ORIGINAL RESEARCH

Effect of safety and hygiene practices on lung function among Indonesian farmers exposed to pesticides

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Abstract

Aim: This study aimed to detect lung function impairment in farmers exposed to pesticides related to safety and hygiene practices in pesticide application.

Methods: This was a cross-sectional study with respondents are 200 farmers who were exposed to pesticides in Grobogan, the main agricultural center in Central Java, Indonesia, which has 95.75% agricultural workers. Data were collected by a questionnaire-based interview, observation, and spirometry measurement. Chi-square and Multinomial Regression were used for the statistical test.

Results*:* The survey results of all respondents showed that 12% had restriction lung function, 32% had obstruction lung function, and 56% had normal lung function. There was a significant effect between work period, pesticide spraying hour per day, spraying against wind direction, changing clothes directly after exposure to pesticides, taking a bath directly after exposure to pesticides with "farmer's lung function" based on statistical test results.

Conclusion*:* The Safety and hygiene practices of farmers exposed to pesticides could affect their lung function. It is suggested that to improve management and regulation control of pesticide application, educational programs and reinforcement of "safety and hygiene practices" in the workplace as effective approaches for preventing respiratory disorders related to pesticide exposures.

Keywords: *farmer's lung function, hygiene, pesticide, safety.*

Conflicts of interest: None declared.

Introduction

Pesticides have been widely utilized in numerous occupational settings, including agriculture, fisheries, forestry, and food (1). Occupational pesticide exposure occurs when pesticides are manufactured, transported, and used in the workplace (2,3). Agricultural employees are frequently exposed to pesticides even when performing duties unrelated to pesticide application (4-6).

Pesticides' harmful characteristics constitute a possible threat to human health (7). People exposed to pesticides frequently have respiratory symptoms such as coughing, wheezing, and airway irritation (8). The correlation between occupational pesticide exposure and chronic respiratory disorders such as asthma, chronic obstructive pulmonary disease (COPD), and lung cancer has been investigated in epidemiological research (8-10). By 2020, COPD is expected to be the third major cause of death (2). Appropriate community-based methodologies that assist the optimum development of prevention strategies are essential in preventing and early detection of COPD. Screening for pulmonary function exams in employees exposed to risk factors is one of the early detection methods for COPD. Farmers who are exposed to pesticides are one of the workers that are at risk for COPD. The objectives of this study were early detection of lung function impairment in farmers exposed to pesticides related to safety and hygiene practices in pesticide application. The hypothesis in this research is safety and hygiene practices of farmers exposed to pesticides could affect their lung function.

Methods

This cross-sectional study was conducted in Grobogan, Central Java, Indonesia, in 2015. Data were collected by interview with a questionnaire, observation, and measurement of lung function by spirometry. Total samples of 200 male farmers in Grobogan, Central Java, Indonesia, participated in this research. Samples were selected through spirometry measurement and medical records in hospital / primary health centers with the help of local people and health officers. The research area was selected because it is one of the largest agricultural centers in Central Java, Indonesia. Inclusion criteria of samples were: i) have a livelihood as farmers ii) age more than or equal to 40 years old iii) gender male iv) willing to be a respondent v) able to communicate well for interviews. Exclusion criteria are as follows i) the health condition does not allow the interview or had died during the study period; ii) medical record can not be found. Lung function tests of the participants were done by BKPM (Lung Health Centres Community) Semarang with MIR Spirolab III as an instrument for measurement. Data were analyzed by a univariate and bivariate statistical test: Univariate analysis to describe the frequency distribution of each variable, and the bivariate analysis using Chi-square test to determine the correlation. A multinomial regression test was used statistically to assess the effect of safety and hygiene practices onlung function.

Results

Based on the data results, the analysis showed that there was farmer's impaired lung function, which consists of restriction and obstruction disorder. There were 112 respondents (56%) with normal lung function, 24 respondents (12%) with restriction, and 64 respondents (32%) with obstruction. It means that almost 50% of respondents showed impaired lung function.

Table 1. Lung function based on spirometry measurement results

Category of Spirometry Measurement Result	Σ	%
Normal Lung Function	112	56.0
Obstruction	64	32.0
Restriction	24	12.0
Total	200	100.0

Table 2. Descriptive analysis of lung function parameters based on spirometry test

Parameter	FVC	FVC/pred	FEV1	FEV1/pred	FEV1/FVC
Mean	2,762.76	95.28	2,143.20	90.27	76.49
Median	2,825.00	97.75	2,275.00	94.59	78.02
Mode	2,380.00	97.75	2,510.00	100.00	100.00
Standard Error	55.71	1.90	54.75	2.13	1.11
Standard Deviation	787.87	26.83	774.23	30.10	15.71
Range	3,830.00	131.55	3,310.00	158.20	64.14
Minimum	750.00	32.60	390.00	19.63	35.86
Maximum	4,580.00	164.15	3,700.00	177.83	100.00
Count of sample	200	200	200	200	200

Based on interviews and observations on farmers' hygiene and safety practices in spraying pesticides, the following data description is obtained.

Table 3. Safety and hygiene farmer's practices of pesticide application

No.	Safety and hygiene practices aspects	%
1.	Work period as farmer	
	• Less than 5 years	2.0
	• 5-10 years	4.0
	• More than 10 years	94.0
2.	Pesticide spraying hour per day	
	• Less than 5 hours per day	31.0
	• More than or equal to 5 hours per day	69.0
3.	Checking hygiene personal protective equipment before used	
	• Never	8.0
	• Sometimes	18.0
	• Always	74.0
4.	Cleaning personal protective equipment after used	
	• Never	8.0
	• Sometimes	15.0
	• Always	77.0
5.	Eating/Drinking while pesticide spraying	
	• Never	97.0
	• Sometimes	3.0
	• Always	0.0

No.	Safety and hygiene practices aspects	%
6.	Smoking while pesticide spraying	
	• Never	2.0
	• Sometimes	18.0
	• Always	80.0
7.	Using the direct pesticide mixing hand	
	• Yes	7.0
	• No (Using the tools mixer)	93.0
8.	Eating/Drinking/Smoking while mixing pesticide	
	• Never	66.0
	• Sometimes	28.0
	• Always	6.0
9.	Blowing clogged nozzles direct using mouth	
	• Yes	16.0
	• No (Using a needle / tools)	84.0
10.	Wiping sweat with fabric / clothes exposed to pesticides	
	• Never	57.0
	• Sometimes	6.0
	• Always	37.0
11.	Wash hands after exposure to pesticides	
	• In the river	55.0
	• In the well	45.0
12.	Change clothes direct after exposure to pesticides	
	• Never	20.0
	• Sometimes	18.0
	• Always	62.0
13.	Washing clothes direct after exposure to pesticides	
	• Never	90.0
	• Sometimes	10.0
	• Always	0.0
14.	Take a bath direct after exposure to pesticides	
	• Never	20.0
	• Sometimes	78.0
	• Always	0.0

The results of hypothesis testing with bivariate and multivariate using "chi-square and multinomial regression test" obtained the following results.

Table 4. Results of data analysis using Chi-square statistical test (Correlation between safety and hygienic practices with lung function)

Variables of safety and hygienic practices on pesticide application		P-value	OR	95% CI
1.	Work period	<0.05	4.148	1.798-9.573
2.	Pesticide spraying hour per day	<0.05	3.165	1.176-8.518
3.	Doing spraying without pay attention to	n.s.	1.362	0.289-6.426

	wind direction			
4.	Doing spraying againts wind direction	<0.05	4.750	2.008-11.236
5.	Doing spraying when strong wind	n.s.	1.417	0.624-3.218
6.	Checking hygiene personal protective equipment before used	n.s.	3.273	0.627-17.071
7.	Cleaning personal protective equipment after used	n.s.	2.136	0.503-9.068
8.	Eating/drinking while pesticide spraying	n.s.	1.285	0.480-3.437
9.	Smoking while pesticide spraying	n.s.	1.285	0.480-3.437
10.	Using the direct pesticide mixing hand	n.s.	1.362	0.289-6.426
11.	Eating/drinking/smoking while mixing pesticide	n.s.	1.195	0.522-2.737
12.	Blowing clogged nozzles direct using mouth	n.s.	1.348	0.460-3.956
13.	Wiping sweat with fabric / clothes exposed to pesticides	n.s.	0.922	0.417-2.035
14.	Wash hands after exposure to pesticides	n.s.	0.556	0.255-1.254
15.	Change clothes direct after exposure to pesticides	<0.05	3.857	1.278-11.638
16.	Washing clothes direct after exposure to pesticides	n.s.	0.392	0.095-1.613
17.	Take a bath direct after exposure to pesticides	<0.05	6.469	2.000-20.917

Table 5. Results of data analysis using multinomial regression statistical test (Effect of safety and hygienic practices on lung function)

Safety and hygiene practices on pesticide application		P-value
1.	Work Period	<0.05
2.	Pesticide Spraying Hoursper Day	<0.05
3.	Doing Spraying against Wind Direction	<0.05
4.	Change Clothes directly after Exposure to Pesticides	<0.05
5.	Take a Bath directly after Exposure to Pesticides	<0.05

Based on results analysis in tables 4 and 5 above, we can see that there are five aspects of hygiene and safe pesticide spraying practices that are significantly related as a risk factor and influence farmers' impaired lung function.

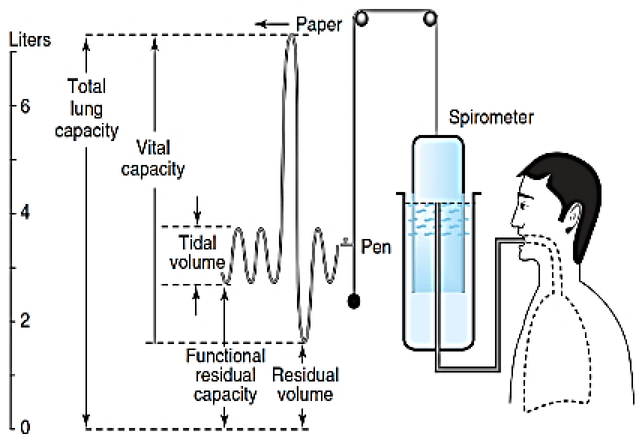
Discussion

People who work with pesticides directly and frequently are at the most significant risk of exposure in the workplace (3). Chemical substances are usually absorbed into the systemic circulation through an external or interior body surface (e.g., skin, mucosa, and respiratory tracts). The concentration of a toxic agent at the absorbing surface, which depends on the rate of exposure and dissolution of the chemical, is connected to the absorption rate of a poisonous agent. It is linked to the exposed site's size, the epithelium layer's features, and the toxicant's physicochemical properties. One of the most significant influences on absorption rate is lipid solubility. Lipid-soluble chemicals are more easily absorbed (11).

In addition, agricultural workers and their family members are frequently exposed to pesticides at work (4-6), and they can be exposed to significant amounts of pesticides (12). Occupational pesticide exposures, whether acute or chronic, are generally at relatively high doses compared to environmental exposures, where levels of exposure tend to be relatively low (2). The major causes of occupational pesticide exposures are accidental pesticide spills, leaks, inappropriate equipment use, and non-compliance with safety rules (3). In occupational settings, respiratory inhalation and cutaneous absorption are the principal routes of pesticide exposure (2,13). When spraying extremely volatile pesticide chemicals, respiratory exposures are common, especially for people working without respiratory protection equipment or in a poorly ventilated working environment (14). According to the findings of this study, farmers had reduced lung function in 12% cases of restriction and 32% cases of obstruction on farmer's lung function. We found that safety and hygiene practices of farmers exposed to pesticides could affect their lung function.

The respiratory route accounts for around 10% of overall pesticide exposure in agricultural jobs, with the rest coming from cutaneous absorption or digestion (15). Inhalation of pesticide-contaminated aerosols or particulate particles can potentially cause respiratory exposure (PM). Gas exchange, which includes perfusion, ventilation, and diffusion, is the lung's primary function. The lung's primary function is to deliver O^2 to the body's target organs and tissues while also removing CO^2, an abundant waste product. Figure 1 depicts the responses of the respirometry systems to hazardous substances (11).

Figure 1. Responses of the respirometry system to toxic agents (11)



Several studies have linked pesticides as hazardous agents in industrial contexts to reduced lung function. For example, a cross-sectional study on Ethiopian state farms of 102 pesticide sprayers and 69 non-sprayers found that pesticide sprayers aged 15–24 years had significantly lower FEV1 and FVC than non-sprayers (16). A similar study conducted among agricultural pesticide sprayers in Spain suggested that short-term pesticide exposure was associated with a reduction in FEV1. In contrast, long-term pesticide exposure was associated with a reduction in FEF25 percent–75 percent (17). Cholinesterase inhibition caused by organophosphate or carbamate insecticides was also linked to decreased lung function. Exposure to organophosphate and carbamate pesticides was linked to lower FVC, FEV1, FEV1/FVC ratio, FEF25 percent-75 percent, and peak expiratory flow rate (PEFR), which was also linked to cholinesterase inhibition, in a matched case-control study of agricultural laborers in India (18). Furthermore, a cross-sectional investigation of pesticide sprayers in Indian mango plantations found a link between reduced acetylcholinesterase activity and poorer lung function (19). Occupational pesticide exposure has been linked to obstructive and restrictive problems in the lungs. The FEV1/FVC ratio was lower (but not significantly lower) among farm pesticide sprayers in the Spanish study (19), implying an obstructive anomaly. Long-term exposure to cholinesterase-inhibiting pesticides was similarly linked to a significant reduction in the FEV1/FVC ratio among agricultural laborers in India (20). Seasonal low-level exposure to organophosphate pesticides among farmers in Sri Lanka was linked to a normal FEV1/FVC ratio but a decrease in both FVC and FEV1 (21), implying a restrictive anomaly. The author of a study of pesticide spraying workers in mango plantations in India suggested that exposure to organophosphate and organochlorine insecticides was linked to a restrictive kind of lung function impairment (22). Pesticide poisoning was also linked to reduced FVC and FEV1 among current smokers in a study of farm operators and their spouses in Colorado, indicating a restrictive defect.

The study's findings also revealed that most farmers had compromised lung function, including limitation and obstruction disorders. Another cohort study of 364 smallholder farmers in Uganda found that exposure to organophosphate and carbamate insecticides can deteriorate lung function (23).

According to the research of pesticide exposures among farmworkers, workplace safety and hygiene habits are crucial for preventing pesticide exposures in the workplace (24). Safe pesticide application procedures, showering after work, wearing and changing clean clothes between work shifts, and often washing hands at work are all examples of safety and hygiene behaviors in the workplace (25). Furthermore, a study of farmers in rural Indonesia who used pesticides, including organophosphates, found that those who did not wear a mask/respirator wore wet clothing, wore short-sleeved shirts, had more skin contact with pesticides. Those who smoked while spraying had the highest risk of developing health problems (26).

Unlike other studies, we discovered that the length of daily exposure and the suitability of pesticide spraying direction is the pesticide application practices that have been demonstrated to affect farmers' compromised lung function in the Indonesian environment. The requirement for the socialization of safe working methods for farmers in using pesticides and perfecting pesticide application techniques effectively and correctly in COPD prevention has implications for public health. Pesticide exposure should be limited to 5 hours per day, and pesticides should not be sprayed towards the wind. In this research, we found that farmers do not yet understand the consequences of spraying without regard for wind direction, which will increase chemical exposure in farmers' bodies. One element that farmers often overlook is contact toxicity. If there are abnormalities on the skin and/or sweat, pesticides will be absorbed more effectively through the skin. The accumulation of pesticide exposure on the responders can be of high intensity related to spraying hours per day. Spraying time is the number of hours per day that pesticides are used to spray plants. Poisoning from pesticides can be reduced if farmers keep their spraying time within the safe range of 1-5 hours. Because the longer a person is exposed to pesticides, the greater the danger of poisoning, spraying should be limited to no more than 4-5 hours each day. It was wise to spray pesticides on the respondents in this study at various times during the day, especially in the morning and evening. Spraying during the day with high temperatures causes the body's metabolism to speed up, resulting in a larger absorption of pesticides into the body. The environment's temperature is harmful to pesticide spraying farmers if it is higher than the temperature of the human body, which is 37°C. If the ambient temperature is high, the body temperature rises as well. Blood vessels dilate to bring them closer to the skin (external environment), allowing heat to escape and more blood in the skin to facilitate heat release by irradiation and sweating. Sweat glands have a particular temperature that allows them to collect much heat and release it into the environment when the sweat evaporates. An increase in the effects of harmful compounds in the air can be caused by an increase in temperature combined with sunshine and the development of reactions from one or more secondary pollutants. A hot climate or working environment will significantly impact the pace of chemical reactions in the air, particularly in the employees' bodies, which are constantly exposed. Farmers frequently underestimate the hazards of pesticides in pesticide application procedures, resulting in non-compliance with pesticide safety regulations. Pesticide poisoning, particularly chronic poisoning, is generally undetectable and has unpredictable results. As a result, most farmers who have been using pesticides in their way for decades have been unaffected. It is widely assumed that the pesticide management procedures used by Indonesian farmers are highly hazardous to both themselves and the environment. Similarly, the results of this study demonstrate that the pesticide application strategy has not been applied correctly in a safe operating manner and has been shown to impact lung function impairment.

Pesticide regulations and management, educational programs on safety precautions, and reinforcement of safety behaviors, particularly hygienic and safety practices at work, have been effective approaches for preventing respiratory disorders linked to occupational pesticide exposures in studies. Pesticide applicators who were given educational interventions to inform them about the risks of using pesticides and how to reduce pesticide exposure showed changes in perceptions of vulnerability and effectiveness measured by surveys before and after the intervention to determine the sustainable effect, according to Rohlman et al. (27). Pesticides are increasingly being viewed as a long-term health concern by a growing number of people, and participants' attitudes toward proper pesticide application hygiene are improving (27). This intervention is an example of a low-cost approach that can enhance the pesticide application and personal hygiene practices of teenagers and young adults during and after pesticide application. The strategy could be replicated in other nations with a comparable pesticide application safety culture. Another study by Bagheri et al. (28) found that continuing education should improve farmers' intentions and behavior toward safe handling of pesticides, i.e., improve hygiene and occupational safety practices (28). Farmers' attitudes and behavior control in the safe use of pesticides can be integrated into various inter-program and cross-cutting initiatives.

Conclusions

People exposed to pesticides at work generally had impaired lung function, including limitation and obstruction issues. In conclusion, ongoing education and training programs on the potential health risks of pesticide exposures and the enforcement of "safety and hygiene behaviors" during pesticide handling effectively prevent pesticide exposures and related respiratory disorders. Controlling risk factors or early prevention of chronic obstructive pulmonary disease in the community is proposed.

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