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Occupational Risk Factors for Acute Pesticide Poisoning among Farmers in Asia

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Abstract

Types of pesticides are used in farming to increase the productivity and protection of crops or to control pests. However, exposure to acute pesticide poisoning is one of the most important occupational risk factors among farmers all over the world. They are directly exposed to high levels of pesticide poisoning when involved in the handling, spraying, mixing, or preparing of it. The low educational level, lack of information, training, judgment or experience, and the inability to read on pesticide safety are playing an important role for farmers' acute poisoning. On the other side, poor technology, inadequate personal protection, inappropriate type of clothing and equipment also leads to farmers' acute poisoning. Hence, this paper focuses on occupational risk factors for acute pesticide poisoning among farmers and their occupational safety. Discovering risk factors is also crucial for investigating health problems of farmers and its inevitable effects on their body. As it is seen from previous studies instead of field research such as deep interview on farmers' acute poisoning, data were mostly collected from hospitals. This study tries to emphasize the importance of field study to discover the risk factors for acute pesticide poisoning among farmers and their occupational safety in Asia.

Keywords: occupational risk factors, farmers, acute pesticide poisoning, occupational safety

1. Introduction

According to the World Health Organization, pesticides are chemical compounds that are used to kill pests, insects, rodents, fungi, and unwanted weeds. By their nature, pesticides are potentially toxic to humans which can also cause harm to human health [1]. The incorrect and unsafe use of pesticides can be a threat to human health [2]. They are mostly used for crop

protection and to increase productivity in agriculture. Due to its widespread use in agriculture, occupational pesticide poisoning is likely to become a major health problem among agricultural workers all over the world. Since they directly contact with pesticides through spraying, mixing, handling, and preparing, farmers are at risk of exposure to pesticides. Hence, exposure to pesticides poisoning is an important occupational risk among farmers [3–5].

Farmers' low education level, lack of information and training on pesticide safety, poor spraying technology, and inadequate personal protection during pesticide use are the main reasons of poisoning [6]. These unsafe and misuses of pesticides can result in serious short-term or long-term health problems [7, 8]. Some of the symptoms of poisoning could affect the skin, nervous system, eyes, respiratory system, cardiovascular system, and gastrointestinal tract [9–11].

Discovering risk factors for acute pesticide poisoning of farmers is a very important issue for occupational safety. It will lead to decrease the number of poisoning cases. However, there have been very few researches that studied the risk factors for acute pesticide poisoning of farmers in agriculture. This chapter describes what the general risk factors of acute pesticide poisoning for farmers in Asia and the importance of their occupational safety are. Below, we present a description of pesticides and their mechanisms of actions.

2. What are pesticides?

Food and Agriculture Organization of the United Nations (FAO) defines that pesticide means any substance or mixture of substances intended for preventing, destroying, or controlling any pest. It also destroys vectors of human or animal disease; unwanted plants or animals causing harm during or otherwise interfering with the production, processing, storage, transport or marketing of food; agricultural commodities; wood and wood products or animal feedstuffs; or substances which may be administered to animals for the control of insects, arachnids, or other pests in or on their bodies. The term also comprises substances anticipated for use as a plant growth regulator, defoliant, desiccant or agent for thinning fruit or inhibiting the premature fall of fruit, and substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport [12].

First of all, pesticides are designed to kill, prevent, destroy, repel, or mitigate living organisms such as pests (insects, mites, nematodes, weeds, and rats) [13], including insecticide, herbicide, fungicide, and various other substances used to control pests [14]. Pesticides are also used for crop protection, preservation of food and materials, and prevention of vector-borne diseases [15] like malaria, dengue, yellow fever dengue, leishmaniasis, and Japanese encephalitis [15, 16]. Briefly, it should be noted that:

- Insecticides (for killing insects) such as organochlorines, organophosphates, and carbamates. This category also includes insect repellents such as diethyltoluamide (DEET) and citronella.
- Herbicides or weed killers include substances such as paraquat, glyphosate, and propanil.

WHO class	LD50 for the rat (mg/kg body weight)	
	Oral	Dermal
Ia. Extremely hazardous	<5	<50
Ib. Highly hazardous	5–50	50–200
II. Moderately hazardous	50–2000	200–2000
III. Slightly hazardous	Over 2000	Over 2000
U. Unlikely to present acute hazard	5000 or higher	

Table 1. Classification of pesticides [18].

- Fungicides (to kill mold or fungi): when applied to wood, they are called wood preservatives.
- Rodenticides to kill mice, rats, moles, and other rodents.
- Fumigants, which kill most organisms.
- Other products such as algacides (to kill algae), miticides (to kill moths), and acaricides (to kill ticks) [17].

Secondly, pesticides are also responsible for thousands of acute pesticide poisoning and human injuries. Many people in developed and developing countries are affected by the negative effects of pesticides. This is mostly due to several reasons such as the lack of proper regulations, low education levels, little experience, and easy availability in markets [16].

The WHO issued classification of pesticides by hazard as seen in **Table 1**. The classification distinguishes between the more and the less hazardous forms of each pesticide in that it is based on the toxicity of the technical compound and on its formulations. Its classification ranges from extremely hazardous (class Ia) to slightly hazardous (class III) to unlikely to present acute hazard (class U) [18].

3. Acute pesticide poisoning

Acute pesticide poisoning has become a main health problem especially in developing countries with more than 300,000 deaths in a year. This is due to the poorer regulation, lack of surveillance systems, lack of experience or judgment, less enforcement, the inability to read, lack of training, and inadequate access to information systems [19]. Besides, the easy availability of highly toxic pesticides in farmers' homes has made pesticides the preferred means of suicide [20, 21].

It is not hard to diagnose symptoms of acute pesticide poisoning in humans due to their diversity and resemblance to other conditions. These symptoms could be classified as [9–11]:

- Skin: skin discomfort, rashes, blistering, burns, sweating, contact dermatitis, jaundice

- Nervous system: poor concentration, feelings of weakness, headache, dizziness, mood disturbances, depression, stupor, muscle twitching, seizures, paralysis, loss of consciousness, coma, excessive sweating, impaired vision, tremors, panic attacks, cramps
- Eyes: tearing, irritation, conjunctivitis
- Respiratory system: sore throat, runny nose, cough, pulmonary edema, difficulty breathing, respiratory failure
- Cardiovascular system: cardiac arrhythmias
- Gastrointestinal tract: nausea, vomiting, diarrhea, abdominal pain

Sometimes, symptoms of acute pesticide poisoning in humans do not become apparent for a long time. Age, body weight, sex, and metabolism all impact the health hazards at different levels. Due to its late effects, they can cause chronic illnesses. Besides general population, both male and female farm workers and children are at high risk to acute pesticide poisoning due to consumer goods or pesticide drift from farm fields. Mostly, women are the major workforce on plantations. They are exposed to pesticides due to mixing, handling, and spraying pesticides in the farm. It is well known that the harmful effects of toxins affect women workforce more than men due to their physiological makeup. According to a study carried on women sprayers, effects of pesticide exposure among them were fatigue, back pain, giddiness, difficulty in breathing, skin problems, nausea, eye irritation, headache, tight feeling in the chest, and swelling. They also stated that some side effects such as bleeding nose occurred initially upon spraying pesticides [22].

According to another study in Pakistan, it was reported upon the use of pesticides in cotton fields; all female workers suffered from headache, nausea, and vomiting [23]. While a study in Bangladesh reported the chronic illnesses on farm workers, about 85% of farm workers reported suffering gastrointestinal disorders during and after spraying, whereas 61, 63, and 47 of them reported, respectively, skin discomfort, eye problems, and feeling of weakness [24].

Moreover, children tend to be involved in more intense contact with their environment than adults. Therefore, they unintentionally ingest pesticides and are poisoned more often than grown-ups [25]. This incident generally occurs because of the unsafe storage and the different behaviors of young children who tend to put everything in their mouths and no ability to read labels and respond appropriately [26].

There have been several researches conducted in developing countries on acute pesticide poisoning. One of them is a study by Hoek and Konradson in a rural area of Sri Lanka [27]. This study was conducted in two rural hospitals in Sri Lanka where 239 acute pesticide poisoning cases were examined. It reported that the large majority (84%) of incidents were intentional self-poisoning, with a case fatality rate of 18% due to endosulfan and paraquat. Ten of the non-intentional poisoning cases were due to exposure to the poison while spraying pesticides in the fields. Whereas 13% of the patients (31 out of the 239) reported a previous admission for pesticide poisoning, 20% reported a previous suicide attempt.

4. Risk factors for acute pesticide poisoning among farmers in Asia

Pesticides play an important role in farming to increase the productivity of agriculture. However, globally acute pesticide poisoning is a major problem for those who are directly involved in the handling of pesticides, particularly farm workers in many developing countries. They routinely are exposed to high levels of pesticides. Farmers' exposure to acute pesticide poisoning occurs during the preparation of the pesticide spray. There are other ways that farmers are exposed to pesticide poisoning. One of them is during cleaning up of pesticide spraying equipment. Farmers who mix, load, and spray pesticides can be exposed to these toxins due to spills and splashes. Farmers can also be exposed to neighboring fields or by direct contact with pesticide residues on the crop or soil [28]. However, the unsafe, unconscious, indiscriminate, and extensive use of pesticides represents health problems [21]. There are many reasons of agricultural workers' exposure to acute pesticide poisoning. One of them is unsafe use or misuse of pesticides by farmers. Others are poor knowledge of storage, handling, and disposal [29]. Mostly hand pump is used as a spraying equipment by farmers. They complain of poor maintenance and leaks in the sprays. However, despite the fact that protective equipment, gear, and appropriate clothing were provided, farm workers did not use protective gear, as it was uncomfortable in the hot and humid conditions. Farm sprayers did not practice common hygiene such as washing their hands or their clothes after spraying [6, 22, 30].

According to a study, approximately 75% of pesticide usage in the United States occurs in agriculture. As such, agricultural workers are at greater risk of pesticide exposure than nonagricultural workers. The findings proved that acute pesticide poisoning in the agricultural industry would continue to be a crucial issue. Of the 3271 cases included in the analysis, 2334 (71%) were employed as farmworkers. The remaining cases were employed as processing/packing plant workers (12%), farmers (3%), and other miscellaneous agricultural workers (19%) [31].

Risk factors for acute pesticide poisoning among agricultural workers are also an important issue. A study explored work-related risk factors of acute occupational pesticide poisoning among male farmers in South Korea in 2011. In this study, a total of 1958 male farmers were interviewed. It suggested that the risk of acute occupational pesticide poisoning increased with lifetime days of pesticide application (OR, 1.74; 95% CI, 1.32–2.29). Reasons were not wearing personal protective equipment such as gloves (OR, 1.29) or masks (OR, 1.39), not following pesticide label instructions (OR, 1.61), applying the pesticide in full sun (OR, 1.48), and applying the pesticide upwind (OR, 1.54) which greatly increased risk of pesticide poisoning [32].

According to a research conducted in China, pesticide poisoning is an important health problem among Chinese farm workers. One thousand farmers were chosen from two villages. Farmers who reported risky behaviors such as not having personal protective equipment, having had a leaky knapsack, not avoiding physical contact with liquid pesticides, or continuing to apply pesticides when feeling ill had greatly higher risk of acute pesticide poisoning than farmers who did not report these behaviors (all $p \leq 0.01$) [33]. Data collection from 482 rice farmers in Thailand about risk factors for acute pesticide poisoning gave almost same results.

Pesticide exposure mostly caused from the misuse of pesticides including erroneous beliefs of farmers about pesticide toxicity, the use of faulty spraying equipment or lack of proper maintenance of spraying equipment, and protective gear and appropriate clothing during handling of pesticides [34].

5. Interventions for reducing risk factors for farmers' exposure to acute pesticide poisoning

Farmers are the major users of pesticides in agriculture. For this reason, they are more vulnerable to acute pesticide poisoning. There are many ways to reduce the farmers' exposure to acute pesticide poisoning. First of all, farmers must be aware of pesticide risks and its effect on health. The duty of national and international organizations, governments and pesticide industry is to disseminate educational materials of all types to pesticide users, farmers, farmer organizations, agricultural workers, unions, and other interested parties. Thus, pesticide users should learn educational materials before applying pesticides and should follow procedures [12]. Special educational programs can be set up by governments for farm workers prior to pesticide application. This procedure will provide knowledge on risks of pesticide poisoning use and also will decrease the pesticide exposure of farmers [35]. On the other side, protective and appropriate type of clothing and equipment must be used by farmers to prevent exposure to pesticides in all stages of pesticide spraying, mixing, and handling [28]. The United Nations Systems encourage international treaties to restrict export and sale of the most toxic pesticides. Many countries have signed them, but practically they are not implementing these agreements [16]. For this, all governments should develop a legal framework for the control of pesticides [36]. Lack of education, insufficient management, and inappropriate legal framework are the proximal causes of acute pesticide poisoning. Studies which were mentioned below illustrate the situation.

A study that was designed to assess participants' knowledge on the safety use of pesticides involved 300 farm workers working in India. As shown in **Table 2**, good knowledge on the safety use of pesticides was greatly influenced by the education level of farm workers. It is also seen that farmers lacked seriousness to practice safety measures despite their sufficient knowledge on the safety use of pesticides [35].

In the same study, there was a significant correlation (r , 0.525; $p < 0.001$) between the knowledge score and the practice score on protective measures.

Table 3 shows that 71.3% of the participants were reported wearing protective clothes and special gloves; 86% were reported wearing of special face mask; 46.1% of farmers were reported wearing face mask while working in the farm; 81.3% of them were reported not eating, drinking, and smoking during spraying; 66.7% of them were reported reading label instructions, 84.7% of the them were mentioned that they used leftover pesticide solutions on the same day, and 55.0% of the participants were reported knowing not to keep the leftover pesticide in a drinking container for later use while only 35% are following. Almost all (100%) participants stated that they wash hands after pesticide application [35].

	Education	N	Mean	Std. deviation	F-value	p-value
Knowledge on the safety use of pesticides	Up to primary	98	78.316	12.3771	6.328**	0.002
	Up to secondary	126	79.934	8.6792		
	10th and above	76	83.929	13.6800		
	Total	300	81.083	12.3728		
Practice on the safety use of pesticides	Up to primary	98	52.870	17.1966	0.233	0.793
	Up to secondary	126	52.034	10.3631		
	10th and above	76	51.563	10.2635		
	Total	300	52.188	12.9429		

*Significant @ 5% level.

**Significant @ 1% level.

Table 2. Knowledge and practice on the safety use of pesticides based on their education [35].

Safety practice	Level of practicing safety measures			Total
	Never	Sometimes	Always	
Wearing of protective clothes and gloves	12	111	91	214
	5.6%	51.9%	42.5%	71.3%
Wearing of special face mask	41	98	119	258
	15.9%	38.0%	46.1%	86.0%
Not eating, drinking, and smoking during the application of pesticides	20	95	129	244
	8.2%	38.9%	52.9%	81.3%
Reading and following label instructions	20	84	96	200
	10.0%	42.0%	48.0%	66.7%
Using leftover pesticide solution in the same day	4	166	84	254
	1.6%	65.4%	33.1%	84.7%
Washing hands after pesticide application	110	54	136	300
	36.7%	18.0%	45.3%	100.0%
Not keeping the leftover pesticide in drinking container	21	86	58	165
	12.7%	52.1%	35.2%	55.0%
Washing contaminated clothes separately	71	79	150	300
	23.7%	26.3%	50.0%	100.0%

Table 3. Safety practices in relation to pesticide knowledge [35].

Another research is carried out in Kuwait with a total of 250 participated farmers. According to the study, the majority (58%) of the farmers did not use any personal protective equipment when mixing or spraying pesticides. Farmers mentioned the reasons for not using personal

protective equipment such as lack of availability when needed (35%), personal protective equipment being uncomfortable in the local hot and humid climate (90%), too expensive (65%), and slowing you down (29%). Younger and educated farmers were more likely to use personal protective equipment compared to older farmers. Farmers were asked if they take safety measures to reduce their risk of exposure to pesticides. The majority of respondents reported not eating (72%), drinking (65%), or smoking (59%) when mixing or applying pesticides. Over 70% of respondents, however, did not wash work clothing used while mixing or spraying pesticides separately from other cloths. Similarly, 46% of respondents reported that they did not consider wind direction when spraying pesticides [37].

The above findings suggest that governments and pesticide-producing industries should develop and promote the use of pesticide application methods and equipment that decreases risks to human health and expose to pesticide poisoning. Therefore, governments, pesticide industries, NGOs, and international organizations should work together to prevent the pesticide poisoning [12].

The initiative, Agricultural Worker Protection Standard (WPS), for example, is aimed at reducing the risk of pesticide poisoning among agricultural workers. It also offers occupational protections to over two million agricultural workers and pesticide handlers. It is intended to decrease the pesticide exposure incidents among farmworkers and their family members. The requirements in the WPS are intended to inform workers and handlers about pesticide safety and provide protections from potential exposure to pesticides. It keeps workers out of areas being treated with pesticides [38]. It is therefore a laudable intervention that should be continued and evaluated in order to learn from it and improve it.

6. Conclusion

Unsafe pesticide use and acute pesticide poisoning are major problems which affect the health of many farm workers all around the world. There are many reasons why acute pesticide poisonings are common among farmers. Some of main risk factors which results to occupational pesticide poisoning of farmers are an insufficient level of knowledge about pesticide use, wearing inappropriate personal protective equipment during spraying, and poor technology. Further studies should specially focus on occupational pesticide poisoning among farmers in order to determine possible short-term and long-term health effects and to develop preventive measures for it.

It is concluded from the existing studies that there are few studies that looked into the risk factors for occupational acute pesticide poisoning. More studies and researches are required in this field to create awareness among governments especially in developing countries. Governments and NGOs must be encouraged and asked for financial support by academicians for better and deep researches on occupational poisoning. It is also the duty of the governments to arrange special educational training programs for the farmers to increase their knowledge on the safety use of pesticide. This educational program will also help farmers to learn more about risk factors of poisoning and occupational safety. In addition, instead of obtaining from hospitals, data must be obtained from quantitative research methods to learn more about the real reasons of occupational poisoning.

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