides, fungicides, and other substances used to control pests. Many of these substances are known to have adverse effects on human and ecosystem health because they are designed to kill or otherwise adversely affect living organisms. The term includes Organophosphate, Carbamates, Pyrethroid, and Organochlorineinsecticides. The definition excludes biopesticides derived from natural materials such as animals, plants, bacteria, and certain minerals (e.g., canola oil, baking soda, garlic, peppers, herb extracts often used in agroecological practices). Biopesticides are divided into three categories: microbial pesticides (bacterium, fungus, virus or protozoan), biochemical pesticides (non-toxic naturally occurring substances such as insect sex pheromones and scented plant extracts), and plant-incorporatedprotectants [source http://www.epa.gov/pesticides/about/].

Farmworkers are aware of the risks associated with pesticide exposure and have varying opinions regarding the individual's perception of personal vulnerability [26]. In research performed with farmers and farmworkers in North Carolina, US, farmworkers believed that they had been exposed to pesticides because they experienced symptoms during or after the application. Farmworkers believed that susceptibility to chemicals was inherent and beyond the individual's control. This is an important finding because ideas about "control" often predict health behavior [22]. Thus, when farm workers felt they had "control" over a specific health outcome, they were more likely to adopt appropriate preventive measures and behaviors when confronting health threats, as in the case of pesticide exposure.

Previous work has indicated that farmworkers experience high levels of perceived risk from pesticides and low levels of perceived control of pesticide use and safety measures. In a study of farm workers, Arcury *et al* (2002) found that receiving information about pesticide safety reduced perceived risk and increased perceived control. However, perceived risk had a limited relationship to safety knowledge and was not related to safety behavior. Additionally, perceived control was not related to pesticide exposure knowledge but was strongly related to safety knowledge and safety behavior [23]. These results demonstrate that, for pesticide education to be effective, it must address aspects of control [28].

In the findings reported by Flocks (2007), farmworkers attributed extreme weather conditions, including hot and dry or hot and humid, as affecting their bodies and making them "weaker" and more vulnerable to pesticide exposure and absorption [25].

In Colombia, the situation related to pesticide use for agriculture is multifaceted and difficult to assess. The country is marked by sociopolitical instability, extreme poverty, rampant violence and corruption, and a rather strong influence of private capital and private interests in the design and implementation of public policies [19, 29]. This situation translates into weak regulatory frameworks in several forms, including work safety, labor rights, and compliance with the management of hazardous materials, of which pesticides are just an example [30].

Farming is a major sector of the Colombian economy [31]. The bulk of agricultural production is achieved by conventional means of cultivation with heavy reliance on the agrochemical industry [31]. Regulation for pesticide use in Colombia exists but is not fully or consistently enforced (30). For example, several pesticides that are banned in other countries are still used in Colombia [6, 17, 29]. Additionally, the cut flower industry, a strong component of national agribusiness with high amount of exports annually, is dependent on the intensive use of synthetic pesticides and fertilizers, putting a large portion of the population of agricultural workers and their communities at high risk [19]. In Colombia, pesticide use and exposure is widespread [6]. Individual factors have been scantily studied finding limited knowledge about the harmfulness of pesticides among *campesino* communities, as well as issues of power with the bosses and social discrimination [19].

This study aims to explore how *campesino* non pesticide users differ in their knowledge, attitudes and beliefs, and perceptions of control and confidence surrounding pesticide use compared to pesticide users. The research question in this study was: What are the attitudes, beliefs, and risk perceptions of *campesino* pesticide users and agroecological† adherents in San Cristobal, and how do they differ in these factors?

San Cristóbal is a *corregimiento* (Rural Division) in the municipality of Medellin (Central Antioquia, Colombia). It includes the head of the township and 17 veredas (rural subdivisions) [32], ten of which were selected for data collection in this project as follows: El Patio, El Llano, Las Playas, La Cuchilla, La Palma, El Carmelo, Travesías, Yolombo, El Uvito, and San José de la Montaña. San Cristobal maintains strong economic, commercial, and administrative ties with Medellin.

Agriculture constitutes the main economic activity in San Cristóbal, including cut flowers and a broad range of vegetables. San Cristóbal ranks as the largest horticultural rural division of Medellin and functions as a major source of produce to the latter [32].

Methodology

This study was based on quantitative methods. In this section, we describe the characteristics of participants, participant recruitment process, steps for the

† Agroecological practices, or agroecology, refer to the application of ecological concepts and principles to the design and management of sustainable agroecosystems. It provides the basic ecological principles for how to study, design, and manage agroecosystems that are both productive and natural resource conserving, and that are also culturally sensitive, socially just, and economically viable. Agroecology goes beyond the use of alternative practices to develop agroecosystems with the minimal dependence on high agrochemical and energy inputs, emphasizing complex agricultural systems in which ecological interactions and synergisms between biological components provide the mechanisms for the systems to sponsor their own soil fertility, productivity, and crop protection. Agroecology is also the holistic study of agroecosystems, including all environmental and human elements. It focuses on the form, dynamics, and functions of agroecosystems' inter-relationships and the processes in which they are involved. By understanding these ecological relationships and processes, agroecosystems can be manipulated to improve production and to produce more sustainably, with fewer negative environmental or social impacts and fewer external inputs [8]

administration of the instrument, data collection and analysis, and protection of human subjects.

Participants

All participants involved in this investigation worked in agriculture, and many of them combined this occupation with other partial jobs. Most of the participants were married (74.68%) adult males (54.43%) who have worked in agriculture for a substantial period (average ~36 years in the field). The average age was 53 years. The average amount of years of education was 6.15 (Std. Dev. 3.82). All the demographic information is described in table 1. The total sample of *campesinos* was 79. Out of this number, 43 (54%) were only pesticide users, 15 (19%) were in the transition stage in which they still used pesticides but were slowly introducing agroecological practices to a portion of the land they cultivate, and 21 (27%) were *campesinos* who had already changed completely to agroecological practices. For the analysis we put together the transition group with the agroecological group in the same non users group and named it *agroecological adherents*.

Table 1. Demographic information of participants

Demographics	(%)
Gender:	
Male	54.43
Female	45.57
Marital status	
Cohabitates	7.59
Divorced	5.06
Married	74.68
Single	8.86
Widow	3.80
Age (median)	53.00 years
Education (mean)	6.15 years
Education (std)	3.32 years

Sampling

This project used a purposive sampling strategy, which consisted of purposefully selecting participants who would best help to understand the problem and provide information pertaining to the research question [33]. The first step was to contact community leaders through personnel at the nongovernmental organization Corporaciónpara la Investigación y el Ecodessarrollo Regional (Corporation for Research and Regional Ecodevelopment) (CIER). We attended several community action board meetings (Juntas de AccionComunal) in some of the rural subdivisions including Travesias, San Jose de La Montaña, El Llano, and La Palma in order to present the project and contact possible participants.

Cognitive Interviews

In this study, we performed two cognitive interviews with *campesinos* to refine the instrument. I asked respondents to thinkaloud as they attempted to answer questions. This technique helped to identify problems with questions and indicated possible solutions [34]. The only confusion for participants was related to the initial five-item Likert scale designed to measure attitudes and beliefs about pesticide harmfulness to human health and the environment and usefulness of pesticides in crop production. This scale originally went from strongly agree to strongly disagree. After completing the cognitive interviews, we reduced the scale of some questions to three items (yes, neutral, and no) in order to simplify the options.

Board Meeting

We also attended the board of directors meeting of *Asociación Campesina Agroecológica de la region de Boquerón*, Corregimiento San Cristobal (*Campesino* Agroecological Association of the Boquerón) (ACAB). This association of *campesinos* works on different activities and at different levels with their associates, including education and training about agroecological practices, the planning of their harvest, technical support with the management of their crops, and organization of crop marketing, among others [35]. We went to this meeting with the aim of presenting the project to ACAB leaders and obtaining permission to contact *campesinos* who belong to this association and constituted the sample of the non pesticide users.

Questionnaire

We constructed the questionnaire based on the following components: questions about attitudes and beliefs in a three-item likert scale [36] (e.g., pesticides affect my health, pesticides can affect water), questions about pesticide decision making in a five-item scale (e.g., when you decided to use pesticides, did you think it was a very good, good, neither good or bad, bad, or very bad decision?), perceived control about stopping pesticide use (the response options were on a scale of 1-10, and the question was: if you decide you want to stop using pesticides, how much control do you think you have?), perceived confidence about stopping pesticide use(the response options were on a scale of 1-10, and the question was:if you wanted to stop using pesticides, how confident are you that you could stop?), and demographic information. The first round of questionnaires was applied to a first group of *campesinos* (seeds) contacted through CIER assistants. Following these initial questionnaires, we asked each contact to provide names and phone numbers of two or three neighbors. We used snowball sampling techniques [37] in this portion of the study. The reading level of the informed consent and questionnaire forms appropriate for the target audience (fifth-grade level).

Data Analysis

This study included 79 questionnaires. First, we filled out the questionnaires on paper,then we entered the data into Excel 7® program sheets, and finally we saved the data on a computer. We stratified data by pesticide user (n = 43) or non-user (n = 36). The semi-structured portion had scales that provided ratings. We processed and analyzed the statistical data using SAS 9.2® software [38].

Analysis encompassed the following steps: 1) descriptive statistics for each item, 2) analysis of principal components of the scales to identify an appropriated structure, 3) Chi-square tests to compare responses among the groups (pesticide users and non pesticide users) across categorical variables, building a *score of probability* for questions about attitudes and beliefs, 4) performing logistic regression analysis to examine the relationship between pesticide use and the variables confidence and control, 5) calculating internal reliability using Cronbach's alpha [39] for attitudes and beliefs, 6) running Spearman correlation coefficients to detect monotonecorrelations between the variable for attitudes and beliefs, and 7) conducting logistic regression analysis with a dichotomized version of perceived pesticide harm.

Human Subjects

Participants signed the informed consent form before the questionnaire started. We conducted all questionnaires in a private space. Each questionnaire had a unique code number to protect the privacy of participants. The study was approved by the Institutional Review Board of the University of Florida.

Results

Below is a description of the analysis and results from an exploration of the following individual factors among participants: attitudes and beliefs related to pesticide use, decision making about pesticide use, perceived control about stopping pesticide use, and perceived confidence about stopping pesticide use. I described and compared the findings between pesticide users and non- users. I report the findings in the following order: descriptive, bivariate, scale development, and multivariate.

Descriptive

We obtained descriptive statistics of both demographic information and each item of the questionnaire to assess the nature of the normal distributions.

Decisions about pesticide use

To evaluate *campesinos'* perceptions about how good or bad the pesticide decision was, we provided a Likert scale with the following question: When you made the decision of using pesticides, do you think this decision was: 1=very good; 2=good; 3=neutral; 4=bad; 5=very bad. We obtained descriptive statistics to see the frequencies of responses. Most *campesinos* expressed that pesticide use is very good (35.9%) or good (28.1%). A minority considered it to be bad (16.67%) (table 2). Therefore, it was clear that pesticide use was accepted in this community, and it was considered to be something very good or good by the majority of participants.

Table 2. Frequency of pesticide decision options.

The decision to use pesticide was	Frequency	Percent %
Very good	28	35.9
Good	22	28.1
Neutral	9	11.54
Bad	13	16.67
Very bad	6	7.69

Bivariate Analysis

Perception about pesticide harm

We wanted to determine if non pesticide users have a increased perception of the dangers and deleterious impacts of pesticide use and exposure on human health and the environment compared to pesticide users. To answer this question, we built a score of probability for questions that measured attitudes and beliefs. This score was based on the questions of attitudes and beliefs and reflected the level of perceptions of impact of pesticide use on health and the environment. Small values of this score are related to high levels of perception of the health and environmental impact of pesticides (pesticide use affects human health and the environment). We confirmed this idea using a logistic regression model to check the variables *perceived pesticide harm*(single predictor variable)related to *pesticide use*(categorical outcome variable, which translates into use or not of pesticides). With a p-value of 0.0007, these variables were strongly associated.

We calculated a Receiver Operating Characteristic (ROC) curve ‡, and the value was 0.776,meaning that the model is suitable for classification. To assess the fit of the model, we calculated a likelihood ratio test (*p-value* < 0.0001). The effect size was measured as (0.205-1) x 100%= -79.5% which means that an increase in one unit in the score of *perceived pesticide harm* decreases the logit of using pesticides by 79.5%.

Perceived control

Campesinos were asked to rate their perceptions on their level of control to stop pesticide use on a scale of 1 (no control) to 10 (extreme control). Out of the total sampled population, 26.5 % responded perceiving no control to stopping pesticide use. However, 33% of participants responded perceiving maximum control (table 3). Participants who perceived maximum control were all non pesticide users. There is a clear difference between the amount of perceived control of pesticide users and non-users.

Table 3. Frequency of perceived control to stop pesticide use, with1 being no control and 10 being maximum control

Perceived control	Frequency	Percent %
1	21	26.5
2	0	0
3	2	2.5
4	2	2.5
5	11	13.9
6	2	2.5
7	0	0
8	6	7.6
9	2	2.5
10	33	41.7

To explore if pesticide users perceive having less *control* over their use of pesticides than non-users, We ran a logistic regression analysis using the variable *pesticide use* as the outcome variable (dependent) and *perceived control* as the predictor variable (independent). I treated the variable *perceived control* as continuous. The result showed that the association between *pesticide use* and *control* was significant (*p-value* = 0.0004), which means that higher *control* decreases the probability of using pesticides. We measured the effect size as (0.2549 - 1) x 100% = -74.5% which means that an increase in one unit in *control* decreases the logit§ of using pesticides by74.5%.

Perceived confidence

To assess how much confidence *campesinos* perceive they have to stop the use of pesticides, we used a scale of 1(no confidence) to 10 (extreme confidence). Most participants (57.7%) perceived no confidence at all to stop pesticide use. However, some participants (16.7 %) expressed perceiving maximum confidence (table 4). It is important to clarify that the class that represented perceiving maximum confidence was composed of agroecologists. In other words, there is a clear difference in perceived confidence between pesticide users and non-users.

Table 4. Frequency of perceived confidence to stop pesticide use, with 1 being no confidence and 10 being maximum confidence.

Perceived confidence	Frequency	Percent %
1	45	57.7
2	2	2.5
3	4	5.1
4	2	2.5
5	8	10.2
6	2	2.5
7	0	0
8	1	1.3
9	1	1.3
10	13	16.7

To explore if pesticide users perceive having less confidence to use pesticides than non pesticide users, we fitted a logistic regression model using the variable *pesticide use* as the outcome variable (dependent) and *perceived confidence* as the predictor variable (independent). We treated the variable *perceived confidence* as continuous. The analysis showed that the association between *pesticide use* and *perceived confidence* was significant (p-value: 0.0007), meaning that higher *confidence* decreases the probability of *pesticide use*. We measured the effect size as (0.3520 - 1) x 100% = -64.8%, which means that an increase in one unit in *confidence* decreases the logit of using pesticides by64.8%.

Pesticide use with other variables

We conducted Chi square tests to compare the groups of pesticide users and non-users (*pesticide*

‡ A Receiver Operating Characteristic (ROC) curve plots the sensitivity against the false-positive rate (i.e., one minus specificity) for a range of thresholds to help visualize test performance [40].

§ Logit refers to the logarithm of the ratio of the probability of not using pesticide versus the probability of using pesticide (log(p/(1-p))) *use)* with other variables. This variable, *pesticide use*, was only significantly related with *occupation* (*p-value* = 0.0494) and *residence* (*p-value* =<.0001). It was borderline significant with *age* (younger than 53 years, which was the median, *p-value* = 0.0561). We dichotomized age in two categories: lower than 53 and higher than 53 (the median value).When we ran the test with age being continuous, we did not find association with *pesticide use*.

Scale Development

Perceived pesticide harm

We carried out principal components analysis (PCA) of the scales to visualize potential structures. We implemented a principal component analysis to reduce dimensionality from questions 1a to 1n (attitudes and beliefs).In order to explain more variability, we combined components 1 and 2 by using a weighted average that was used to create an individual score called *perceived pesticide harm*. This score went from 42 (maximum score, when the participant answered no to all the questions) to 14 (minimum score, when participant answered yes to all the questions). Large values of this score were associated with people who do not have a high perception of harm caused by pesticide use and exposure on human and environmental health. Because this perceived pesticide harm does not have a reference value, to assess the definition of how large is "large," we mapped the score into the scale 0-1 by using a logistic transformation. We called it *perceived pesticide harm (logistic)*.

We wanted to explore if these variables that measure attitudes and beliefs were inter-related. For this, we used an internal consistency indicator of reliability called Cronbach's alpha for variables that measured attitudes and beliefs (1a-1n). Results indicated an alpha of 0.64, indicating that the correlations of each item with every other item were good, although not very strong. We checked the values of alpha after deleting each item, and alpha only increased to 0.67when variable *e* (pesticides can affect the soil) was deleted.

To see the correlation between these variables, we ran Pearson correlation, which detects just linear correlation. We also ran Spearman correlation, which is very appropriate because it detects correlations when they are not necessarily linear (monotonic associations). These correlations can be curvilinear. The most important correlation of the variables 1a-1n (attitudes and beliefs) included: pesticide affects pregnant women's health with pesticides can harm children's health);pesticides can harm good insects with pesticides affected my health; pesticides can harm the water with pesticides can harm children's health; pesticides can harm children's health with pesticides can harm the water; and using pesticides allows me to provide more for my family economically with pesticides make the crop look cleaner (Table 4 and 5).

Table 5. Beta regression procedure for estimating the odds of perceived pesticide harm as a function of variables such as age, residence, and occupation.

Type of variable	Name or variable	p-value	Parameter estimate
Dependent variable	Perceived pesticide harm		
Independent variable	Age (younger than 53)	0.0480	-0.2480
Independent variable	Residence: Llano Other San José de la Montana Travesias	0.0097	0.1805 -0.2054 -0.1805 0.3219

Multivariate Analysis

Because *perception of harm* includes values between 0 and 1, we implemented a beta regression model using this score as a response. It is important to observe that a high *perception of harm* (closer to 1) means that the person has an enhanced perception of pesticides being harmful for health and the environment. Only *perception of harm* was significant with *age* (p-value: 0.0480) (younger than 53 years, which was the median) and with *residence* (p-value: 0.0097) (table 5).

Additionally, we explored how the variable *perceived pesticide harm* depends on the other variables. For this, we conducted a logistic regression procedure with a dichotomized version of the variable *perceived pesticide harm* as response (0 if perceived pesticide harm < 0 and 1 if perceived pesticide harm ≥ 0). Only *perceived pesticide harm* with *age* (younger than 53 years) as significant (*p-value* = 0.0529, borderline significant). This is crucial, as it implied that *campesinos* younger than 53 years have less of a perception of the degree of harmfulness of pesticides for human health and environmental than *campesinos* older than 53 years. It is important to clarify that, in this analysis, logistic regression works with *perceived pesticide harm* dichotomized.

Discussion

There was a consistent coherency in the results of parameters assessed between users and non-users (e.g., non-users perceiving more confidence and control than pesticide users). This was an indication that both groups were well differentiated in terms of what the use pesticides implies for human health. It also delineated a characteristic pattern of acceptance of the conditions imposed from the outside (external, e.g., market pressure, social norm, etc.) in the case of the user sample vs. a commitment to confront the established dogma in the case of the non-user.

Pesticide users largely believe that pesticides are not harmful for human health and the environment. In contrast, nonpesticide users have a higher perception of the harmfulness of pesticides for human health and the environment, especially among older participants (older than 53 years). Therefore, public health interventions in this pesticide user population should focus on increasing awareness about the harmfulness of pesticides for human health and the environment; this would be beneficial especially when targeted to younger community members.

Non pesticide users perceive that they have more control in relation to pesticide use than pesticide users. In the case of perceived confidence, most *campesinos* expressed having very little or no confidence to stop pesticide use. However, the few participants who perceived having high confidence were all nonpesticide users. Having higher control and higher confidence decreased the probability of using pesticides.

This study demonstrated that pesticide use for *campesinos* represents an environmental justice concern, as was also found in a study carried out with farmworkers in the US [23]. A basic principle of environmental justice is that local communities must have control over their environment. The environmental justice framework not only recognizes environmental injustice as it is associated with humans harming nature, but it also recognizes that environmental injustice arises from class, racial, and gender discrimination [41, 42].

For education on preventing/reducing pesticide use to be successful, it must address the crucial component of control over pesticide use. In pesticide use and safety education interventions, *campesinos* should be told not only what they should do to reduce pesticide use and exposure but also why and how this behavior will decrease exposure and improve their health, i.e., building a clearer justification to explain behavior [23]. Subsequently, future public health interventions should be aimed at increasing perceived control and perceived confidence mainly among pesticide users. As a consequence, this could lead to greater behavioral change of decreasing pesticide use. In other words, the tools for community empowerment should be built with local communities instead of being brought in as an external set of appropriate rules and procedures. Examples of achievement in the change of paradigm implied for the non-users can serve as a valuable preliminary experience and a demonstration of how the problem of human health alterations and environmental degradation should have an interdisciplinary approach, for example in the conjunction of agroecology, public heath, and human behavior.

The individual factors that played a relevant role in the decision-making process of pesticide use included entrenched, and often interdependent, sets of beliefs such as those related to pesticide use benefits (is necessary for crops, benefits crops), low perceived control, low perceived confidence, and low perception of pesticide harm for human health and the environment. *Campesinos* who adhere to these established categories were more likely to use pesticides. We built a conceptualmodel that describes the most influential individual factors in the decision-making process of pesticide use in San Cristobal, Colombia. The most relevant components included beliefs (pesticides are necessary for the crops, pesticides are not harmful for human health and the environment, and pesticides benefit crops, making them bigger and increasing their amounts), low perceived control, low perceived confidence, and low perception of pesticide harm (for human health and the environment). All these factors increase the probability of using pesticides (figure 1). Therefore, future public health interventions must include these components in order to reduce pesticide use in this community.

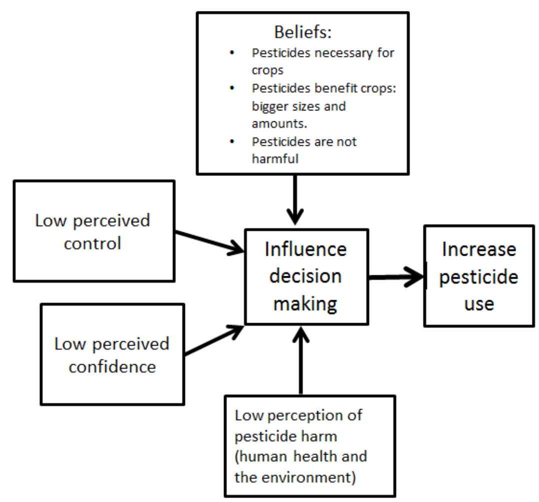

Figure 1. Conceptual model of the decision-making process of pesticide use

In terms of education, more programs and interventions are needed for *campesinos* who express the need and interest to learn more about the harmfulness of pesticides and the benefits of agroecological practices. Undoubtedly, this education must be accompanied by more support from stakeholders, institutions, and the local government in order to provide sustainability in these processes of change. These interventions must not be limited to present pre-manufactured information. Rather, these programs must help affected communities to build an appropriate local knowledge so as to gain awareness, control, and confidence in the process for implementing behavioral change on pesticide use and exposure dynamics.

Moreover, future studies should attempt to use behavioral, environmental, and psychosocial measures to build a body of evidence with which to better understand the risk factors for pesticide exposure among agricultural workers [20].

Results obtained after statistical treatment of perceived pesticide harm are more than worrying. They imply that younger agriculture workers possess less of a concern on the detrimental effects of pesticides on their personal health, on the health of the community around them, and, in general, on the health of the natural environment on which the local community ultimately depends. The new generation of *campesinos* may have a hard time reorienting its approach to agriculture in the direction of abolishing pesticide use though agroecological practices, therefore imposing serious threats for the health of the rest of the community. This finding stresses the idea of reinforcing research projects, educational campaigns, and public health programs among communities of agriculturalists in rural Antioquia where the adverse effects of pesticide use-abuse are just beginning to be documented. Doing so, this will work in the direction of strengthening our prospects in the struggle for social and environmental justice.

Research of this kind is limited in Colombia; therefore, more research is needed on different regions of Colombia with the aim of exploring in more detail the level of local knowledge, perceptions of risk and control, and the beliefs and attitudes related to pesticide use.

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