

# Occupational Safety of Farmers in the Vegetable Industry

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*This study aimed to determine unsafe farming practices, nonergonomically designed equipment, and possible adverse health effects of pesticide exposure. Data were gathered with a structured survey, physical examination and blood extraction. Environmental monitoring was done for vegetables to determine multipesticide residue. Forty-eight percent of respondents reported feeling sick because of work. Vegetable residue was found in 16.67% of the samples. Vegetable profenofos of ~1 mg exceeded the necessary average daily intake of a maximum of 0.006 mg. Data also showed nonergonomically designed tools and unsafe work practices that increased pesticide exposure such as re-entering recently sprayed areas, a damaged backpack sprayer, spills during spraying, and no ventilation in greenhouses.*

farmers   pesticide exposure   pesticide-related problems   geographic information system  
pesticide residue

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## 1. INTRODUCTION

Agriculture is a very important economic sector in the Philippines since crops comprise ~48% of the total agricultural output [1]. Crop damage would, therefore, paralyze many families so farmers rely on pesticide use for vector management due to its apparent lower cost.

Health and environmental impact of pesticide misuse greatly affects farming communities in the Philippines negating the economic advantages of its use. Many researchers both locally and abroad have correlated the extent of direct and indirect pesticide exposure and health hazards such as increased mortality [2], dermal contamination [3], fetal abnormalities [4], decrease in cholinesterase level [5], spontaneous abortion [6], the risk of such abortion increasing with exposure before or after conception [7], myocardial infarction [8] and genotoxic risks [9]. Even DNA damage in workers

occupationally exposed to pesticide mixtures has been documented [9].

It is discouraging that with knowledge of health risks, many Filipino families still perceive crop yield outweighs the health risks associated with pesticide use.

Pesticides benefit farmers in many ways. Aside from reducing agricultural losses to pests, pesticides also improve the quality of produce in terms of visual appeal [10]. However, in Philippine agriculture, there is an increasing reliance on pesticide without the thought for its deleterious effects on the community, health and the environment. In addition, there is poor policy implementation as to pesticide use and regulation [11].

Benguet is the largest vegetable producer in the northern part of Luzon, the Philippines, with its major agricultural crops consisting of tubers, roots and bulbs, and leafy vegetables, stems and

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flowers. There are ~154000 farmers in Benguet, and in 2007, Benguet produced a value of 1.4 million pesos<sup>1</sup> of vegetables [1].

## 2. METHODOLOGY

For the environmental sampling, 49 samples of vegetables were taken, at 1 kg each, placed in an icebox and delivered to the laboratory within 12 h for analysis with gas chromatography. Gas chromatography establishes the residue level taken from environmental samples such as soil and water with a chromatograph (a separator). It is used to analyze compounds that can be vaporized without decomposition to determine the purity of a substance, or to determine the relative amounts of specific compounds in a mixture such as multipesticide residue in a soil or water sample. The area for monitoring was determined with geographic mapping and a geographic positioning system.

For health assessment, the following were done: (a) a survey of 400 farmers, (b) 395 of them underwent comprehensive physical examination conducted by medical personnel, and (c) 376 agreed to have blood samples taken for laboratory parameters. The interview of 400 farmers used a 9-page survey questionnaire on health and pesticide exposure assessment. The physical examination guide was adapted from the standard form used by the National Poison Control and Information Service (NPCIS) of the UP-Philippine General Hospital in its toxicological and neurologic assessments. Thirty doctors from the regional and municipal health offices of Benguet, St. Louie's University and Baguio General Hospitals as well as medical interns conducted the physical examination.

Ten to fifteen millilitres were extracted per respondent for blood count and serum creatinine. A licensed medical technician extracted blood.

The GIS was mapped using GIS software. The health and work practices data were encoded and analyzed with SPSS 13.0 and GIS 3.2. Data were analyzed with descriptive statistics, and

the  $\chi^2$  test of independence. Participants were informed about the nature of the study including the research objectives, purposes and goals.

This study was given ethics clearance by the Institutional Review Board of the National Institutes of Health, University of the Philippines Manila which is duly accredited with the Forum for Ethical Review Committees in Asia and the Western Pacific (FERCAP).

## 3. RESULTS AND DISCUSSION

### 3.1. Pesticide Residue in Vegetables

Benguet is characterized by timberlands and mountainous regions; 58% of the soil is suitable for forest growth or industrial tree plantation, 1% for upland field crops and 30% for tree farming [12].

Pesticide residue of chlorpyrifos, endosulfan, cyhalothrin, deltamethrin, profenofos and cypermethrin was detected in 7 of the 49 vegetables submitted for analysis. These samples were taken from four municipalities. Pesticide residue in the vegetable samples was found in 16.67% of the total samples submitted. Of the four municipalities, municipality 4 had the most residue at 42.86%. The vegetables taken from municipality 3 had negative residue. Chlorpyrifos was the most common pesticide residue found in all the municipalities.

The adverse effects of pesticide residue on vegetables depend on the pesticide, as well as on the amount and duration of exposure. While an occasional intake of a vegetable with residue above the acceptable daily intake (ADI) values will not result in an immediate health hazard, chronic intake will (Table 1). ADI should be multiplied by a person's weight to show the acceptable intake one can have in a day. Table 2 calculates the intake for ADI for an average Filipino, whose weight is arbitrarily set at 60 kg, and then compares it to the residue found in the vegetable samples.

<sup>1</sup> €24000 or 31 890 USD

**TABLE 1. Acceptable Daily Intake (ADI) Values for Pesticide Residues**

Pesticide	ADI (mg/kg body weight)
Chlorpyrifos	0.0030
Cyhalothrin	0.0500
Cypermethrin	0.0200
Deltamethrin	0.0100
Profenofos	0.0001
T-endosulfan	0.0060

Source: Joint Expert Committee on Food Additive: <http://www.doh.gov.ph>

If the residue found in each vegetable is compared with ADI values, 7 vegetables were significant for this study. For chlorpyrifos, only the second celery exceeded the computed ADI value. Deltamethrin and T-endosulfan were significant for the first celery sample. However, the actual ingested residue may be lower than the residue found at analysis.

Profenofos, an organophosphate, had a very high residue level at 1 mg/kg when the acceptable level was only about a thousandth of that. For this study, this was significant especially for profenofos, which has ADI of 0.0001 mg/kg of body weight. This indicates that for an average person with a weight of 60 kg, the average daily intake should not exceed 0.006 mg. Yet, the sample had ~1 mg of profenofos residue.

### 3.2. Health Assessment of Vegetable Farmers

Four hundred farmers surveyed; 51.8% were males and 48.2% were females. Most were aged 36–50 years; 79.3% were married. The respondents were mainly agricultural farmers (85.6%) while the remaining 14.4% were purely

growers, pesticide applicators, mixers or loaders and pesticide distributors. Only 10.8% were smokers, 2% chewed tobacco and ~4% chewed betel nut.

### 3.3. Pesticide Use

Pesticides were used by 384 farmers (96.5%). Most farmers had lived in their current residence for over 5 years (95.2%), and 41.8% lived within 50 m from the farms. Half (53.8%) also had family members working with pesticides, 17.25% of them were older children (over the age of 15), and 9.25% were young children. Pesticides have adverse effects and they may be higher in children. Nine percent of children under 15 were exposed to pesticides as they were pesticide applicators or worked in the farm.

Most farmers used pyrethroids (70.2%), organophosphates (67.5%). and carbamates (56.75%). Other pesticides used were organochlorides and nitrites. Fenvalerate (Sumicidine) was the most common pyrethroid used at 34.25%, methamidophos (Tamaron) (39%) for organophosphate, and mancozeb (Dithane) for carbamate (32.5%).

### 3.4. Occupational Safety in Pesticide Application

The farmers can be involved in either mixing (89.25%), spraying (87.8%), or loading (86.5%) pesticides or a combination of the three. Most sprayed pesticides with the use of a knapsack or a backpack sprayer (88.2%), 11.8% used other equipment: a power sprayer (6.95%), a hand spray (0.5%), a mechanical, tank, or compressor sprayer (0.25% each). About 85% reported that they received instructions on

**TABLE 2. Comparison of Calculated Acceptable Daily Intake (ADI) (mg/60 kg body weight) Values and Actual Pesticide Residues (mg/kg)**

Pesticide	ADI	Carrot	Celery 1	Celery 2	Chinese Cabbage	Baguio Beans	Pechay	Strawberry
Chlorpyrifos	0.18	0.06		0.95				0.07
Cyhalothrin	3		0.07					
Cypermethrin	1.2					0.04	0.32	
Deltamethrin	0.6		0.09					
Profenofos	0.006				1.00			
T-endosulfan	0.36		0.73					0.01

pesticide use and risks. However, despite this high percentage, most still did not use pesticides properly. Ninety-one percent reported they wore proper clothing but when itemized, most did not wear coveralls (84.25%), goggles (89.25%), face shield (82.75%), mask (77.75%), or use respirators (83.25%). Slightly fewer than half (44.5%) used gloves and ~85% used boots. Farmers used makeshift protective clothing that did not really provide protection against pesticide exposure.

Periodic inspection of the backpack sprayer is also important as it can leak. The farmers reported spillage on body parts due to leaking backpack sprayer (76.75%), spills during spraying (80%), and spills while mixing (61.75%). The farmers were also asked about their equipment and the design of their greenhouses. Most pesticide containers did not have any labels (34.75%), 30% of the farmers had short sprayer snouts, 38% had no air vents in greenhouses to facilitate diffusion of air outside.

There are also practices that should be used after pesticide use to minimize the risk of intoxication or poisoning. Such practices include washing hands, keeping away from recently sprayed areas, especially if the area is poorly ventilated, and avoiding spraying against the wind. Among the farmers surveyed, 92.25% washed their hands after pesticide use; they also bathed after application (92%). Over half used cloth that had been exposed to wipe sweat off their faces (46.25%), and 29.5% reentered recently sprayed areas. In using pesticide in open areas, 81.5% sprayed against the wind.

Seventy-five percent washed their own clothes and ~12% of that number shared this responsibility with their families. Seventy-two farmers had their spouses, children or relatives wash their clothes for them. Most farmers also kept their pesticides in storage areas, whereas the others left them either beside or inside the house, in the backyard, garden or fields. Used pesticide containers were either buried (32.5%), thrown away (29.5%), sold (19%) or burned (6.5%). Others stocked used containers inside their storehouses. Very few respondents cleaned their sprayers and devices; 12.3 and 6.8% of those were cleaned in creeks and rivers respectively; 9.9% cleaned their devices at home.

### 3.5. Pesticide Exposure and Illness

Of the 400 respondents, 192 (48%) reported feeling sick because of work. For most, this occurred 1–3 times. However, only ~45% of those who reported feeling sick sought medical attention for their illness and/or exposure.

Occupational-related exposure occurred during spraying pesticides in the field (80.18%), mixing (50.15%) or loading (44.98%). Accidental exposure occurred for bystanders (5.47%) or during transportation of the pesticides (3.35%). Exposure occurred in their fields (65.27%), gardens (42.22%), homes (7.19%) or even in their storage sites (4.2%).

Table 3 shows the association between unsafe farming practices and unsafe conditions and certain respiratory symptoms. The  $\chi^2$  test showed an association between the use of a damaged backpack sprayer and occurrence of pulmonary

**TABLE 3.  $\chi^2$  Association Between Risk Factors and Respiratory Health Symptoms ( $n = 400$ )**

Risk Factors (Unsafe Practices)	Respiratory Health Symptoms*			
	Coughing	Pulmonary Secretion	Breathlessness	Noisy Breathing
Damaged backpack sprayer	—	8.156** (0.004)***	4.961 (0.026)	4.169 (0.041)
Wiping sweat with contaminated piece of fabric	7.595 (0.006)	—	—	6.68 (0.010)
Spraying against the wind	—	—	5.614 (0.018)	—
Spills when spraying	—	—	5.699 (0.017)	3.899 (0.048)
No ventilation in greenhouse	—	6.639 (0.010)	—	—

Notes. \*—Respiratory health symptoms that WHO underscores as part of the constellation of symptoms associated with pesticide poisoning, \*\*— $\chi^2$  value, \*\*\*—significance level.

secretion, breathlessness and noisy breathing, between wiping of sweat with a contaminated piece of fabric and coughing, and noisy breathing.

### 3.6. Physical Health Assessment of Farmers

Neurologic examination was conducted, and affection of cranial nerves 1, 2, 7 and 8 was higher for the sample population compared to a less exposed group consisting of 142 farmers. All individuals tested for reflexes, meningeals, and autonomies were normal ( $n = 283, 383, 346$ ). Seventeen out of 367 respondents had cerebellar dysfunction characterized by dysmetria, inability to walk with feet in tandem, and difficulty maintaining balance. Two were reported for the low-exposure group.

A statistical analysis of abnormal neurologic examination revealed the following: (a) olfactory nerve affectionation was associated with loading, mixing, and applying of pesticides, respiratory route of exposure, and farm exposure; and (b) facial nerve affectionation was associated with spills on the back and spills while applying (Table 4).

### 3.7. Blood Indices

Complete blood count was done for 376 subjects. Hemoglobin was normal for 265 respondents (70.1%) but 17.7% of those with abnormal values had lower hemoglobin values than normal, indicating anemia. About one fourth had abnormal hematocrit values. Certain hematological parameters were also abnormal, such as hemoglobin, hematocrit, and eosinophil count. Six point one percent had abnormal WBC counts. Of those with abnormal counts, 5.57% had leukocytosis, while 5.84% had leucopenia. Platelet was abnormal in 11.4 % of the farmers. Creatinine clearance ranged from 6.9 to 746.4 ml/min with a mean of  $82.2 \pm 45.2$ . Also one fourth of the respondents had abnormal creatinine clearance (Table 5).

### 3.8. Discussion

Seven vegetables were significant for pesticide residue. For chlorpyrifos, only the second celery exceeded the computed ADI value. However, the results of the residue were gathered using ~1 kg of vegetables. Deltamethrin and T-endosulfan was

**TABLE 4. Statistical Association Between Risk Factors and Neurological Exam Findings Using  $\chi^2$ ,  $\phi$  and Odds Ratio (OR) ( $P = .05$ )**

Risk Factors	Cranial Nerve	$\chi^2$	Sig.	$\phi$	OR
Involved in mixing while working	olfactory nerve	14.202	.000	.148	10.611
Farm exposure	olfactory nerve	6.136	.013	.139	9.491
Respiratory route of exposure	olfactory nerve	4.063	.044	.112	4.614
Experienced spill on the back	facial nerve	6.680	.009	.139	12.583
Experienced spill while spraying	facial nerve	8.582	.003	.155	15.336

**TABLE 5. Distribution of Abnormal Blood Laboratory Results Among Farmers in Benguet (%)**

Blood Parameters	Sample Population ( $n = 376$ )	Control Population ( $n = 142$ )
	Abnormal (%)	Abnormal (%)
Red blood cells	11.4	12.6
Hemoglobin	30.1	24.6
Hematocrit	25.5	22.5
Mean corpuscular volume	8.2	6.3
MCH	67.8	62.7
Mean cellular hemoglobin concentration	25.5	12.6
White blood cells	11.4	7.7
Platelet	6.1	3.5
Creatinine clearance	18.6	31.0

significant for the first celery sample. However, the actual ingested residue may be lower than the residue found at analysis. Profenofos, an organophosphate, had a very high residue level at 1 mg/kg when the acceptable level was only about a thousandth of that. For this study, this was significant especially for profenofos which has ADI of 0.0001 mg/kg of body weight. This indicates that for an average person with a weight of 60 kg, the average daily intake should not exceed 0.006 mg. Yet, our sample had ~1 mg of profenofos residue. One way to reduce pesticide residue in vegetables is to thoroughly wash and cook them. Washing and cooking may reduce pesticide residue by 62–87% [13].

Organophosphate use in this study was prevalent accounting for 67.5%. Organophosphate has been implicated as a leading cause of morbidity and premature loss of life in many developing countries of the Asia-Pacific region [14].

Almost half of the respondents lived adjacent to agricultural fields. Proximity to farms can be a risk factor to pesticide poisoning [15]. In the area of investigation, houses were adjacent to farms and thus may predispose household members to pesticide residue that remains in the environment.

Half (53.8%) of the farmers had family members working with pesticides, 17.25% of them were older children (over the age of 15), and 9.25 % were young children. The effects of pesticide may be higher in children. Pesticides have been linked to cancer, birth defects, and damage to the nervous system, and the functioning of the endocrine systems [16]. Other research showed a link between pesticide exposure and adverse effects on children and fetuses such as low birth weight [17, 18], preterm birth or toxemia [19], stillborn infants [20] and miscarriages [21]. In China's Anhui province, DDT was associated with miscarriages in the first few weeks of pregnancy [22]. In Ecuador, women exposed to pesticides in the cut-flower industry were at risk of spontaneous abortion [23]. Parental exposure to pesticide was also associated with childhood brain cancer [24].

Almost 88% of the farmers in this study were involved in pesticide spraying. In this study, pesticide exposure occurred during spraying,

and adverse effects due to a damaged backpack sprayer and spraying against the wind were documented. In a study of Japanese farmers, exposure also occurred during spraying and pesticide poisoning led to acute dermatitis (5%) and chemical burns (3%) [25]. Lee, London, Paulauskis et al.'s study showed that working as a pesticide applicator was a predictor of chronic toxicity that included abdominal pain, nausea, rhinorrhea, dizziness, headache, somnolence, fatigue, gait disturbance, limb numbness, paresthesias, limb pain and limb weakness [22].

About 30% farmers re-entered recently sprayed area. Re-entry in sprayed areas has been the cause of a poisoning outbreak in Poland in 2002 after applicators re-entered a contaminated area before the required safety period has lapsed [26].

Farmers made use of ordinary clothing to protect themselves from pesticides. A study documented the absorption and retention of pesticides in everyday clothing materials [27]. They found that starching and heavy weight fabric, such as denim, increased absorption and retention thereby reducing pesticide transport to the skin. This might be useful to many farmers in the country who could afford proper PPE equipment and thus, frequently use improvised materials to protect themselves. Similarly, performance of different work clothing types for reducing skin exposure to pesticides were also shown in another study [28].

Eighteen percent reported that family members washed their clothes used in pesticide application. These findings are very substantial on take-home pesticide exposure that may occur upon contact with clothes used in pesticide work [29]. The study showed that 50% of the individuals responsible for the laundry of pesticide contaminated clothes did not receive any educational information on appropriate laundering.

The study has also shown the association between respiratory symptoms and unsafe work practices such as use of damaged backpack sprayer ( $p = .05$ ). Another study also showed that the pesticide chlorpyrifos has been implicated with airway hyperreactivity [30]. In Costa Rica, pesticide exposure was associated with

respiratory health problems among indigenous women [31]. Rhinitis arising from pesticide exposure was also noted among commercial pesticide applicators [32].

Twenty-two farmers had abnormal neurologic findings. Three out of 367 respondents have cerebellar dysfunction characterized by dysmetria, inability to walk with feet in tandem, and difficulty maintaining balance. Davies Ahmed and Freer already documented neurologic affection of exposed individuals [33]. Firestone, Smith-Weller, Franklin, et al. also concluded there is growing evidence linking pesticide exposures with idiopathic Parkinson's disease [34]. In another study, neurologic symptoms such as difficulty in concentrating, feeling irritable, memory difficulties, and difficulty understanding reading materials were also seen among farmers exposed to pesticides [35]. Dizziness, headaches, fatigue, and abdominal cramps were also reported in another study [36].

Blood indices among farmers were also investigated in this study. Certain hematological parameters were abnormal, namely hemoglobin which can lead to anemia. Similarly, lymphohematopoietic cancers was found among applicators [37], and aplastic anemia among farmers in Latin American countries [38].

### 3.9. Conclusions

The farmers for the most part were middle aged men who had been farming for more than 10 years and have also been using pesticides since the beginning of their agriculture practice.

Although 91% of the respondents reported that they wore proper clothing, boots and gloves. The proper protective clothing were also replaced by makeshift clothing that did not provide sufficient protection to pesticide exposure. The other practices that increased the risk for possible pesticide exposure were spraying against the wind as less than a half of them re-entered recently sprayed areas. Spillage of pesticides from either a defective back pack sprayer, while spraying the pesticide or while mixing were also risk factors to exposure.

The top three pesticides used were pyrethroids, carbamates and organophosphates. Fenvalerate

was the most used pyrethroid, followed by Lambda-cyhalothrin (Karate). Methamidophos was the most used organophosphate followed by Profenofos. Mancozeb (dithane) is the most used carbamate.

Mean corpuscular hemoglobin was the top abnormal laboratory value. However, it means nothing unless it is associated with an abnormal hemoglobin level. Hemoglobin is the next abnormal laboratory value. These findings are evidence of the hematotoxic effects of pesticide exposure.

The risk factors and work behaviors identified in this study could be utilized as a target for modification and improvement of safety practices among vegetable farmers who significantly contribute to the country's growth. A more in depth study is needed to differentiate between acute and chronic effects. Simple and flexible risk assessment as suggested in other occupational studies [39] should also be developed but conformed to the data gathered in this study.

This research is also a local level policy research that could be a basis for program intervention among vegetable farmers using intensive pesticides.

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