Pesticide Usage and Its Association with Health Symptoms among Farmers in Rural Villages in West Java, Indonesia

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The improper handling of pesticides in agriculture has caused serious health problems in many developing countries. In this study, we report the pesticide usage condition among Indonesian farmers and its association with symptoms of pesticide toxicity. A questionnaire survey on personal history regarding agricultural labor, pesticide storage and disposal, pesticide use and health history was conducted using a structured questionnaire in rural Sundanese villages in West Java, Indonesia. The most frequently used pesticides included dithiocarbamates, pyrethroids and organophosphates. In approximately 80% of sprayings, category II pesticides (World Health Organization (WHO) categorization; "moderately hazardous") were used. Many of the subject farmers worked in a highly unsafe occupational environment; protective measures and safe handling were rarely observed, whereas smoking and drinking during spraying were frequently practiced. Correlation analysis revealed that farmers who wore a long sleeve shirt and headgear showed health symptoms less frequently. Moreover, farmers who had skin contact with the spray solution during measuring or mixing (excluding the hands), who wore wet clothing (skin exposure to pesticide), and who smoked and rubbed their eyes during spraying showed more symptoms. Among these factors, headgear use, wearing wet clothing (skin exposure to pesticide), and smoking during spraying were the significant determining factors for developing health symptoms. Preventing such behaviors will be an effective method of reducing health problems among the subject farmers.

1. Introduction

Over the past three decades, the indiscriminate use and improper handling of pesticides in agriculture have caused serious human health problems in many developing countries.[(1)] Approximately 220,000 workers die from pesticide exposure every year with the majority of deaths occurring in developing countries.[(2–4)]

In Indonesia, 55,000 tons of pesticide was produced in 2003. In the same year, there were 317 cases of pesticide poisoning, although this number could be higher owing to unreported incidents.[5] In developing countries such as Indonesia, the real extent of the problem is hard to grasp for various reasons. First, many of the short-term effects go unreported unless they are life-threatening or require visits to health-care facilities. People with milder symptoms who seek health care at health facilities often go unrecognized because their symptoms often mimic other health conditions. Furthermore, healthcare providers commonly fail to record the occupational health history of patients due to inadequate toxicology training. Therefore, the association between clinical symptoms and pesticide usage is often overlooked. Moreover, the most heavily exposed low-income farmers do not often have the means of seeking medical advice. They consider ill health from pesticide use as part of the price one has to pay to produce healthy crops.[6]

The health and environmental hazards of pesticides can be partly avoided by education and the creation of incentives to prevent the trend of pesticide overuse. For an effective intervention/education to prevent such hazards, a clear understanding of the farmer's perception of risk and pesticide application behavior is necessary. So far, however, systematic studies on these aspects of pesticide usage have been scarce in developing countries.

In this study, we examined 73 farmers in two villages located in the watershed of the Citarum River, West Java, Indonesia. This area has been reported to be contaminated with various types of hazardous material including pesticides and metals from industrial and agricultural runoff as well as domestic sewage.[7] Information on pesticide use was collected using structured questionnaires. By combining these data, we evaluated pesticide usage among farmers and assessed the correlation between the use and handling of pesticides and the symptoms of pesticide toxicity among Indonesian farmers.

2. Subjects and Methods

2.1 *Study village and respondents*

The subject area is located in the watershed of the Citarum River, Bandung district, West Java, Indonesia (Fig. 1). The river has a watershed area of 6,000 km^2 and three reservoirs. Over the past 30 years, the downstream area has experienced rapid industrialization and urbanization, whereas the upstream area experienced an expansion of cultivated fields (including illegal expansion to the forest area), both of which contributed to environmental pollution.

The first study site (Village C) is situated in the western foothill of Mt. Puncak Cae, 35 km Southeast of Bandung, and is 1,200–1,600 m above sea level (ASL). Most of the area was forested area (78.3%), and cultivated fields and residential areas constituted 18 and 3.5%, respectively. The number of households was 1,300 and the population was 5,070 in 2002 (village statistic data). The primary subsistence was crop cultivation and dairy farming.

The second study site (Village T) is situated in the western foothill of Mt. Puncak Cae, 40 km Southeast of Bandung, and is 1,500–1,600 m ASL. Most of the area was forested area (37.7%) and tea plantation area (57.6%), and cultivated fields and residential areas constituted 3.2 and 0.6%, respectively. The number of households was 3,226 and the population was 11,545 in 2000 (village statistic data). The primary subsistence was crop cultivation, dairy farming and tea planting.

Seventy-three farmers from the two villages were enrolled in the study. The average age of the respondents was 38.9±8.3 years.

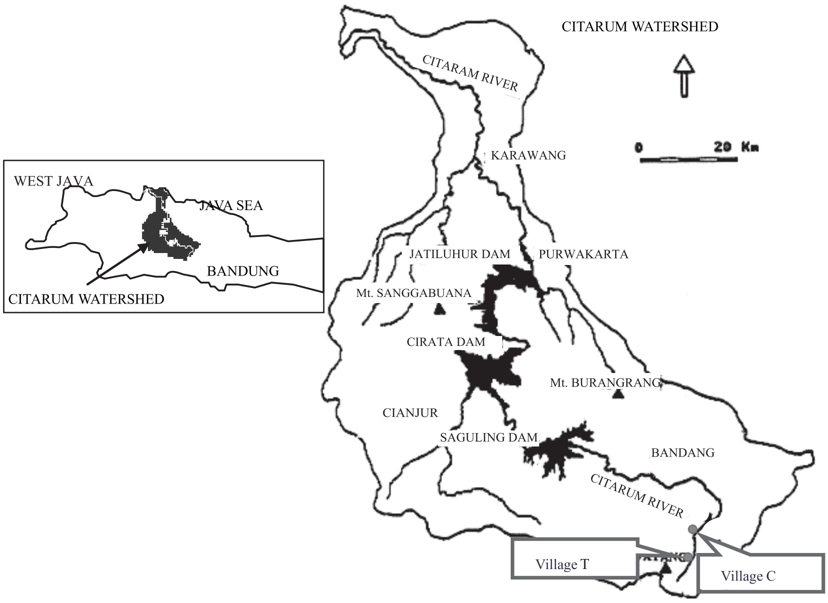

Fig. 1. Map showing study sites.

2.2 *Field survey*

In the field survey conducted in March 2006, an interview survey using a questionnaire regarding the personal history of agricultural labor, pesticide storage and disposal, pesticide use and health history was conducted.

2.3 *Personal history of agricultural labor*

Information on the personal history of agricultural labor of the participating farmers was obtained through interview, in which the working duration as an agricultural worker, the frequency of spray operation and the types and amounts of pesticides used in the previous month, and the types and amounts of pesticides used per crop in the last cultivation were asked.

2.4 *Pesticide storage and disposal*

The pesticide storage condition for each farmer was observed and recorded by the interviewer during a household visit. Pesticide disposal and reuse was investigated separately for plastic bags, plastic bottles and metal bottles.

2.5 *Pesticide use*

Information on the implementation of protective measures, handling practices (skin contact with spray solution, spray procedures and equipment condition), oral and eye exposure (food, drink and tobacco consumption during spraying, and eye rubbing), and laundry and bathing hygiene was obtained using a structured questionnaire.

2.6 *Health history*

A questionnaire listing 33 signs and symptoms was developed using the local language. This was based on the known health effects of the common pesticide chemical families used, namely, organophosphates, carbamates and organochlorines, which are neurotoxic, and pyrethroid and thiocarbamates, which irritate the skin, eyes, nose, throat and respiratory tract.[8] The questions were made in a format such as "Have you ever experienced dizziness immediately after you sprayed pesticides?" A reported acute sign or symptom was considered to be associated with a spray operation.

2.7 *Statistical analysis*

The correlation between the pesticide usage and the health symptoms reported by farmers was examined using Spearman's correlation analysis. To identify the determining factors for the number of reported health symptoms, stepwise multiple regression analysis was conducted. All statistical analyses were carried out using the SPSS software package (Version 10.0, SPSS Inc., Chicago).

3. Results

3.1 *Types of pesticide used*

Table 1 shows the names of the pesticides used by the subject farmers during the last cultivation. The active pesticide ingredient used by each farmer was indexed by chemical family and World Health Organization (WHO) hazard grades: moderately hazardous (II), slightly hazardous (III) and unlikely to present acute hazard in normal use (U).[9] No pesticides were categorized as extremely hazardous (Ia) or highly hazardous (Ib). There was a total of 25 types of pesticide used. The most frequently used pesticides were mancozeb, profenofos, and permethrin. Table 2 shows the pesticides used by the subject farmers classified by chemical family. The results revealed that dithiocarbamate, pyrethroid and organophosphate were the most frequently used pesticides among the subject farmers. Regarding hazard grade, about 40% of the pesticides used were moderately hazardous (Table 3). Usually, farmers carry out pesticide spraying by mixing two or three pesticides. Pesticides that are moderately hazardous were used in more than 80% of the spraying occasions.

3.2 *Pesticide storage and disposal*

Table 4 shows the conditions of pesticide storage and disposal. Pesticide storage was observed and recorded by the interviewers during household visits. Thirty and 25% of the farmers stored pesticides in the kitchen and inside their house (excluding the kitchen), respectively. Moreover, 33% of the farmers stored pesticides in places within the reach of children. These observations suggest that family members, particularly children are at high risk for pesticide exposure at home. Most containers of pesticides were left open after use. As a consequence, left over pesticides were left scattered in various areas in the village. Some farmers sold the plastic bottle of the pesticide they used to garbage collectors to be able to get some snacks.

3.3 *Pesticide use*

Table 5 shows the personal hygiene practices of the farmers associated with the handling of pesticides, including the use of protective clothing and gadgets, handling practices, oral and eye exposure, and laundry and bathing hygiene. Most of the farmers had never used protective clothing and gadgets such as masks, eye shields and gloves. About 50% of the farmers reported that their hands were always directly in contact with the pesticide during measuring (61.6%) and mixing (42.5%). About one-third of the farmers always smoked (31.5%) and drank something (27.4%) during pesticide spraying. These results indicate a high possibility of direct exposure to pesticides among the subject farmers.

3.4 *Health history*

Table 6 shows the symptoms self-reported by the farmers after spraying. Of the 33 symptoms reported, the most frequently reported symptoms were dizziness (similar to the feeling after you spin around many times; 63.0%), burning and stinging eyes (similar to the feeling you have when smoke or soap gets into your eyes; 57.5%), itchy eyes (similar to the feeling when you get pollen in your eyes; 57.5%), fatigue (similar to the feeling after climbing a mountain all day long; 50.7%), and headache (a sharp or squeezing pain in the head; 49.3%). The mean number of reported symptoms per farmer was 6.7±4.3 (range 0–21).

Table 1
Pesticides used by farmers.

Common name	Brand name	Chemical family	WHO class	*N*	%
Mancozeb	Dithane M-45 80WP	Dithiocarbamate	U	106	24.3
Profenofos	Curacron 500EC, Profile 430EC	Organophosphate	II	59	13.5
Permethrin	Ambush 2 EC, Pounce 20 EC	Pyrethroid	II	57	13.0
Chlorothalonil	Daconil 25 WP	Nitrile	U	25	5.7
Spinosad	Success 25 SC	Biological	U	21	4.8
Iprodione	Rovral 50 WP	Carboxamide	U	18	4.1
Cypermethrin	Arrivo 30EC	Pyrethroid	II	16	3.7
Dimethomorph	Acrobat 50 WP	Morfolin	U	16	3.7
Carbosulfan	Marshall 200 EC	Carbamate	II	15	3.4
Bacillus thuringiensis	Florbac FC, Bactospeine WP	Biological	U	14	3.2
B-Cyfluthrin	Buldok	Pyrethrin	II	14	3.2
Propineb	Antracol 70 WP	Dithiocarbamate	U	12	2.7
Abamectin	Agrimex	Unknown	—	10	2.3
Metalaxyl	Ridomil Gold 350 ES	Acylalanine	III	8	1.8
Mono- and di-potassium phosphate	Agrifos	Unknown	U	6	1.4
Cymoxanil	Curzate, Curci 10 WP	Urea	III	5	1.1
Lambda-cyhalothrin	Rolidor, Rudal	Pyrethroid	II	5	1.1
Maneb	Pilaram 80 WP	Thiocarbamate	U	5	1.1
Propykel	Propicure	Thiocarbamate	—	5	1.1
Dimehypo	Spontan	Biological	—	3	0.7
Emamectin	Proclaim	Unknown	—	3	0.7
Deltamethrin	Decis	Pyrethroid	II	2	0.5
Cartap hydrochloride	Padan 50 SP	Thiocarbamate	II	1	0.2
Gibberelins	ProGibb	Unknown	U	1	0.2
Glyphosate	Round Up	Organophosphate	U	1	0.2
Unknown				9	2.1
Total				437	100.0

WHO hazard grades: moderately hazardous (II), slightly hazardous (III) and unlikely to present acute hazard in normal use (U). No pesticides were classified as extremely hazardous (Ia) or highly hazardous (Ib).

Table 2
Pesticides classified by chemical family used by farmers.

Chemical family	*N*	%
Dithiocarbamate	118	27.0
Pyrethroid	80	18.3
Organophosphate	60	13.7
Biology	38	8.7
Nitrile	25	5.7
Carboxamide	18	4.1
Morfolin	16	3.7
Carbamate	15	3.4
Pyrethrin	14	3.2
Thiocarbamate	11	2.5
Acylalanine	8	1.8
Urea	5	1.1
Unknown	29	6.6
Total	437	100.0

Table 3
Pesticides classified by hazard level used by farmers.

WHO class	*N*	%
II	169	38.7
III	13	3.0
U	225	51.5
Unknown	30	6.9
Total	437	100.0

No pesticides were classified as class Ia or Ib pesticides.

Table 4
Pesticide storage and disposal.

Variable		%
Pesticide storage		
Pesticide repository	Waterhouse	31.5
	Outside the house	13.7
	Inside the house (excluding the kitchen)	24.7
	In the kitchen	30.1
Pesticide bottles open	Yes	2.7
	No	97.3
Pesticide bottles leaking	Yes	32.9
	No	67.1
Pesticides within reach of children	Yes	32.9
	No	67.1
Pesticide disposal		
Disposal of plastic bags	Buried	15.3
	Burned	6.9
	Left in open	76.4
	Others	1.4
Disposal of plastic bottles	Buried	9.6
	Burned	4.1
	Left in open	75.3
	Sold	2.7
	Others	8.2
Disposal of metal bottles	Buried	12.3
	Burned	2.7
	Left in open	78.1
	Others	6.8
Reuse of plastic bags	Yes	1.4
	No	98.6
Reuse of plastic bottles	Yes	2.7
	No	97.3
Reuse of metal bottles	Yes	4.2
	No	95.8

Table 5
Personal hygiene associated with pesticide handling.

	Always	Often	Seldom	Never
Use of protective clothing and gadgets				
Eye shields	0.0	1.4	4.1	94.5
Mask	8.2	2.7	6.8	82.2
Gloves	6.8	0.0	4.1	89.0
Long sleeve shirt	67.1	16.4	11.0	5.5
Long pants	90.4	6.8	1.4	1.4
Shoes	94.5	4.1	1.4	0.0
Headgear	95.9	1.4	1.4	1.4
Handling practices				
Skin contact with spray solution during measuring (hands)	61.6	16.4	16.4	5.5
Skin contact with spray solution during measuring (excluding the hands)	0.0	5.5	46.6	47.9
Skin contact with spray solution during mixing (hands)	42.5	26.0	24.7	6.8
Skin contact with spray solution during mixing (excluding the hands)	1.4	5.5	57.5	35.6
Upwind spraying	8.2	42.5	45.2	4.1
Pays attention to the direction of spraying	30.1	16.4	11.0	42.5
Use of leaky equipment (with skin, respiratory or eye effects)	16.4	34.1	37.0	12.3
Wearing wet clothing (skin exposure to pesticide)	9.7	41.7	34.7	13.9
Oral and eye exposure				
Smoking	31.5	19.2	12.3	37.0
Eating	21.9	19.2	31.5	27.4
Drinking	27.4	31.5	23.3	17.8
Rubbing eyes	5.5	23.3	39.7	31.5
Laundry and bathing hygiene				
Washing spray tank	68.5	9.6	20.5	1.4
Changing clothes in the field	0.0	2.7	4.1	93.2
Changing clothes at home	94.5	2.7	1.4	1.4
Washing hands after spraying	87.7	5.5	55.0	1.4
Washing clothes after spraying	23.3	13.7	58.9	4.1

Numbers are expressed in % (*N*=73).

3.5 *Associations between symptoms and pesticide usage*

To clarify the associations of the self-reported symptoms and pesticide usage, correlation analysis was conducted (Table 7). The frequency of each personal hygiene behavior associated with pesticide usage was rated as 1=always, 2=often, 3=seldom, and 4=never. Thus, if the use of eye shields showed a positive correlation with the number of the type of self-reported symptoms, it means that the farmers who used eye shields showed symptoms less frequently. The result of the analysis revealed that farmers who used a long sleeve shirt and headgear showed fewer symptoms. Also, the farmers who had skin contact with pesticides (excluding the hands) and wore wet clothing (skin exposure to pesticide) showed more symptoms. Moreover, the farmers who smoked and rubbed their eyes during spraying showed more symptoms.

Table 6
Self-reported symptoms of farmers after spraying.

	% of farmers exhibiting symptoms after spraying
Dizziness	63.0
Burning/stinging eyes	57.5
Itchy eyes	57.5
Fatigue	50.7
Headache	49.3
Itchy skin	47.9
Nausea	45.2
Red eyes	35.6
Dry throat	27.4
Shortness of breath	27.4
Blurred vision	23.3
Chest pain/burning feeling	16.4
Coughing	16.4
Skin scaling	16.4
Sore throat	15.1
Muscle weakness	13.7
Tremors	13.7
Eyelid twitching	11.0
Skin redness	11.0
White patches on skin	9.6
Staggering gait	8.2
Excessive sweating	6.8
Runny nose	6.8
Burning sensation of nose	6.8
Vomiting	6.8
Wheezing	5.5
Diarrhea	5.5
Excessive salivation	4.1
Muscle cramps	2.8
Stomach cramps/pain	2.7
Numbness	2.7
Convulsions	1.4
Loss of consciousness/coma	0.0

Numbers are expressed in % (N=73).

To determine the most relevant factors affecting the number of reported symptoms, stepwise multiple regression analysis was conducted (Table 8). The results revealed that the use of headgear, wearing wet clothing (skin exposure to pesticide) and smoking during spraying were the most significant factors affecting the number of symptoms for each farmer.

4. Discussion

The subject farmers in this study worked in a highly unsafe occupational environment. In about 80% of the sprayings, pesticides categorized under WHO category II were used. Moreover, the use of protective clothing and gadgets and safe pesticide handling were rarely observed, and smoking and drinking during spraying were frequently practiced.

Table 7
Simple correlation coefficients between pesticide usage and number of symptoms reported by farmers.

Variable	Correlation	
Use of protective clothing and gadgets		
Eye shields		
Mask		
Gloves		
Long sleeve shirt	0.277	*
Long pants		
Shoes		
Headgear	0.280	*
Handling practices		
Skin contact with spray solution during measuring (hands)		
Skin contact with spray solution during measuring (excluding the hands)	–0.255	*
Skin contact with spray solution during mixing (hands)		
Skin contact with spray solution during mixing (excluding the hands)	–0.307	**
Upwind spraying		
Pays attention to the direction of spraying		
Use of leaky equipment (with skin, respiratory or eye effects)		
Wearing wet clothing (skin exposure to pesticide)	–0.305	**
Oral and eye exposure		
Smoking	–0.247	*
Eating		
Drinking		
Rubbing the eyes	–0.276	*
Laundry and bathing hygiene		
Washing spray tank		
Changing clothes in the field		
Changing clothes at home		
Washing hands after spraying		
Washing clothes after spraying		

Only significant correlations are shown.
Spearman's correlation analysis: *, $p<0.05$; **, $p<0.01$

Table 8
Stepwise multiple regression analysis of number of reported symptoms.

Significant variable	β	P	Adjusted R^2
Headgear use	0.315	0.005	0.187
Wet clothing exposing the skin	–0.280	0.012	
Smoking while spraying	–0.262	0.017	

Dependent variable: number of reported symptoms per person (mean =6.7±4.3; range 0–21).
Independent variables: use of long sleeve shirt, use of headgear, skin contact with pesticides during measuring (excluding the hands), skin contact with spray solution during mixing (excluding the hands), wet clothing exposing pesticides to the skin, smoking while spraying and rubbing the eyes during spraying. Only variables with significant coefficients are shown.

The adverse health effects of pesticides can be reduced significantly by changing the behavior of farmers such as instructing them to use protective clothing and gadgets, although the use of such products is rarely practiced in developing countries.[10] One explanation for such behavior, particularly in developing countries, is that protective clothing and gadgets are expensive for farmers and their use is inconvenient in a tropical climate.[11,12] In our study, the correlation analysis demonstrated that wearing a long sleeve shirt and headgear showed a negative correlation with the total number of self-reported symptoms. Thus, the use of such protective clothing and gadgets was judged to be effective for reducing health problems among the subject farmers. Such clothing and gadgets were not expensive for the farmers because a long sleeve shirt is commonly worn as daily clothes and the headgear actually referred to ordinal towels that are also commonly used by the villagers. Furthermore, a hot climate was not a contributing factor in the study area, which was located at a high altitude (1,200–1,600 m ASL); the temperature was not so high.

Another explanation for the failure to use protective clothing and gadgets is that farmers do not understand the health consequences of exposure to pesticides and they fail to appreciate the protection given by certain types of protective clothing.[10] In the target village, we further interviewed village leaders regarding pesticide use among the villagers. The questions asked included the following areas, when and how pesticides came to be used in the village, what guidance was given by the government/companies in terms of the use of pesticide, how the villagers obtain information regarding pesticide use, what villagers think about pesticides, and who would be the most appropriate person to provide education to farmers. The results revealed that the farmers lacked formal training and information on the use and safe handling of pesticides in the subject area. Government officers from the Department of Agriculture firstly introduced pesticides to the villages, but subsequent guidance/training of farmers on pesticide use has rarely been provided. As a consequence, farmers use pesticides in their own ways; they are always fascinated with commercial messages from agricultural companies and try new products even at the expense of borrowing money to buy pesticides. In our study, the result of the multiple regression analysis revealed that wearing wet clothing (skin exposure to pesticide) and smoking during spraying were also significant factors causing health problems. In this study area, some farmers intentionally refrained from practicing such behaviors while others did not. This result indicates that if farmers have knowledge and pay attention to the proper use of pesticides, health hazards from pesticide spraying might be alleviated. Thus, training programs for farmers, particularly in terms of the proper use of pesticides should be implemented and information on the health hazards of pesticides and the appropriate behavior during pesticide spraying should be conveyed to the farmers. Furthermore, according to the interview result, villagers think that farmers' association (*kelompok tani* in Indonesian) or specialists of agriculture (including NGOs and universities) are the most appropriate people for providing education to farmers. Some trials such as education for organic farming provided by local universities have already started in the targeted village. In such education programs, utilizing villagers' network such as farmers' associations or community leaders would be useful and using information technology such as computers would motivate and fascinate local people.

In this paper, we did not discuss the biological markers of the health effects of pesticide use. However, our preliminary survey in the same study area showed that the pesticide exposure level of schoolchildren (will be published elsewhere), estimated by evaluating the levels of four different urinary metabolites of organophosphorus pesticides, was lower than that of children in Japan (unpublished data). To evaluate the significance of such a comparison, we need to collect more systematic data with a larger sample size. Moreover, the exposure level of adult males, who spray pesticides in a target area, should be investigated for further study.

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