

Economic Characteristics, Agrochemical use and Health Risk Among Grenadian Farmers

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ABSTRACT

Background: Agrochemicals are commonly used in the Caribbean islands, however, the relationships between the use of the chemicals and health outcomes have not been studied extensively. Previous studies primarily focused on farmers' use of personal protective equipment while handling agrochemicals. The authors conducted this first study in Grenada to investigate the relationships between the characteristics of farmers, use of agrochemicals, and health risk.

Method: The cross-sectional study investigated the relationships between the characteristics of 8868 farmers in the 2012 agriculture census in Grenada and the use of three agrochemical ingredients. Logistic regression analysis generated odds ratio indicting the likelihood of farmers experiencing health problems based on the use of the chemicals.

Results: Farm labor and market presence were found to be the most critical factors that influenced the used of agrochemicals and greater odds of experiencing health problems. The odds ratio was >6 and statistically significant for having ever used agrochemicals by farmers who hired non-household workers and farmers who paid farm workers. Having experienced production issues, receiving technical assistance, not receiving credit and farm located in St. John, the second poorest parish and fishing capital of Grenada were found to be protective factors.

Conclusion: Commercial activities that have direct bearing on expenditure and income were found to have the most significant influence on farmers' use of agrochemicals and increased risk of health problems. To address this public health issue, farmers must be given the support to produce safe and healthy foods without compromising their own health. Policies must be developed to provide for incentives and restrictions to improve stewardship in the use of agrochemicals. Finally, education and other interventions are also necessary to increase farmers' awareness and to build and support capacity to address the issue at all ecological levels.

INTRODUCTION

Agrochemicals are commonly used in the Caribbean islands, however, the relationships between the use of the chemicals and epidemiological outcomes have not been widely studied. Most studies focused on the use of agrochemicals and farmers' adherence to good agricultural practices, in particular, use of personal protective equipment while handling or applying agrochemicals^[1,2]. Most of the studies were also conducted in the larger Caribbean islands, such as Jamaican, Cuba and Trinidad, while there was a virtual absence of recent publications on stewardship in handling and applying agrochemicals in smaller islands, such as Grenada, Dominica, St. Lucia and St. Vincent.

Recently, a study was published by the authors in Research & Reviews: Journal of Agriculture and Allied Sciences on the relationship between social characteristics of farmers in Grenada and the odds of experiencing specific health problems resulting from the use of agrochemicals [3]. The health problems were found to be associated with the use of glyphosate, carbaryl, and paraquat in the Agriculture Health Study (AHS) in Iowa and North Carolina in the United States [4,5]. Exposure to carbaryl was associated with the farmers experiencing sleep apnea [6] decrease in LINE-I DNA methylation [7] rheumatoid arthritis [8] and allergic wheeze [9] exposure to paraquat was associated with farmers experiencing a decrease in LINE-I DNA methylation [7] exposure to glyphosate was associated with farmers experiencing allergic and non-allergic wheeze [9] and exposure to paraquat was associated with farmers experiencing Parkinson's disease [10] and end-stage renal disease [11].

The need for further research on agrichemical use and exposure profiling in Caribbean populations was emphasized by Forde and Dewailly in a study published in 2015 [12]. The authors, therefore, conducted this study to address the gap in the literature regarding the use of agrochemicals and possible exposures and health problems. The results of this study have important implications for public health practice and social change in Grenada. Policies and interventions can be better guided to improve the stewardship in the use of agrochemicals, monitoring the use of agrochemicals and to address the gaps in knowledge, practice, and response systems. Lastly, the findings regarding the potential health outcomes among Grenadian farmers may be referenced in other Caribbean countries with similar demographic profile and level of use of agrochemicals.

METHODS

The method for investigating the economic characteristics of farmers associated with agrochemical use and health risks among Grenadian farmers. In summary, algorithms used in the AHS in the United States were adopted to conduct a correlational cross sectional study investigating the relationships between the characteristics of 8868 farmers in the 2012 agriculture census in Grenada and the frequency of use of agrochemicals. In Grenada, the relationship between the economic characteristics of farmers in the 2012 agricultural census in Grenada and the frequency of use per year of agrochemicals at levels that can potentially cause farmers to experience sleep apnea, rheumatoid arthritis, decrease in LINE-I DNA methylation, and allergic and non-allergic wheeze was investigated. In Grenada, the frequency of use of three agrochemical ingredients – paraquat, glyphosate, and carbaryl- was compared with the findings in the AHS to determine which Grenadian farmers were at highest risk of experiencing health problems based on the level of use of the three chemicals.

Logistic regression analysis was conducted to generate odds ratio, indicating the likelihood that farmers will experience sleep apnea, rheumatoid arthritis, and decrease in LINE-I DNA methylation, allergic and non-allergic wheeze, end-stage renal disease and Parkinson's diseases given their economic characteristics. The statistical significance of the effect of each independent variable on the dependent variable was interpreted with alpha.05 as the cutoff point. The results of the odds ratio were interpreted with a 95% level of confidence. The study was approved by Walden University IRB in the United States and by St. George's University IRB in Grenada.

RESULTS

Descriptive characteristics of the farmers

Of the 9295 farmers in the agriculture census dataset, 95.4% (N=8868) were involved in only crop production or in both crop production and animal husbandry. Farmers that were involved only in animal husbandry were excluded from the analysis. A total of 11.9% (n=1059) farmers reported they used agrochemical in the last 12 months (census year). A total of 71.5% of the farmers were males (n=6343) and 28.5% were females (n=2525). Overall, the majority of farmers were in the middle to older age groups; 35-44 (18.1%, n=1608), 45-54 (26.2%, n=2324), 55-64 (19.1%, n=1694), and 65-74 (12.7%, n=1127); more than half completed education at the level of secondary school, (56.9%, n=5044), and smaller numbers of farmers completed their education at primary school level (0.8%, n=70) and university (2.6%, n=230). Most of the farmers had household with 1-4 members (74.8%, n=6633). More than half of the farmers did not have membership in a farm organization (67.8%, n=6013).

Statistical analysis

Table 1 show results from logistical regression analysis with odds ratio less than 1 (OR .159 - .245) and statistically significant ($p < .05$) for having ever used agrochemicals by farmers who experienced production issues as compared to those that did not experience production issues; received technical assistance as compared to those who did not receive technical assistance; received credit as compared to those who did not receive credit; and had lands located in St. John, a rural parish, as compared to those who had lands located in St. George's, the main urban parish. Odds ratio less than 1 indicate the variable is a protective factor for having ever used agrochemicals and a lower chance of experiencing the health problems.

Table 1. Odds ratio from logistic regression analysis with having ever used agrochemicals and economic characteristics of farmers in Grenada.

Variable	ODDS Ratio	Reference Group
Experienced Production Issue	Experienced production issue (OR .193, 95 CI: .159 – .234, p <.01)	Did not experience production issues
Receipt of Technical Assistance	Received technical assistance (OR .245, 95 CI: .203 – .296, p <.01)	Did not receive technical assistance
Receipt of Credit	Did not receive credit (OR .211, 95 CI: .149 – .300, p <.01)	Received credit
Farm Location	Farm located in St. John (OR .159, 95 CI .122-.208, p<.01)	Farm located in St. George
Income from Agriculture Production	Half of total income from agriculture production (OR 1.578, 95 CI: 1.305 – 1.907, p <.01)	All income from agriculture production
Land Ownership Status	Joint ownership with non-household members (OR 1.537, 95 CI: 1.088 – 2.171, p=.015)	Individual land ownership
	Joint ownership with household members (OR 1.617, 95 CI: 1.192 – 2.194, p <.01)	
Hours of Work on Farm	Full time work on farm (OR 2.378, 95 CI: 1.594 – 2.895, p <.01)	Part time work on farm
Parcels of Land Operated	>3 parcels of land operated (OR 2.854, 95 CI: 2.425 – 3.359, p <.01)	≤3 pieces of land operated
Market Presence	Sell to markets (OR 3.535, 95 CI: 3.088 – 4.047, p <.01)	Do not sell to markets
Non-household Workers On Farm in Last Week	1-2 non-household workers on the farm (OR 10.165, 95 CI: 2.27 – 45.487, p <.01)	No non-household workers on the farm
	3-4 non-household workers on the farm (OR 6.930, 95 CI: 1.524 – 31.517, p =.012)	
	≥5 non-household workers on the farm (OR 6.545, 95 CI: 1.281 – 33.451, p =.024)	
Paid Workers on Farm in Last Week	1-2 paid workers on the farm (OR 7.804, 95 CI: 2.822– 21.584, p <.01)	No paid workers
	3-4 paid workers on the farm (OR 3.998, 95 CI: 1.437 – 11.121, p =.012)	

The highest odds ratio for having ever used agrochemicals was by farmers with market presence (OR 3.535, 95 CI: 3.088 – 4.047, p<0.01), farmers who had 1-2 non-household workers on the farm (OR 10.165, 95 CI: 2.27 – 45.487, p<0.01) and farmers who paid farm workers (OR 7.804, 95 CI: 2.822– 21.584, p<0.01) on the farm in the week before the census was conducted. The odds ratio, however, varied for the number of non-household members and for the number of paid workers on the farm. The odds ratio was slightly lower, but above 3 and statistically significant, for having ever used agrochemicals by farmers with 3 or more non-household workers on the farm and by farmers that paid 3 or more farm workers as in the previous week.

The odds ratio for having ever used agrochemicals was slightly higher than 1 and statistically significant, but lower than 3, for farmers that earned half of their income from agriculture production compared to farmers that earned all income from the activity, farmers that had joint ownership of the land compared to farmers with individual ownership, farmers who worked full time in agriculture compared to farmers who worked part time and farmers with ≥ 3 parcels of land compared to farmers with ≤3 parcels

DISCUSSION

The public health challenges related to agrochemical use, identified in studies across the world, validate the importance of this first study in Grenada focusing on the relationship between agrochemical use and health risk among farmers. Agriculture is a traditional mainstay in Grenada. In recent years, tourism has replaced agriculture as the sector with the highest contribution to GDP. Nonetheless, Caribbean governments have continued to promote agriculture for livelihood and for food security. Within the Caribbean context, the health and safety of agriculture workers is, therefore, important for national development. In this study, farmers likelihood of exposure and risk of experiencing health problems is based on previous findings of low use of personal protective equipment in the Caribbean region [1,2] as well as in Grenada [13]. Studies outside of the Caribbean region also show many farmers are at risk for health problems from failing to use protective equipment when handling or applying agrochemicals [14-17].

Five constructs of the Social Cognitive Theory (SCT) are applicable to explain differences in the use of agrochemicals by farmers. The constructs are knowledge, outcome expectations, observational learning, social support, and reinforcement and punishment. The results of studies show social characteristics, such as gender [18], age [9,19,20] and education [21], have significant relationships with the level of use of agrochemicals. Although several factors can influence farming practices, economics can have significant bearing on farmers’ perspectives and health behaviors. Studies show that while agrochemicals are commonly used in agriculture production, personal safety is frequently compromised [22-25].

The results from the logistic regression analysis show four economic characteristics may be protective for farmers in Grenada with regard to experiencing health problems from the use of agrochemicals. The odds ratio <1 for ever used agrochemicals by farmers who experienced production issues, received technical assistance, did not receive credit or had lands located in the rural parish of St. John. A range of social and economic factors may explain this finding. In the absence of previous studies, however, there is no reference to confirm the magnitude of the effect of any single factor. As such, there is a need for further studies to understand, in greater detail, the relationship between local agriculture practices and the use of agrochemicals in ways that can be considered as risky or protective.

While the influence of technical assistance and credit on access to and use of agrochemicals is more obvious, it was interesting to have also found odds ratio <1 for having ever used agrochemicals by farmers who experienced production issues.

It can be expected that agrochemicals will be used more commonly by farmers who experience production problems from weed, insect, fungus and bacterial infestations. It is commendable if, indeed, farmers use safer methods to manage production issues. The results may also indicate that socio-economic issues have a greater impact on production in Grenada than agronomical issues that usually require chemical remedies. In any case, further studies should be conducted to understand how farmers deal with different production issues and, specifically, which issues warrant or hinder the use of public health-significant agrochemicals. Farmers should also be supported to use good agricultural practices, including the use of protective equipment when applying agrochemicals. A system should also be developed to monitor the use of agrochemicals and to enable an evidenced-based approach to the management of agrochemicals in Grenada.

The results show farmers who received technical assistance were less likely to use agrochemicals and, therefore, had a lower risk of experiencing health problems related to the use of agrochemicals. In a study in Trinidad, Ganpat et al. found that farmers who were visited by extension officers 1-4 times per month were more consistent with GAP than farmers who were visited 5 or more times per month [26]. The study in Trinidad is interesting, showing that high demand for technical assistance may be related to poor agriculture practice which can also include inappropriate use of agrochemicals. While odds ratio for having ever used agrochemical and number of visits by extension officers was not investigated in Grenada, the findings may indicate a general preference by technical officers to restrict the use of agrochemicals. This may warrant the need to distinguish between how much technical support is for prevention and how much support is to address problems. The need to understand the relationship between technical support, farming practices and, in particular, the use of agrochemicals in Grenada is recognized.

In Grenada's context, access to credit and location of the farm/farmer's residence may also be indicative of the likelihood of purchasing agrochemicals and other commercial resources. With just about 12% of farmers reporting they used agrochemicals in agriculture production [3], there is indication that the overwhelming majority of producers in Grenada are subsistence farmers. Small and part-time (subsistence farmers) farmers are, however, unlikely to solicit credit for production which may explain why the odds ratio was <1 for having ever used agrochemicals by farmers who did not access credit. The two largest agriculture supply shops were also located in St. George's (town) and, farmers that reside or have farms in the city area may have greater access to chemicals. St. John is the second poorest parish in Grenada and is also known as the "fishing capital of Grenada." Understandably, the farmers in St. John are, therefore, least likely to do commercial farming that may require high use of agrochemicals.

Table 1 shows employment and market presence are the most significant factors associated with the use of agrochemicals among farmers in Grenada. These factors have direct, and usually significant, effects on expenditure and income. An important indication from the results is that farmers in Grenada may perceive there is a positive relationship between the use of agrochemicals, production and profitability. Profitable affects productivity through the amount of income generated. Productivity also affects profitability through the amount of produce sold to markets. The higher odds ratio, OR 6.545-10.165, may indicate farmers with hired labor are more likely to use agrochemicals to increase yields and minimize losses and this, in turn, increases profitability to support inputs for labor. This reciprocal relationship between productivity and labor input enables higher exposure and risk of experiencing the health problems through increased use of agrochemicals which is a mediating factor. Understanding the relationship between economic factors and the use of hazardous chemicals is important to guide actors to address public health challenges. In this case, interventions for preventive health should target large farmers and commercial farmers that are also more likely to hire workers and pay for labor. Farmers with ≥ 3 parcels of land should also be targeted as there was a slightly higher odds of these farmers having ever used agrochemicals and risk of experiencing health problems.

Fresh produce market is another critical point of entry to address indiscriminate use of agrochemicals and health risk. The farmers who sold to markets were at least 3 times more likely to have used agrochemicals than farmers who did not sell to markets. Controlled markets generally require produce that are safe for consumers and may discourage the frequent use of agrochemicals. However, agrochemical use is increasing to protect crops from emerging and traditional problems. As such, the SCT construct of expected outcome may provide a plausible explanation for why farmers with market presence used agrochemicals more frequently than farmers without market presence. However, the safe use of agrochemicals can be promoted through reinforcement, concessions and other incentives from markets.

The results show a slightly higher odd for farmers who had joint ownership of land with household or non-household members to have ever used agrochemicals and, therefore, had a higher risk of experiencing health problems from exposure. Apart from the farmer, other owners of the land may also provide labor and other support or visit the farm. In doing so, household members and other residents can be exposed to the hazardous chemicals. Studies in other countries show household members were at risk for health problems from assisting on farms and poor hygienic practices by farmers [27-29]. Further research is, therefore, necessary to understand risk from agricultural practice for household and community members in Grenada. Appropriate interventions should be developed and implemented to address exposures beyond the farm environment.

CONCLUSION

In conclusion, the study produced results about the relationship between social-economic characteristics of farmers in Grenada and the frequency of use of agrochemicals at levels that can potentially cause farmers to experience sleep apnea, rheumatoid arthritis, decrease in LINE-I DNA methylation, and allergic and non-allergic wheeze. It is clear from the results that

commercial activities have direct bearing on expenditure and income had the most significant influence on farmers' decisions to use agrochemicals. This study, therefore, provided crucial information that both the Ministry of Health and Ministry of Agriculture, primarily, can use to inform campaigns to create awareness, build capacity and address public health challenges in Grenada. A limitation of this study is the absence of reporting the specific agrochemicals that were used by the farmers. While the results provide a general indication of the health problems that Grenadian farmers can experience as a consequence of the use of agrochemicals further studies are encouraged for comprehensive and in-depth information about the agrochemical use and health risk in Grenada. By using the findings from this study, an adhoc approach can be avoided and interventions can be better mainstreamed to improve stewardship in the use of agrochemicals; monitoring and control the use of agrochemicals; and address gaps in knowledge, practice, and systems to improve and maintain the health and well-being of citizens in Grenada. In addition, this study contributes to close the gap in knowledge about the potential impacts on health from the use of agrochemicals in the Caribbean region. Paraquat, glyphosate, and carbaryl were also commonly used in other Caribbean countries. By addressing the excessive use of these chemicals and the lack of use of personal protective equipment significant benefits to public health can be realized. These benefits reflect improved health outcomes and reduction in morbidity and mortality rates. Ultimately, there is benefit for the national economy as spending on health care as well as the health financing burden among the farming population is reduced.

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