Macrothink Institute™

Journal of Environment and Ecology
ISSN 2157-6092
2020, Vol. 11, No. 2

Pesticide Exposure: The Case of Open-field and Greenhouse Workers

Jovita O. Esechie

Department of Political Science, Texas Southern University, Houston, TX 77004, USA

Tel: 1-832-746-1089 E-mail: jovita.esechie@tsu.edu

Received: March 19, 2020 Accepted: July 25, 2020 Published: July 31, 2020

doi:10.5296/jee.v11i2.16721 URL: https://doi.org/10.5296/jee.v11i2.16721

Abstract

A study was conducted among greenhouse and open field pesticide workers at the Batinah Coast of Oman in 2008 - 2009 to compare their level of pesticide exposure. A total of 74 greenhouse and 79 open field pesticide workers using pesticide mixtures consisting mostly of organophosphates were interviewed. Eighteen self-reported toxicity symptoms were recorded, with 9 and 3 of them being more prevalent among the greenhouse and open field workers, respectively. Although toxicity symptoms were generally higher among the greenhouse workers, it was observed that many of them indulged in smoking and gum chewing during pesticide application and these habits may have contributed to increased exposure. Most of the workers complained of discomfort when using protective devices, therefore it is recommended that protective materials adapted to the climate and socio-economic conditions of the pesticide workers be developed, and that they be encouraged to use them through appropriate educational efforts and incentives.

Keywords: Pesticide exposure, Toxicity symptoms, Personal protection equipment, Oman

1. Introduction

Pesticide applicators are the most exposed to toxic levels of chemicals within the general population because they are often involved in mixing, spraying, repackaging and storage of pesticides. Despite this, Lu (2005) reported that much of the research done in the field of occupational health is focused on service and manufacturing industries, with very little data on agricultural hazards. The World Health Organization (WHO) and the United Nations Environmental Program (UNEP) estimate that one to five million cases of pesticide poisoning occur among agricultural workers each year (Kedia & Palis, 2008). Of all the pesticide poisonings, about 3 million cases are hospitalized and there are approximately 220,000 fatalities and about 750,000 chronic illnesses every year (Pimentel, 2005).

Farmers and farm workers continue to use pesticides because they believe, and rightly so, that the potential benefits of an application, such as increased yield or quality, outweighs the hazard and expense of pesticide application. In many developing countries, however, pesticide use is unregulated either because no pesticide laws exist or are not enforced, resulting in serious damages to the ecosystem and human health. In India, majority of pesticide applicators do not use recommended personal protection equipment (PPE) and they also do not read the instructions given in the pesticide safety manual (Tyagaraju et al., 2016). Many apply pesticides using leaky backpacks, resulting in skin and clothing being soaked with pesticides (Polidoro et al., 2008). All these practices result in pesticide related poisonings among pesticide workers which, according to Kedia and Palis (2008), are fairly well characterized, but the health effects of routine, smaller exposures are uncertain. Nausea, dizziness, vomiting, blurred vision, headaches, skin irritation, chest pain and breathlessness are some of the acute toxic symptoms associated with pesticide exposure (Ecobichon, 2000, Esechie & Ibitayo, 2011, Esechie et al., 2012) and may appear immediately or within 24 hours of exposure. On the other hand, chronic pesticide related symptoms such as cancer, depression, neurological deficits, miscarriages and birth defects have also been reported (Arcury et al., 2003; Strong et al., 2004) and may not appear until several years after exposure to a pesticide.

It is generally believed that greenhouse workers have a greater exposure risk because of the enclosed environments in which they work. Conditions in the greenhouse are designed to optimize the environment for plant growth, rather than workers' health (Illing 1997). Additionally, the warm, humid conditions and abundant food are ideal for pest build up, and hence more pesticides are used in greenhouses compared to the open field. However, published reports showing a direct comparison in exposure among pesticide workers in the greenhouse and the open field are scanty. The present study investigates the acute symptoms among greenhouse and open field pesticide workers using similar mixtures of organophosphorus pesticides in the same region, over the same time period.

2. Material and Methods

The study was conducted between December 2008 and February 2009, a period coinciding with the planting season in the Sultanate of Oman. Pesticide workers included in the study were those using mixtures of parathion, malathion, methyl malathion and mancozeb. Some also used lindane, even though it had been banned by the government of the Sultanate of Oman. A total of 75 greenhouse pesticide workers were randomly selected from the north, central and south Batinah regions of Oman, along with 85 open field pesticide workers. The volunteers were informed about the objective of our study and were assured that their responses would be treated with confidentiality, and that their names and farms where they worked would not appear in our final report. Subsequently, a set of questionnaires was designed according to the World Health Organization Field Surveys of Exposure to Pesticide Standard Protocol concerning pesticide use in agriculture (WHO, 1982). Following an approval by the Texas Southern University Committee for Protection of Human Subjects on November 24, 2008, copies of the questionnaire were administered to the workers between December 2008 and February 2009. Face to face interviews/administration of questionnaire were used because most of the workers had little or no formal education, and those who had some education were not familiar with the pesticide terminologies used in the questionnaire.

During the interview sessions, which were usually on a one to one basis, the respondents were asked to list the health symptoms they have had since the onset of pesticide application in the past month or two. Most existing studies rely on farmers' self-reported symptoms because appropriate pathological tests are expensive and relatively difficult to administer (Dasgupta et al., 2007). The questionnaire addressed the use of protective equipment; pesticide storage and disposal of empty containers; average length of stay in the field or greenhouse during application; how soon re-entry is made after pesticide application; personal hygiene during and after pesticide application; and knowledge about pesticide route of entry into the body. One respondent from the greenhouse group and 6 from the open field group were reassigned to other farm duties a month after the commencement of the study and were dropped from the study. Accordingly, a total of 74 and 79 questionnaires from greenhouse and open field workers, respectively, were properly completed.

2.1 Statistical Analysis

Data were coded and statistically analyzed with the Statistical Package for Social Sciences (SPSS). Differences between means were performed using the Chi-square test. Significance was set at two levels, $p<0.05$ (significant) and $p<0.01$ (very significant)

3. Results

The demographic characteristics of the greenhouse and open-field workers are presented in Table 1. The greenhouse workers were generally older, 73% of them being more than 30 years old, compared to 38% of the open field workers. Most of the workers were married (73% of the greenhouse workers compared to 61% of the open field workers). However, almost all the workers left their families in their home countries and were, therefore classified as unmarried and given single status by their employers. With regards to education, 58% of the greenhouse workers had more than 8 years of education, compared to 27% of the open field workers ($P<0.01$).

Table 1. Characteristics of the greenhouse and open field pesticide workers

	Characteristics	Greenhouse n(%)	Open field n(%)	p-value
Age				
	<30 years	27(36)	45(57)	<0.05
	>30 years	47(64)	34(43)	ns
Marital status				
	Married	54(73)	48(61)	ns
	Single	20(27)	31(39)	ns
Years of education				
	<8years	31(42)	58(73)	<0.005
	>8 years	43(58)	21(27)	<0.01

Regarding pesticide practices that may aggravate exposure, it was noted that some of the workers smoked (36% of the greenhouse workers vs 16% of the open field workers, $p<0.05$) or chewed gum (32% vs 13%, $p<0.025$) during pesticide application (Table 2). Only 28% of the greenhouse workers showered immediately after application compared to 57% of the

open field workers (P<0.01). A comparable percentage, (24 vs 38%, p<0.05), changed their clothes, while washing of work clothes after spraying was practiced by 39% of the greenhouse workers and 54% of the open field workers.

Table 2. Knowledge and practices of the greenhouse and open field pesticide workers

Knowledge and practices	Greenhouse n(%)	Open field n (%)	p-value
Read warning label			
Yes	17(23)	14(18)	ns
No	57(77)	65(82)	ns
Know names of banned pesticides			
Yes	13 (18)	6(8)	ns
No	61(82)	73(92)	ns
Know entry route of pesticides			
Nasal	16(22)	28(35)	ns
Dermal	14(19)	20(25)	ns
Ocular	11(17)	16(20)	ns
Oral	47(63)	56(71)	ns
Know harmfulness of pesticides			
Domestic animals	7(10)	26(33)	<0.005
Elderly	11(17)	14(18)	ns
Children	16(22)	23(29)	ns
Know usefulness of pesticide training			
Yes	21(28)	47(59)	<0.005
No	53(72)	32(41)	<0.025
Habit during spraying			
Smoke	8(11)	13(16)	ns
Chew gum	13(17)	24(30)	ns
None of the above	53(72)	42(53)	ns
Hygiene after spraying			
Shower immediately	21(28)	44(57)	<0.01
Wash equipment	26(35)	17(22)	ns
Change clothes	18(24)	29(38)	<0.05
Wash clothes	21(26)	43(54)	<0.01
Storage of partially used pesticides			
Store room	29(39)	34(43)	ns
Locked cupboard	21(28)	19(24)	ns
Bedroom	17(23)	8(10)	ns
Other rooms	7(10)	18(23)	<0.05
Disposal of empty containers			

Burn/ bury	11(15)	14(18)	ns
Store food/ water	16(22)	7(9)	ns
Garbage dump	47(63)	58(73)	ns
Types of PPE* used			
Nose mask	20(27)	8(10)	<0.025
Overall	32(43)	14(18)	<0.01
Boots	18(24)	31(39)	ns
Gloves	37(50)	16(20)	<0.005
Long pants	34(46)	46(58)	ns
Eye goggles	25(34)	7(9)	<0.005

*PPE = Personal protection equipment.

Only 23% of the greenhouse compared 18% of the open field workers read the warning labels on pesticide containers before spraying. Similarly, knowledge about the names of banned pesticides was low, being 18% and 6% among the greenhouse and open field workers, respectively. About 22% of the greenhouse workers knew that pesticide could enter the body through the nose, compared to 35% of the open field workers. Knowledge about dermal entry was also low, being 19 and 25% for the greenhouse and open field workers, respectively. Only 17% of the greenhouse had knowledge about ocular, compared to 20% of the open field workers. The corresponding figures for oral entry were relatively high, being 63 and 71%, respectively.

In order to reduce exposure, the appropriate place to store partially used pesticides is the store room. Less than half of the workers (28% of the greenhouse vs 43% of the open field) stored partially used pesticides in store rooms. Alternate store areas were bedroom (33 vs 10%) and other rooms (39% vs 47%). Disposal of empty containers was by burning or burying (15 vs 18%) and in garbage dump (63 vs 73%). Some workers (22 vs 9%) used the empty containers to store food or water.

Neither the greenhouse nor the open field workers had a good knowledge about the harmfulness of pesticides to domestic animals, elderly and children. Although, the rather poor knowledge about pesticide harmfulness may be alleviated by some form of pesticide training, only a small number of the greenhouse workers (28%) were aware of the usefulness of training compared to 59% of the open field workers ($p<-0.005$).

The use of personal protective equipment (PPE) by the greenhouse and open field workers was also described. Overall was the most commonly used PPE (84% of the greenhouse workers and 49% of the open field workers, $p<0.025$). Only 46% of the greenhouse workers and 20% of the open field workers ($p<0.01$) availed themselves of the use of nose masks during pesticide application. Other PPE's used were boots (24 vs 39%); gloves (22 vs 49%, $p< 0.005$); long pants (46 vs 58%); and eye goggles (66 vs 16%, $p<0.005$).

Record of pesticide spraying frequency shows that most of the greenhouse workers (65%) sprayed pesticides only twice a week, compared to the open field workers (20%; $p<0.05$) (Table 3). On the other hand, most of the open field workers (71%) sprayed more than twice,

compared to the greenhouse workers (17%; p< 0.05). Only a small percentage of workers (3-14%) sprayed once or less than once a week.

Table 3. Pesticide exposure history of the greenhouse and open field pesticide workers

Exposure	Greenhouse n(%)	Open field n(%)	p-value
Spraying frequency (weekly)			
<once	5(7)	2(3)	ns
Once	10(14)	5(9)	ns
Twice	48(65)	16(20)	<0.005
>twice	11(17)	56(71)	<0.005
Average time spent daily (hr)			
1-2	1(1)	3(4)	ns
3-4	4(5)	2(3)	ns
5-6	6(8)	11(14)	ns
6-8	51(69)	21(27)	<0.005
>8	12(16)	42(53)	<0.005
Re-entry (hr)			
>10	4(6)	5(6)	ns
8-10	7(9)	4(5)	ns
5-7	13(18)	14(18)	ns
2-4	19(26)	11(14)	ns
<2	31(42)	45(57)	ns
Distance from home to farm (km)			
>10	1(1)	2(3)	ns
8-10	4(5)	2(3)	ns
5-7	2(3)	4(5)	ns
2-4	4(5)	23(29)	<0.005
<2	63(85)	48(60)	ns
Years of pesticide work			
>10	40(54)	22(28)	<0.025
8-10	24(32)	11(14)	<0.05
5-7	6(8)	27(34)	<0.005
2-4	2(3)	18(23)	<0.005
<1	2(3)	1(1)	ns

A majority of the greenhouse workers (69%) spent 6-8 hr daily on their job, compared to 27% of the open field workers. More of the open field workers ((53%) tended to stay longer (more than 8 hr) on the field, compared to the greenhouse workers (16%, p < 0.005). Only 3-14% of the workers spent less than 6 hr in the field or greenhouse. Re-entry period after pesticide

application varied between 2 to 10 hr+. Majority of the workers (66% of the greenhouse and 63% of the open field) re-entered the sprayed areas 2-4 hr after spraying, while a small percentage (11% of the greenhouse and 9% of the open field) re-entered 8 hr or longer after spraying.

Generally, most of the pesticide workers lived less than 2 km from their farms (85% of the greenhouse and 60% of the open field). The remaining workers lived 2- 4 km from the farm (5% of the greenhouse and 29% of the open field, $p<0.005$) or more than 8 km from their farms (5% of the greenhouse and 4% of the open field).

A record of years of pesticide work shows that 54% of the greenhouse workers compared to 28% of the open field workers had more than 10 years of spraying experience ($p<0.025$). Other lengths of working experience were: 8-10 years (32% of greenhouse vs 14% of open field, $p< 0.05$); 5-7 years (8% of greenhouse vs 34% of open field, $p<0.005$); and 2-4 years (3% of greenhouse vs 23% of open field, $p<0.005$).

A total of 18 pesticide related toxic symptoms were reported by the workers (Table 4). Among the greenhouse workers, skin rash was the most common (69%), followed by dizziness (62%). Other symptoms were shortness of breath (58%); itching (53%); nausea/ vomiting (50%), burning eyes (46%); headache (40%); cough (36%); and blurred vision (35%). Among the open field workers, unusual tiredness was the most prevalent (62%, $p<0.01$). Increased salivation was reported by 53% of the workers ($p<0.01$), while 27% of the workers had runny nose ($p<0.01$). Generally, toxic symptoms were generally higher among the greenhouse workers than the open field workers, including dizziness ($p<0.05$); bloating ($p<0.05$); cough ($p<0.01$); shortness of breath ($p<0.05$); blurred vision ($p<0.01$); itching ($p<0.01$); and skin rash ($p<0.05$).

Table 4. Self-reported symptoms among greenhouse and open field pesticide workers

Symptoms	Greenhouse n(%)	Open field n(%)	p-value
Dizziness	46(62)	29 (37)	0
Headache	31(42)	24(30)	0.13
Unusual tiredness	23(31)	49(62)	0
Nausea/vomiting	37(50)	18(23)	0
Stomach cramp	11(15)	14(18)	0.63
Diarrhea	26(35)	21(27)	0.25
Bloating	24(32)	10(13)	0
Increased salivation	17(23)	42(53)	0
Constipation	13(18)	18(23)	0.42
Cough	27(36)	11(14)	0
Shortness of breath	43(58)	25(32)	0
Runny nose	8(11)	21(27)	0.01
Sore throat	15(20)	18(23)	0.71
Blurred vision	26(35)	9(11)	0
Itching	39(53)	14(18)	0

Burning eyes	34(46)	12(15)	0
Skin rash	51(69)	29(37)	0
Numbness	9(12)	13(16)	0.45

4. Discussion

From the study, it was noted that the greenhouse workers were older, more educated and had longer pesticide spraying experience than the open field workers. Based on these attributes, the greenhouse workers were expected to have a better risk perception than the open field workers and adopt pesticide practices that would lead to reduced exposures. On the contrary, more greenhouse workers indulged in smoking and chewing gum during application than the open field workers. Previous reports have shown that smoking during pesticide application could increase the absorption pesticides through inhalation of both airborne particles attached to the cigarette, resulting in respiratory symptoms (Nordin et al., 2002). Smoking and chewing of gum during spraying may deter the use of face mask. Oral exposure can also occur when hands are not properly washed before eating or smoking (Damalas & Koutroubas, 2016). A poor knowledge by our subjects about the mode of entry of pesticides into the body may have contributed to their poor hygiene practices, leading to increased exposure. According to Negatu et al. (2018), adverse health effects related to pesticide exposure are more common in less developed countries because of low hazard awareness of users. In our study, although a majority of the workers knew that pesticide could enter the body orally, knowledge about dermal, nasal (inhalation) and ocular entries was low. This is unfortunate, since most of the workers were involved in mixing, loading and spraying, with little or no protective devices and skin contamination was inevitable. A study of Greek tobacco-growing farmers suggested that dermal exposure was the major route of exposure (58%) during occupational pesticide uses (Damalas et al., 2006) and not through the respiratory system as commonly believed. There is a need for this misconception to be corrected through educational programs on the safe use of pesticides, even though 72% of the greenhouse and 41% of the open field workers in our study did not believe that they would benefit from training.

Pesticide workers need to have a good knowledge of the potential risk of prolonged bodily contact with pesticides through delay in changing work clothes (Kishi et al., 1997). Some of our respondents did not change their clothes nor shower soon after spraying. These habits obviously increased the duration of possible absorption of pesticides from the skin. Indonesian farmers wearing clothes contaminated with pesticides reported a greater number of symptoms compared to those wearing uncontaminated clothes (Kishi et al., 1995). In our study, while some workers attributed their poor hygiene habits to fatigue resulting from the long walking hours, others, especially the greenhouse workers, claimed that, because of their long pesticide experience they knew how to carefully handle pesticides and have minimized or completely avoided body contact with pesticides during application. However, according to Mekonnen and Agonafir (2002), while carefulness may be useful for reducing exposure, the use of personal protective equipment (PPE) is more efficient. Some pesticide workers even believe that, over a long period of time their bodies could develop resistance against

pesticides (Yassin et al., 2002).

Majority of the workers, notably the greenhouse workers, wore overall and eye goggles when spraying pesticides, but other PPE's such as gloves, nose/face masks were sparingly used. Many were aware of the benefits of using protective devices but their excuses for not using them were discomfort and unavailability of suitable gears, although carelessness/indifference may also be factors. The low PPE usage by pesticide workers in the developing countries have been addressed by several researchers (Andrade-Rivas & Rother, 2015; Kishi et al., 1995; Lu, 2007; Esechie & Ibitayo; 2011; Esechie, 2018). In South Africa, Andrade-Rivas & Rother (2015) observed that PPE compliance was influenced by external factors such as weather conditions (extreme heat) and working environment. In Indonesia, Kishi et al. (1995) reported that full protective equipment was too hot for the pesticide workers, and have therefore accepted becoming ill as part of their job. In Oman, Esechie et al. (2012) reported that, among workers involved in loading and mixing of pesticides, only a paltry 9% of them wore gloves, while nose mask and eye goggles were worn by 3% and 5% of them, respectively. In Brazil, Delgado and Paumgartten (2004) observed that boots were the only protective equipment worn by a majority of pesticide workers. In Sri Lanka, most of the farmers were aware of the protective measures to be used when applying pesticides but none of them used the suggested protective gadgets such as face mask, goggles, head cover, rubber gloves, full sleeves shirts and boots (Sivayoganathan et al., 1995). This is consistent with the study done in Lebanon where it was reported that there was a high level of knowledge of pesticide use but the use of protective measures was poor (Salameh et al., 2004). In view of the efficacy of PPE in reducing pesticide exposure, there is an urgent need for the development of appropriate protective equipment for pesticide work in the developing countries which are mostly in the warm climatic zones, and encourage pesticide workers to use these gears through appropriate educational efforts and incentives.

The exposure of farm workers and even of the general population to pesticide contamination may be due to accidental poisoning. The elements of accidental poisoning investigated in this study included the improper use and disposal of empty containers, and improper storage of partly used pesticides. Majority of the pesticide workers disposed of empty pesticide containers in environmentally unsafe manner. Such disposal methods included burning/ burying, and throwing them into garbage dumps. Some used the empty containers to store food and water. These observations are similar to the findings of past research (Ibitayo, 2006). According to Zyoud et al. (2010), pesticide suppliers often recommend these practices, but they are potentially hazardous to human health and the environment and should be discouraged. Safe burning requires a good understanding of pesticide chemistry, while a good knowledge of local hydrology is essential for safe burial. It is highly unlikely that such knowledge exists among the subjects in our study. In order to discourage the recycling of empty containers and their use to store food and water, Huici et al. (2017) reported training sessions in Bolivia focused on the proper management of empty pesticide containers, with triple rinsing and puncturing of the containers to prevent reuse.

Regarding storage of partly-used pesticides, over 50% of the greenhouse workers and open field workers reported storing partly-used pesticides in their bedrooms or in other rooms in the house. In a recent study, Adje and Aremu (2020) reported that some households still

stored pesticides in the bedroom and kitchen. The improper use or disposal of empty pesticide containers and improper storage of partly-used pesticides increases the pesticide contamination not just for the farmers and farm workers but also their families and the general public. Such practices are considered the main problems associated with pesticide use and its management in developing countries (Yassin et al., 2002)

Pesticide exposure is closely related to the frequency of spraying, the average time spent in the field daily and the length of re-entry time to sprayed plots or greenhouses. In the current study, majority of the open field workers sprayed pesticides more than two times a week, increasing the probability of pesticide exposure among this group, especially since the use of protective devices was not popular habit. Other practices contributing to exposure were long working hours and shorter re-entry periods. Przyhylska (2004) reported a poisoning outbreak in Poland after pesticide applicators re-entered contaminated area before the required safety period had elapsed. Faria et al. (2004) also found a relationship between pesticide poisoning and re-entry into a recently sprayed area. Esechie and Ibitayo (2011) noted that re-entry interval was negatively correlated with burning sensation on face/eyes, weakness and cough among greenhouse pesticide workers. Earlier report by Giles et al. (1995) has shown that the concentration of airborne pesticide decreased by 60% in the first hour after application and by 95% during 12 h after application.

A total of 18 toxic symptoms were reported in the current investigation by the pesticide workers. The following nine symptoms were statistically more prevalent among the greenhouse workers: dizziness; nausea; bloating; cough; shortness of breath; blurred vision; itching; burning eye; and skin rash. Significantly higher incidents of unusual tiredness, increased salivation and runny nose were found among the open field workers. Thus, there were more pesticide related toxic symptoms among the greenhouse workers than the open field workers. In Gaza Strip, Yassin et al. (2002) also reported that the prevalence of self-reported toxic symptoms was higher among green house workers than open field workers. Indirect exposure of the greenhouse worker as he walks up and down the confined rows of the greenhouse and comes in contact with plants that have been treated with pesticides may partially explain the higher rate of toxic symptoms experienced by the these workers. Additionally, the habits of smoking and gum chewing by this group of workers during pesticide application may have also contributed to exposure. Despite their indifference to pesticide training, it is strongly recommended that training be made mandatory for all pesticide workers.

5. Conclusion

Pesticide workers are routinely exposed to pesticides during their spraying sessions and these exposures give rise to toxicity symptoms. The level of exposure can be significantly reduced by the use of protective devices and the adoption of good hygiene practices during and after pesticide application. The need for pesticide training for the workers is strongly recommended. Many of the workers complained of discomfort when using protective devices, therefore it is recommended that protective materials adapted to the climate and socio-economic conditions of farmers be developed, and that farmers be encouraged to use these protective materials through appropriate educational efforts and incentives. Farmers in developing countries will continue to use pesticides in increasing quantities because of lack

of alternatives, therefore there is an urgent need to restrict the importation and use of highly toxic pesticides in order to decrease intoxication. Many developing countries, including the Sultanate of Oman, have passed legislation to control pesticide importation, but enforcement is often inadequate or nonexistent.

Ethical Approval

The study was approved by the Texas Southern University Committee for the Human Subjects on November 24, 2008.

Acknowledgements

This study was supported through a fellowship to the author by the National Aeronautics and Space Administration Center for Bio-nanotechnology and Environmental Research (NASA-CBER). The author is grateful to NASA-CBER for the support. The author also acknowledges the assistance of Issa Al-Maamari, Ahmed Al-Moqbali, Ahmed Al-Saadi and Ismail Al-Rashdi for the administering the questionnaires.

References

Adje, U. D., & Aremu, T. O. (2020). Evaluating safety practices associated with use of household pesticides: an interventional study in Kurmin Mashi Rural Community, Kaduna. *Nigeria Journal of Applied Sciences and Environmental Management, 24*, 279-285. https://doi.org/10.4314/jasem.v24i2.14

Andrade-Rivas, F., & Rother, H. A. (2015). Chemical exposure reduction: Factors impacting on South African herbicide sprayers' personal protective equipment compliance and high risk work practices. *Environ Res, 142*, 34-45. https://doi.org/10.1016/j.envres.2015.05.028

Arcury, T. A., Quandt, S. A, & Mellen, B. G. (2003). An exploratory analysis of occupational skin disease among Latino migrant and seasonal farmworkers in North Carolina. *J Agric Saf Health, 9*, 221-232. https://doi.org/10.13031/2013.13687

Damalas, C. A., Georgiou, E. B., & Theodorou, M. G. (2006). Pesticide use and safety practices among Greek tobacco farmers: A survey. *Int. J. Environ. Health Res, 16*, 339-348. https://doi.org/10.1080/09603120600869190

Damalas, C. A., & Koutroubas, S. D. (2016). Farmers' exposure to pesticide: Toxicity types and ways of prevention. *Toxics, 4*(1), 1. https://doi.org/10.3390/toxics4010001

Dasgupta, S., Miesner, C., Wheller, D., Xuyen, K., & Lam, N. T. (2007). Pesticide poisoning of farm workers-implications of blood test results from Vietnam. *Int J Hyg Environ Health, 210*, 121-132. https://doi.org/10.1016/j.ijheh.2006.08.006

Delgado, L. E., & Paumgartten, E. J. (2004). Pesticide use and poisoning among farmers from the county of Paty do Alferes, Rio de Janeiro. Brazil. *Cad Saude Publica, 20*, 180-186. https://doi.org/10.1590/S0102-311X2004000100034

Ecobichon, D. J. (2000). Our changing perspectives on benefits and risks of pesticides: a historical review. *Neurotoxicology, 2*, 211-218.

Esechie, J. O., & Ibitayo, O. (2011). Pesticide use and related health problems among greenhouse workers in Batinah Coastal Region of Oman. *J Forensic Leg Med., 18*, 198-203. https://doi.org/10.1016/j.jflm.2011.02.009

Esechie, J. O., Ibitayo, O., Onwudiwe, I. D., & Obinyan, E. O. (2012). Toxicity symptoms

among migrant agropesticide workers in Oman. *J Environ Sci Eng., B1*, 656-662.

Esechie, J. O. (2018). Farm workers' knowledge, habits and health issues associated with pesticide use. *J Environ Ecol., 9*, 15-26. https://doi.org/10.5296/jee.v9i1.11094

Faria, N. M., Facchini, L. A., Eassa, A. G., & Tomasi, E. (2004). Rural work and pesticide poisoning. *Cad Saude Publica, 20*, 298-308. https://doi.org/10.1590/S0102-311X2004000500024

Giles, D. K., Welsh, A., Steinke, W. E., & Saiz, S. G. (1995). Pesticide inhalation exposure, air concentration, and droplet size spectra from greenhouse fogging. *T ASAE, 38*, 1321-1326. https://doi.org/10.13031/2013.27954

Huici, O., Skovgaard, M., Jørs, G. E., & Jensen, O. C. (2017). Management of Empty Pesticide Containers—A Study of Practices in Santa Cruz, Bolivia. *Environmental Health Insights, 11*. https://doi.org/10.1177/1178630217716917

Ibitayo, O. O. (2006). Egyptian rural farmers' attitudes and behaviors regarding agricultural pesticides: Implications for pesticides risk communication. *Risk Anal., 26*, 989-895. https://doi.org/10.1111/j.1539-6924.2006.00794.x

Illing, H. P. A. (1997). Is working in the greenhouse healthy? Evidence concerning the toxic risks that might affect greenhouse workers. *Occup Med., 47*, 281-293. https://doi.org/10.1093/occmed/47.5.281

Kedia, S. K., & Palis, F. G. (2008). Health Effects of Pesticide Exposure among Filipino Rice Farmers. *The Applied Anthropologist, 28*, 40-59.

Kishi, M., Hirschhorn, N., Djajadisastra, M., Satterlee, L. N., Strowman, S., & Dilts, R. (1995). Relationship of pesticide spraying to signs and symptoms in Indonesian farmers. *Scand J Work Environ Health, 21*, 124-33. https://doi.org/10.5271/sjweh.19

Lu, J. L. (2005). Risk factors to pesticide exposure and associated health symptoms among cut-flower farmers. *Int J Environ Health Res., 15*, 161-169. https://doi.org/10.1080/09603120500105638

Mekonnen, Y., & Agonifir, T. (2002). Pesticide sprayers' knowledge, attitude and practice of pesticide use on agricultural farms in Ethiopia. *Occup Med., 52*, 311-15.

Negatu, B., Vermeulen, R., Mekonnen, Y., & Kromhout, H. (2018). Neurobehavioral, symptoms and acute pesticide poisoning: a cross-sectional study among male pesticide applicators selected from three commercial farming systems in Ethiopia. *Occup Environ Med, London, 75*, 283. https://doi.org/10.1136/oemed-2017-104538

Nordin, R. B., Araki, S., Sato, H., Yokohama, K., Wan-Muda, W. A. M., & Win-Kyi, D. (2002). Effects of safety behaviors with pesticide use on occurrence of acute symptoms in male and female tobacco-growing Malaysian farmers. *Ind Hlth., 40*, 182-90. https://doi.org/10.2486/indhealth.40.182

Polidoro, B. A., Dahlquist, R. M., Castillo, L. E., Morra, M. J., Somarriba, E., & Bosque-Pérez, N. A. (2008). Pesticide application practices, pest knowledge, and cost-benefits of plantain production in the Bribri-Cabécar Indigenous Territories, Costa Rica. *Environmental Research, 108*, 98-106. https://doi.org/10.1016/j.envres.2008.04.003

Pimentel, D. (2005). *Environment, Development and Sustainability, 7*, 229-252.

Przyhylska, A. (2004). Poisoning caused by chemicals for plant protection in Poland in 2002. *Prscgl Epidemiologica, 58*, 11-121.

Salameh, P. R., Baldi, I., Brochard, P., & Abi Saleh, B. (2004). Pesticides in Lebanon: a knowledge, attitude and practice study. *Environ Res., 94*, 1-6. https://doi.org/10.1016/S0013-9351(03)00092-6

Shin, D. C., Kim, H. J., Jung, S. H., Park, C. Y., Lee, S. Y., & Kim, C. B. (1998). Pesticide poisoning and its related factors among Korean farmers. *Med Lav., 89(*Suppl. 2), S129-135.

Sivayoganathan, C., Gnanachandran, S., Lewis, J., & Fernando, M. (1995). Protective measure use and symptoms among agropesticide applicators in Sri Lanka. *Soc Sci Med., 40*, 431-436. https://doi.org/10.1016/0277-9536(94)00143-H

Strong, L. L., Thompson, B., Coronado, G. D., Griffith, W. C., Vigore,n E. M., & Islas, I. (2004). Health symptoms and exposure to organophosphate pesticides in farmworkers. *Am J Ind Med., 46*, 599-606. https://doi.org/10.1002/ajim.20095

Tyagaraju, M. R., Gannur, D. G., Nuchhi, U. C., & Bhuyyarm, C. B. (2016). Prevention of accidental pesticide poisoning. *International Journal of Current Research, 18*(03), 28585-28586.

WHO. (1982) Field Surveys of Exposure to Pesticides, Standard Protocol. VBC/82.1, WHO, Geneva.

Yassin, S. H., Mourad, T. A. A., & Safi, J. M. (2002). Knowledge, attitudes, practice and toxicity syymptons associated with pesticide use among farm workers in the Gaza Strip. *Occup Environ Med., 59*, 387-394. https://doi.org/10.1136/oem.59.6.387

Zyoud, S. H., Sawalha, A. F., Sweileh, W. M., Awang, R., Al-Khalil, S. I., Al-Jabi, S. W., & Bsharat, N. M. (2010). Knowledge and practices of pesticide use among farm workers in West Bank, Palestine: safety implications. *Environ. Hlth Prev Med., 15*, 252-261. https://doi.org/10.1007/s12199-010-0136-3

Copyrights