Assessment of health hazards and risk perceptions of market garden producers towards the effects of pesticides in Western Region Cameroon

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Abstract

Objective and Methods

The spraying of chemicals pesticides is a key factor for the improved quality and productivity of agricultural products. Nevertheless, the increased health issues among the agrarian population in Africa, and particularly in Cameroon, involves to lay an emphasis on how producers' risk perception toward pesticides can contribute to mitigate their effects. The risk assessment of pesticides on the literature focuses mainly on the pesticide itself, but the studies on producers' risk perception and the drivers of this perception on their behavior are insufficiently known. Therefore, this article assess the health risks and risk perceptions of 560 producers towards the effects of pesticides in 7 subdivisions of Western region Cameroon. A cross-sectional dataset was use during the period of July 2020 to May 2021 for our interviews and an ordered Logit model was use to perform our analyses.

Results

The results showed 74.62% and 63.93% of producers attested that herbicides and insecticides are among the extremely hazardous products. Otherwise, excessive sweating (61.07%), general tiredness (61.96%), nausea and vomiting (54.46%) and headaches (53.04%), were among the main symptoms of health issues reported. In addition, some socioeconomic characteristics including health, age, education, training and awareness of producer were the main significant drivers of risk perception.

Conclusion and recommendations

Our observations led to fundamental implications for policymakers, as the overuse of pesticides and their negative effects on the health of Farmers may be aggravated, if there is no support by the integration of social norms. Furthermore, more training program from agricultural extension services should place emphasis on imparting basic precautionary knowledge for limited producers.

1. Introduction

The spraying of chemicals pesticides in modern agriculture is a major component with evidence benefits on yields and product quality. ^[1] Indeed, according to ^[2, 3], it is more than 3 billion tons of hazardous chemicals pesticides that are used each year to control weeds, pests and plants diseases by at least 1.5 billion people worldwide who are involved in agriculture-related activities. And as in other developing countries of sub-Saharan Africa, Cameroon's agricultural sector also consume massively agrochemicals pesticides with more than 1.373 tons of pesticides sprayed only in 2018. ^[4, 5]

Over the past 10 years, with the growing population, the demand for market garden products and other food crops has increased in the country. ^[6] Thus, to guarantee the crop protection and then reduce the supply and demand gap, heavy amounts of pesticides have been used across the country. ^[7, 8] Indeed ^[9]

attested that since 2015, it has been recorded more than 600 pesticides products in Cameroon, with dominant products being insecticides (33.93%); herbicides (26.55%) and fungicides (24.26%).

Although very clear instructions about the judicious use of chemicals pesticides are available in Cameroon's pesticide management legislation, and specifically on the labels of the recommended products, the regulation of their residues on food and nonfood crops has not been meticulous at all ^[6]. Usually, Cameroonian producers do not fully conform to the standard pesticides practices in monitoring harmful pests and diseases. ^[9] As consequences, the overuse of chemicals pesticides have been highly associated with the health hazards and acute pesticide poisonings who tragically claim many lives worldwide each year. Indeed, ^[10, 11] estimate that acute pesticide poisonings affect nearly 3 million people and they are responsible for more than 20.000 accidental deaths each year, which generates some high economic costs in developing countries such as Cameroon. ^[12, 13–14]

Considering the above stylized facts, the producer's perception towards overuse of pesticides and their effects is very important and should be considered as an important issue for the harmful effects on health and their closer environment. In the literature, the risk assessment of pesticides uses focuses mainly on the pesticide itself, through studies like ^[15, 16], on the toxicological effects of pesticides, or the one from ^[15] on the development of formulations to reduce pesticides doses and exposure, or finally on contamination routes for the producer like the study of. ^[18] But the studies on producers' risk perception of pesticides and the influence of this perception on their behavior are insufficiently known. Nevertheless, some studies indicate that the use of pesticides by producers and their perception are sometimes related to one another. Indeed, ^[19] observe early that perception affects peoples' behavior and their careful management of a risk. So as an example, ^[20, 21] have examined the relationship between risk perception and household's knowledge regarding water pollution and its potential effect on human health. Also, ^[22, 16–26] concluded that perception is fundamentally influenced by a producer's education.

Other authors such as ^[24, 25– 26] defined the risk perception as a subjective assessment of the probability of a specific type of accident occurring and the extent to which the individual concerned values the consequences. According to ^[2], people receive signals and stimuli from their surroundings and use these to develop their perceptions. Hence, when producers observe adverse pesticide effects, they may be aware of these effects because of possible health issues. Even if the perception of risk goes beyond the individual, as it is a social and cultural construct that reflects the symbols, values, history and ideology of a society.

In the line with this, we therefore postulate in this paper that the more producers perceive the effects of pesticides as risks to their health, the more vigilant they will be with their handling. Our main objective is thus to quantify risk perceptions of pesticides and adverse health effects of exposure to pesticides among the market garden producers of western region in Cameroon. The purpose of the results of this research is to serve as a decision-making tool for agricultural and health policy makers to design more effective policies for sustainable agriculture.

Analysis of socioeconomic factors underlying producers' perception: A Ajzen's Theory of Planned Behavior (TPB)

As previously stated, most Camerounian market garden producers are not informed and trained enough on the recommended measures against the effects of pesticides and their toxicity. This problem has thus become an important question that has driven researchers to develop theoretical model on the basis of existing studies in the literature. Based on ^[2] observations, this model is especially supported by the Theory of Planned Behavior (TPB), an improvement of the early theory of reasoned action which has its foundation in psychology. A pioneer of this theory is the American psychologist Ajzen, who in the early 1990s established a link between some convictions and the individual's behaviors. ^[28]

Over the past decade Ajzen's theory has then been recognized in various fields of research and implemented to understand a wide diversity of human behavior. ^[29, 30–31] As an example, the earlier study of ^[26] on producers' perception of pesticides, the recent one of ^[32, 33] on producers' perception over pesticides effects, or the research of ^[34] are among the recent studies who have applied this theory. Indeed, the relevance of this theory's approach to studies of producers' perceptions of pesticides stems from the fact that producers' pesticide use behavior is not only influenced by institutional factors like pesticide prices, distribution chains, access to market information, but also unobservable emotional factors such as motivating forces on a single decision maker. ^[2]

Technically, Ajzen's theory describes how an individual shapes his perception by taking into account attitude, subjective norms and perceived behavioral control. In our study, producers' perceptions toward pesticides are influenced by sociodemographic characteristics like (Age, educational level, farm income, rural cooperative membership, land ownership, agricultural knowledge and experience ...), and by family members characteristics (family size and family labor, marital Statut, health diseases effects...) (Fig. 1). Regarding ^[2], our subjective criteria influencing producers to adopt a particular behavior can be associated with the level of consumption of agricultural products.

From an empirical point of view, ^[31] concluded that the significant influence of a related subjective norm can improve the perception and probability of executing a particular behavior. Also, ^[33, 35] discussed about the individual's practice and obstacles that may inhibit the perceived behavioral control and then influence farmers' perception of pesticide. The authors identified seven main determinants treated as antecedents to producers' risk perception. Since the complexity of the health diseases occurrence, our understanding of the relationship between individual's factors such as producer's age, level of education, agricultural income and producers' perceptions could thus be improved by analyzing these characteristics.

The empirical evidence of ^[36] considered producers' age as an important factor in differentiating exposure to pesticide toxicity. Similarly, some studies of ^[37, 29] indicated that there is a significant and positive correlation between level of education, knowledge and producers' perception of quantity of pesticides to be sprayed. Fundamentally, knowledge refers to a set of information acquired through

education. In fact, knowledge of pesticide effects can familiarize patients with health issues and help them take preventive measures in a timely method. Therefore, awareness of pesticides effects is considered as the attention and sensitivity of an individual to health issues. In the rural setting of Cameroon, market garden producers achieve awareness through the rural community, agricultural field officers, health agents, and some suppliers in the rural markets.

2. Materials And Methods

Study area

This study was precisely carried out in the Noun Division, West region of Cameroon (Fig. 2). It is located roughly 5° N by 10° 30 E. The river Noun separates two main plateaus, one of which is 1,200m high, the other 1,500m high. These two plateaus have been beveled during the past geological times and covered by volcanic materials which have altered relief and disturbed the hydrography pattern. The local population cultivates their land with great care in the sprawling part of the plateaus but without any care on the escarpments. They are grouped around the seven main localities (Magba, Djinoun, Koutaba, Fouban, Kouoptamo, Foubot, and Massagam), which made up our survey area.

The primary data used for our empirical analysis were obtained from a survey conducted within the period from July 2020 to May 2021 in 7 subdivisions which form one of the important agricultural production pool of the country, due to their fertile land. (Tab. 1) below presents the distribution of sub-samples by subdivisions. The Noun Division was selected for two reasons: firstly, because of the high production of market garden products which is approximately 30-40% of the whole vegetable production of the country. ^[38] Secondly, because of the significant consumption of chemical pesticides in this Division. ^[8] But also, as a result of the presence and organization of rural cooperatives, the Socio-economic importance of agriculture for rural households, the intensity of agricultural activities, and finally the soil and climate characteristics favourable to agricultural production.

Survey design and data collection

The multistage sampling technique was applied for the present study. In the first step, the stratified random sampling technique was used, and Noun division was geographically divided into three main zones the North, the West and the Centre (Fig. 2). In the second step, one district was selected from each geographical stratum, followed by the selection of villages per district and finally market garden producers per village (Tab. 1). In the third stage, a random sample technique was used, and a sample of 560 market garden producers was obtained.

Table 1
Distribution of market garden producers by survey location

Localities	Number of producers (N)	Percentages (%)	Total
Foumbot	130	23,21	130
Koutaba	80	14,28	80
Djinoun	80	14,28	80
Kouoptamo	70	12,5	70
Massagam	100	17,85	100
Magba	50	8,92	50
Foumban	50	8,92	50
Total	560	100	560

Source: Authors' construction 2021

Prior to the field survey, verbal approval was obtained from the traditional chief and his senior advisors in the respective villages to conduct face-to-face interviews with the producers. Face-to-face interviews are a more sophisticated way of collecting adequate information, although they are expensive. Finally, out of 560 interviewed producers, 130 were from the Foumbot village, 100 were from the village of Massagam, and 80 were from the Koutaba and Djinoun respectively. All farmers included in the sample list were obtained from 7 villages. The interview process was conducted from July 2020 to May 2021

The main informations collected on the surveys were on household socio-demographic characteristics, symptoms of poisoning, and risk perceptions of agrochemicals pesticides effects. After data spring-cleaning, 560 valid observations were finally used for the study. (Tab. 2) presents a descriptive statistics of the selected variables.

Table 2
Distribution of descriptive statistic of socioeconomic variables

Variables	Description	Code	Value	S.D
Age	Age of producer (head of farm)	Year	42.587	12.009
Education	Level of education of the producer (head of farm)	0= illiterate		
		1=Primary 2=Secondary 3=Tertiary	1.442	0.800
Exp	Producer experience in years of large-scale farm management	Number of Year	15.180	9.877
Membership	Whether the producer is an Agricultural Cooperative member	1=Yes 0=No	0.617	0.486
Area	Size of land operated by farms	hectare	2.683	1.877
Ownership	Land ownership by the producer	1=Yes 0=No	0.941	0.235
Pesti_training	Whether the producer have received a training on pesticides management	1=Yes 0=No	0.216	0.41
Size	The proportion of family labors in the total farm labor force	Number of people in the house	7.235	3.626
Health	Whether the producer has had health problems	1=Yes 0=No	0.748	0.434
Knowledge	Producer has a good knowledge on pesticides effects	1=Yes 0=No	0.423	0.465
Awareness	Whether the producer is aware of the dangers of pesticides	1=Yes 0=No	0.412	0.457
<i>Source: Authors' construction 2021</i>				

Estimation Technique and data analysis

In order to determine the degree of correlation and the significance of the link between the perception of market gardeners and socioeconomic characteristics, Pearson's point biserial correlation tests and Spearman's correlation tests were used. Factors which influence producers' perception of the effects of pesticides are estimated by regressing one dependent variable with eleven independent variables.

This model is a continuation of the binary ordered Logit regression which is used when the dependent variable is in binary or rank form. Based on the approach of ^[39], who estimate risk perception, we also adopt the ordered Logit as an estimation technique. Indeed, this model can be specified to identify producer responses that influence the perceived health risks of pesticide use in market garden production such as:

$$P_i^* = \beta'Y_i + \delta_i \quad (1)$$

With P_i^* the unobserved and continuous measure of health-related risk perception of using pesticides for market garden production, Y_i is a vector of sociodemographic variables, β a vector of parameters to be estimated and δ_i is a disturbance term supposed to be normally distributed. And since P_i^* is unobserved, we evaluate the coded discrete responses of the variable P_i as follows:

$$P_i^* = \begin{cases} 1 & \text{if } -\infty \leq P_i^* \leq \lambda_1 \text{ (not hazardous)} \\ 2 & \text{if } \lambda_1 \leq P_i^* \leq \lambda_2 \text{ (very hazardous)} \\ 3 & \text{if } \lambda_2 \leq P_i^* \leq \lambda_3 \text{ (fairly hazardous)} \\ 4 & \text{if } \lambda_3 \leq P_i^* \leq \lambda_4 \text{ (strongly hazardous)} \\ 5 & \text{if } \lambda_4 \leq P_i^* \leq \lambda_{+\infty} \text{ (extremely hazardous)} \end{cases} \quad (2)$$

While considering the maximum likelihood method which provides consistent and asymptotic estimators we can alternatively estimate the vectors of β' parameters and λ' thresholds according to. [2] The marginal effects of the dependent variables were estimated using the coefficients of the ordered Logit model. The probabilities associated with the coded risk perception responses of the farmers in the ordered Logit model are given as follows:

$$\begin{aligned} T_i(0) &= T_r(P_i = 0) = T_r(P_i^* \leq \lambda_1) = T_r(\beta'Y_i + \delta_i \leq \lambda_1) \\ &= T_r(\delta_i \leq \lambda_1 - \beta'Y_i) = \phi(\lambda_1 - \beta'Y_i) \\ T_i(1) &= T_r(P_i = 1) = T_r(\lambda_1 \leq P_i^* \leq \lambda_2) = T_r(\delta_i \leq \lambda_2 - \beta'Y_i) - T_r(\delta_i \leq \lambda_1 - \beta'Y_i) = \phi(\lambda_2 - \beta'Y_i) - \phi(\lambda_1 - \beta'Y_i) \\ T_i(k) &= T_r(P_i = k) = T_r(\lambda_k \leq P_i^* \leq \lambda_{k+1}) = T_r(\delta_i \leq \lambda_{k+1} - \beta'Y_i) - T_r(\delta_i \leq \lambda_k - \beta'Y_i) \\ &= \phi(\lambda_{k+1} - \beta'Y_i) - \phi(\lambda_k - \beta'Y_i) \\ T_i(K) &= T_r(P_i = K) = T_r(\lambda_K \leq P_i^*) = 1 - \phi(\lambda_K - \beta'Y_i) \end{aligned} \quad (3)$$

With k symbolizing a marginal response of the producer; $T_r(P_i = k)$ representing the probability that a market garden producer i give a responds k , $\phi(.)$ is the cumulative Logit distribution function. Appreciated health hazards is theoretical depend on the quantity and quality of pesticides sprayed by the market garden producers of the sample. Risk perception is a latent variable as producers had to choose one answer among a set of five possible options. The positive signs of the parameters β show higher health-related risk towards the use of pesticides, while negative signs indicate the contrary.

3. Results

Socioeconomic characteristics of the market garden of the study area are presented in (Tab. 2). Based on initial observations, the mean age of the producers in the area is 42 years, with primary level as the mean educational level. About 0 to 25 family’s members worked on the farm, with an average of 7 persons per farm. The average farm size was 2.6 hectares, indicating that producers operate on large areas of land, and produce a wide range of vegetable products in the region. Most of the producers (94.1%), owned the agricultural land. Also, the results revealed that 74.82% of the producers of the study area claimed to have adverse health effects due to pesticide spraying activity, and very few (21.67%) had received pesticides management training. In addition, 42.34% and 41.23% of the producers respectively, had knowledge and were aware about the effects of pesticides on health and the environment.

Our field investigations revealed that market garden producers use 4 main pesticide products (herbicides, insecticides, fungicides, nematicides). According to first stage of the producer’s perception analysis shown in (Fig. 4), about 28% among them agreed that pesticides have a hazardous effect on health, while 34% strongly agree to this. In contrast, only 2% strongly believed that pesticides products are not hazardous to human health, and approximately 23% were neutral. In the same line, the study of ^[40] observed that there were few producers in Ethiopia who had a good understanding of the health implications.

For the second stage of perception analysis, producers were asked about their awareness of the health hazards of each product (Tab. 3). Thus, the analysis shows that about 63.93% and 74.62% of producers testify that insecticides and herbicides are among the extremely hazardous products, while 43.25% and 65. 36% consider fungicides and nematicides as strongly hazardous for their health.

Table 3
Health hazards perception of pesticides effects

Percentage					
Perception	extremely hazardous	strongly hazardous	fairly hazardous	very hazardous	not hazardous
Perception of insecticides	63.93	33.07	0	0	0
Perception of fungicides	12.32	43.25	40.20	0.18	4.50
Perception of herbicides	74.62	22.41	0.54	0	2.43
Perception of nematicides	0	65.36	34.64	0	0
Source: Authors’ construction 2021					

Furthermore, only 4.50% and 2.43% of producers respectively estimate that fungicides and herbicides were not hazardous for human health. All these results confirm the idea that the perception of pesticides effects by producers is sufficiently interesting to better understand their behavior in managing pesticide products on the farm. However, ^[41a] believe that they are still a few farmers in Africa, especially in Ethiopia that have a good knowledge of the health implications of pesticides application, while most producers still lack the training to improve their knowledge.

Symptoms of intoxication reported by the exposed producer

If we refer to earlier studies, most producers who use pesticides on their farms face numerous health problems. ^[41b, 42] Indeed, ^[43] compared two producers' groups and indicated that toxic pollutants were found in higher concentrations in blood tests taken from cancer patients compared to controls. In (Tab. 4) we noted excessive sweating (61.07%), general tiredness (61.96%), nausea and vomiting (54.46%), excessive salivation and loss of appetite (49.46%), headaches (53.04%), and dizzy (37.86%) are among the main symptoms of health issues reported. Furthermore, confused and blurry vision (30.18%), tremors of upper limbs (28.75%) and convulsions (26.79%) were also attested by the producers.

Table 4: Diseases symptoms reported by producers suffering pesticide poisoning

Pictogram	Health symptoms	Percentage/Total (560)
Dizzy	37.86 (212)
Headaches	53.04 (297)
Excessive sweating	61.07 (342)
Confused and blurry vision	30.18 (169)
Nausea and vomiting	54.46 (305)
Tremors of upper limbs	28.75 (161)
Convulsions	26.79 (150)
Excessive salivation and loss of appetite	49.46 (277)
General tiredness	61.96 (347)

Source: Authors' construction 2021

In the literature a similar the study from ^[44] indicated that after spraying pesticides, skin irritation and stomach ache after inhalation seemed to be the most common symptoms of poisoning. Just like this

author, several studies have highlighted a variety of approaches to assessing the effects of pesticides on producers' health. The vast majority have confirmed their significant role in the development of various health complications such as chronic diseases, degenerative diseases, neuronal disorders and certain cancers. It would be therefore imperative to consider the implementation of structured interventions to reduce exposure to health risks.

Correlation between the effect of pesticides and producers' perception of risk

The results of the Pearson's point biserial correlation and Spearman's correlation tests between producers' perceptions of risks and their socioeconomic characteristics are presented in (Tab. 5). The first observations indicate that producers' perception had significant and positive correlations at the 1% level of significance with the age, level of education, training on pesticide management, health effects, and knowledge. While sex, awareness, pesticides training were significant at 5% and Membership of rural organization and experience were at 10% level of significance. In contrast, household size and farm area showed a negative and non-significant correlation with producers' perception.

Table 5
Correlations between producers' risk perception and socioeconomic characteristics.

Variables	Correlation coefficient	p-value		Correlation type
Age	0.0453	0.000	***	Spearman
Sex	-0.0364	0.009	**	Point biserial
Education	0.0022	0.000	***	Spearman
Exp	-0.0033	0.093	*	Spearman
Membership	0.0633	0.013	*	Point biserial
Pesti_training	0.0087	0.006	**	Point biserial
Size	0.0026	0.9517		Spearman
Area	-0.0261	0.5382		Spearman
Health	0.0165	0.000	***	Point biserial
Knowledge	0.0754	0.000	***	Spearman
Awareness	-0.0548	0.008	**	Spearman
<i>Source: Authors' construction 2021</i>				

__Significant at p<0.01; __Significant at p<0.05; _Significant at p<0.10.

Determinants of market garden producers' risk perception of pesticides effects

The estimated results of the producers' perceptions of pesticides effects using an ordered Logit model through the maximum likelihood approach are presented in (Tab. 6). Furthermore, in order to measure the robustness of the relationship between dependent variable and socioeconomic parameters we have analyzed and interpreted the coefficients of the statistical regression.

Table 6 Estimated results of the producers' risk perception of pesticide using the ordered Logit model.

	Estimate	Std. Err	Sig		Lower bound	Upper bound
Age	.024802	.0122916	0.044	**	.0007109	.048893
Sex	-.148876	.1603057	0.353		-.463066	.1653207
Education	.002845	.1094798	0.079	**	-.2117309	.2174222
Exp	-.01308	.0145746	0.036	**	-.0416539	.0154751
Membership	.323127	.1734207	0.062	*	-.0167759	.6630209
Area	-.086683	.0502886	0.085	*	-.1852474	.0118804
Ownership	-.546845	.3468379	0.115		-1.226635	.1329449
Pesti_training	.051919	.1911596	0.000	***	-.3227466	.4265851
Size	-.023241	.0262506	0.376		-.0746902	.0282101
Health	.035909	.2021921	0.009	***	-.3603795	.432199
Knowledge	.048642	.1902586	0.000	***	-.2411678	.3526187
Awareness	-.023759	.2047321	0.000	***	-.1937836	.0127489
<i>Source: Authors' construction 2021</i>						

__Significant at $p < 0.01$; _Significant at $p < 0.05$; _Significant at $p < 0.10$.

Thus, this shows that there is a positive relationship between the producers' risk perceptions and some variables like age ($\beta = .2480$), education level of producers ($\beta = .00284$), health ($\beta = .0359$), training on pesticides ($\beta = .0519$) and knowledge ($\beta = .0486$). Furthermore, the results of this table reveals that there are four variables (training on pesticides, health, knowledge, and awareness) were at a 1% level of significance $p < 0.01$, while age, education level, producers' experience were significant at 5% $p < 0.05$, and membership of rural organization and total area at 10% of significance $p < 0.10$ respectively. These results are globally confirmed by other existing studies like the one of [22, 45]. Other statistical results, including pseudo R^2 measures (0.174), log-likelihood statistics (-265), and LR χ^2 (108.53), indicate the robustness of the ordered Logit model.

Table 7
Marginal effects of producers' health-related risk perceptions of pesticides effects

	dy/dx	Std. Err	Sig		Lower bound	Upper bound
Age	-.0026009	.00131	0.047	**	-.005162	-.00004
Sex	.0156117	.01687	0.355		-.017454	.048677
Education	-.0002984	.01148	0.979		-.0228	.022203
Exp	.0013726	.00153	0.071	**	-.001633	.004378
Membership	-.034733	.01928	0.072	*	-.072519	.003053
Area	.0090902	.00532	0.088	*	-.001337	.019517
Ownership	.0487679	.02614	0.062	*	-.002464	.185403
Pesti_training	-.0053923	.01967	0.784		-.043948	.033163
Size	.0024371	.00276	0.377		-.002969	.007843
Health	-.0037875	.02145	0.006	***	-.045824	.038249
Knowledge	.04864219	.00287	0.000	***	-.034573	.025786
Awareness	-.00265972	.001391	0.000	***	-.0246579	.013546
<i>Source: Authors' construction 2021</i>						

__Significant at p<0.01; __Significant at p<0.05; _Significant at p<0.10.

In (Tab. 7), the marginal effects indicate that market garden producers in the study area are very likely to perceive the use of pesticides for food production as leading to significant health and biodiversity impacts.

4. Discussing The Microeconomic Framework Of Pesticide Use: A Need For Structural Changes

In the field of pesticides researches, producers risk perception seems to be an important issue in vulgarizing the safe management of pesticides in the farms. Yet, there still much emphasis on education and technical training of producers for their safe handling in Cameroon. Considering the lack of empirical data in the literature on this concern, this paper sheds light on the perception of health-related risks among agricultural producers. Through the context of this study's perspective, it is our aim to establish the theoretical link between the main socioeconomic characteristics and producers' perception of the risk of pesticide effects. But also, discussion about health symptoms of pesticide poisoning which provides

at the end important recommendations for policymakers, association of producers, rural communities and so far health agencies. Thus, the coefficients of the ordered Logit model which represent age, level of education, training on pesticides revealed that it is a positive and significant relation on the risk perception of pesticide effects and some socioeconomic variables. Indeed, the few years of conventional learning that are completed by producers indicate that education, as a source of human capital, has positive effects on health risk perception.

This empirical evidence have been confirmed earlier by ^[46, 47] who concluded that education provides well informed producers with better technical capacities for effective pesticide use. Furthermore, ^[47] showed that educated producers are more aware of the dangers of mishandling pesticides and thus adopt the necessary protective measures to reduce their level of exposure to harmful products. Although the educational level is very low among the producer community of our study area, unexpectedly, his related coefficient was found to be positive and significant.

The adverse health effects brought by the overuse of pesticides have led to a high perception of the risks. Our results are consistent with the conclusion of ^[48] for whom the adverse health effects faced by producers could strongly influence risk perception. In the same line, ^[49] observed that producers confronted with the adverse health effects of pesticides "were more expected to consider pesticides as very hazardous [...]." Following this empirical observation, underlying evidence indicates a relationship between pesticide poisoning and some specific diseases such as respiratory problems ^[50] or breast cancer ^[51]. Moreover, the toxic effects of pesticides were investigated, and the results showed that the farmers in the selected study area faced different health-related issues (Tab. 4). Among all health problems identified, excessive sweating, general tiredness, nausea and vomiting, excessive salivation and loss of appetite, headaches, and dizzy constitute the major symptoms reported by the producers living in our study area.

In terms of access to technical training on pesticides, this study showed that it definitely reduces health risks for producer. Indeed, some studies have stated that in addition to receiving pesticides training, an access to extension services is important for enlightening producers' knowledge, and awareness of the rational spraying of pesticides ^[45]. Thus, the level of perception in our investigation was significantly associated with farmers' knowledge and awareness, which according to ^[52], are usually transmitted through online media, and multiple additional sources. Also, an empirical research study piloted by ^[53] highlighted that the social community in rural areas facilitated the flow of information, which in turn influenced local farmers' decisions about the adoption of new agricultural practices.

A Similar results have been established by ^[54] who observed that awareness is generally based on previous experiences, but generally, farmers receive different information concerning modern farming from development workers, traders, input suppliers, social networks, and farm training schools. At the end, ^[55] concluded that knowledge and awareness critically determine how health risks are perceived and systematically handled by farmers. Unfortunately, the main economic consequences of such issues are

an increase in health costs associated with these diseases. Meanwhile, the issue of health costs can be mitigated through health insurance. Unfortunately, health insurance in Cameroon is not properly widespread for certain reasons, such as credit constraints and information asymmetry about health insurance.

5. Conclusion And Agricultural Policies Recommendations

In this paper, we have examined the health hazard and main determinants of market garden producers' risk perception toward pesticides effects. This is based on a field survey that was conducted in 2021, and socioeconomic information collected from 560 producers from west region of Cameroon. The results of the ordered Logit model indicated that the age, education, health effects, training on pesticides management, producers' knowledge and awareness, had a positive and significant influence on producers' perceptions of pesticides effects. Our results are in line with the empirical evidence of ^[56] who confirm that pesticide spraying are the outcome of farmers' behavior and the influence of social structure.

The present method used in this research is one of the first attempts to analyze Cameroonian market garden producers' perceptions towards pesticides effects based on the TPB theory, which indicates good efficiency in analyzing producers' perceptions. The results further show that in addition to individual characteristics, producers' behavior under the influence of subjective norms, influences their intentions to adopt specific behavior. Due to an increase demand of food crops (including market garden products) and the ever-growing population in Cameroon, specifically in rural areas, a sufficiently robust set of policy initiatives are required to ensure the reduction of health risks from pesticides spraying.

Founded on the previous evidence, this paper suggests that information campaigns should be conducted to improve producers' perceptions so that they can implement risk reduction strategies. This could be accomplished by increasing producers' knowledge of pesticides and initiating pesticide health safety education with qualifications certified programs through ministry of agriculture and rural development. These trainings should specifically address issues related to good agricultural practices on spraying pesticides in the field, storage and waste management, but also on producer health related to pesticide toxicity. In addition, retailers who are the main source of information on pesticides in rural areas should be oriented to better assist farmers. Other intervention strategies through routine investigation and strict monitoring by agricultural field officers at the retail and farm levels should also be strengthened. Furthermore, the Cameroonian government through ministry of agriculture should strictly regulate the commercialization of chemicals such as Dichlorodiphenyltrichloroethane (DDT) as there are still widely sprayed on food and non-food crops in Cameroon. ^[27]

Other government policy approaches include involving media actors in the extension of more secure food production and improving the role of extension workers through stepwise supervision. In addition, the government could further develop partnerships with some organic food producers and traders to ensure product safety via a national traceability system such as Good Agricultural Practices (GAPs) in the certification system. The implementation of these GAPs at national level would help to control the

inappropriate use of pesticides as exceeding the maximum residual limit (MRL) is technically unsustainable. Finally, it should be emphasized that consumer perception has not been captured here. As such, future research would need to cover a wider range by analyzing consumer opinions on the health risks of pesticide residues with broader data.

Declarations

-Ethics approval and consent to participate

Not applicable.

-Consent for publication

Not applicable.

-Availability of data and materials

All data generated or analyzed during this research are included in this article.

-Competing Interest

The authors declare that the study was conducted in the absence of any conflicting commercial or financial relationships.

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-Authors' contributions

The paper has been prepared by all the authors. Kaldjob Christian Bernard conceived the study and revised the manuscript. Simo Brice Herman, Kaldjob Christian Bernard and Nso Ngang Andre contributed to data searching screening, extraction and data analysis, Kaldjob Christian Bernard, Tata Ngome Precillia and Bamou Tankoua Lydie revised the paper and approved the final version to be submitted. Douya Emmanuel participated in screening the titles, abstracts and full text screening, he also advised on the analysis of the data and revised the manuscript. Finally, all authors read and approved the final manuscript.

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Figures

Figure 1

Theoretical framework of factors affecting producers' perception toward pesticide effects.

Source: authors' construction 2021

Figure 2

Study area Source: Authors' construction 2021

Figure 3

field survey with producer/ sprayer practicing without protective devices.

Source: Authors from field survey 2021

Figure 4

Producers' appreciation of pesticides risk

Source: authors' construction 2021