ORIGINAL ARTICLE

A Survey on Pesticide Use and Self-Reported Respiratory Health Symptoms Among Paddy Farmers in Tanjung Karang, Malaysia

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ABSTRACT

Introduction: Tanjung Karang is a paddy growing town in Selangor, Malaysia. The paddy farmers in Tanjung Karang were using pesticides to control pests from invading the crops during agricultural activities with limited knowledge of its deleterious effects on their health. **Objective:** This study aims to (i) determine the respiratory health symptoms of paddy farmers due to occupational exposure of commonly used pesticides through inhalation and (ii) assess correlations between climatological conditions and the concentrations of pesticides in personal air samples among paddy farmers in Tanjung Karang, Malaysia. **Methods:** A cross-sectional study was carried out to assess the occupational exposures to pesticides among 83 paddy farmers in Kampung Sawah Sempadan. The data were collected with face-to-face interviews with the farmers based on a set of questionnaire. **Results:** The self-reported respiratory health symptoms of paddy farmers were as follows: breathing difficulty (16.9%), chest pain (15.7%), cough (41.0%), phlegm (39.8%), and wheezing (18.1%). Simple logistic regressions analysis indicated that exposure to azoxystrobin, buprofezin, chlorantraniliprole, fipronil, isoprothiolane, pretilachlor, propiconazole, tricyclazole and trifloxystrobin were contributing factors that affect self-reported respiratory health symptoms in this study. Spearman's correlation coefficient test stated that the concentrations of chlorantraniliprole, fipronil and pymetrozine were affected by wind speed and temperature. **Conclusion:** The information obtained in this study is useful to understand the exposure of pesticides among paddy farmers and useful for risk management in the agricultural community.

Keywords: Air, Inhalation, Occupational exposure, Wind speed, Temperature

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INTRODUCTION

Pesticides are used almost everywhere that not only in agricultural fields, but also in homes, parks, schools, buildings, forests, and roads. The application of pesticides is often not very precise, and unintended exposures may occur to people in the general area where pesticides are applied and can cause adverse health effects to human (1).

Occupational exposure to pesticides in agriculture may cause acute and long-term health effects (2). The risk of health hazards due to the improper handling of some pesticides that leads to pesticide exposure depends not only on how toxic the ingredients are but also on the level of exposure (3). Pesticide exposure is an unavoidable reality for farmers because pesticides are in the air they breathe, the water they drink, the food they eat, and the soil they cultivate (4). Epidemiological studies carried out on farmers show a connection between repeated exposure to pesticides and specific chronic illnesses (5). Based on a study by Mamane et al. (6), which reviewed the available literature regarding the link between occupational exposure to pesticides and respiratory symptoms or diseases, they have suggested that occupational exposure to pesticides is associated with an increased risk of respiratory symptoms, asthma and chronic bronchitis. A study by Faria et al. (7) on pesticides and respiratory symptoms shows that the prevalence of asthma symptoms was 12% and chronic respiratory disease symptoms was 22% among farmers and the study results provide evidence that farming exposure to pesticides is associated with higher prevalence of respiratory symptoms.

There are many types and causes of pesticide incidents that cause farmers to experience unintentional pesticide exposures such as not following label instructions, applying too much pesticide product, applying pesticide product in breezy conditions, not following label safety instructions when using a pesticide and not wearing recommended personal protective equipment (8).

In handling pesticides, the risk is determined by the pesticide toxicity and whether there is an exposure to the pesticide and one way to reduce the risk of exposure is to use the proper personal protective equipment (PPE) (9). According to Malaysian standard code of recommended practice (MS 479:2012) developed by The Department of Standards Malaysia and SIRIM Berhad (10), all farmers that involves in preparation (mixing and loading) and application (spraying) of pesticides should wear appropriate protective clothing/devices as prescribed on the container's label.

Tanjung Karang is a paddy growing town in Selangor, Malaysia. The paddy farmers in Tanjung Karang were using pesticides to control pests from invading the crops during agricultural activities with limited knowledge of its deleterious effects on health especially on respiratory health. The lack of awareness among farmers regarding safety protocol while handling pesticides, may lead to chronic health effects after long term exposure, such as cancer, affecting the nervous system, irritate the skin or eyes and also affect the hormone or endocrine system in the body (11). Research on pesticide exposure to farmers is quite limited in Malaysia, where data limitations are still the major obstacle toward establishing clear environmental trends. In general, pesticide exposure history among farmers is obtained almost exclusively via self-reported information because farmers are self-employed and there are limited alternate sources of information regarding their exposure to pesticides (12). The concentrations of commonly used pesticides in personal air samples among paddy farmers in Tanjung Karang were previously reported in Hamsan et al. (13). This paper is the continuation of the study reported by Hamsan et al. (13) where the objectives of this study were to (i) determine the respiratory health symptoms of paddy farmers due to occupational exposure of commonly used pesticides through inhalation and (ii) assess correlations between climatological conditions and the concentrations of pesticides in personal air samples among paddy farmers in Tanjung Karang, Malaysia.

MATERIALS AND METHODS

Study area

This study was carried out in a paddy field located in Tanjung Karang, Kuala Selangor. It is part of the Barat Laut Paddy Project within the north of Selangor state which is in the southeastern part of peninsular Malaysia. Specifically, this study was conducted in Kampung Sawah Sempadan, a rice farming village where most of the communities in the area are involved in rice farming and exposed to pesticides. A cross-sectional study was carried out from December 2015 until February 2016, which was the paddy cultivation period in the study area.

Selection of sample

The study population consisted only adult male farmers from Kampung Sawah Sempadan, Tanjung Karang, Kuala Selangor as female farmers were absent in the study area. The inclusion criteria were (i) age of the farmers was between 18 years old to 60 years old, (ii) farmers who directly handled pesticides (preparation and spraying) in the paddy field, (iii) farmers who had chronic inhalation exposure of pesticides for more than one year. The sampling frame of this study was paddy farmers that fulfilled the stipulated inclusive criteria as mentioned and a name list of farmers in the study area was obtained from Farmers' Organization Authority in Tanjung Karang. Farmers were briefed on the study, and only those who met the inclusion criteria and gave written consent were recruited as study respondents. A total of 83 farmers were successfully recruited in this study through simple random sampling. With simple random sampling, there is an equal chance (probability) of selecting each unit from the population being studied.

Ethical considerations

The study was approved by the University Research Ethics Committee of Universiti Putra Malaysia, Selangor, Malaysia (JKEUPM) [Ref: FPSK (EXP15) P019].

Data collection

Data of this study were collected with face-to-face interviews with the farmers based on a set of questionnaire. The questionnaire was modified according to two standard questionnaires: (i) Recommended Respiratory Disease Questionnaires for Use with Adults in Epidemiological Research (14) and (ii) Vietnam: Pesticide Use Survey (15). The questionnaire comprises personal information, lifestyle, occupational background, pesticides usage information and self-reported respiratory health symptoms. The questionnaire was prepared in Malay language (local language in Malaysia). The farmers were interviewed to fill up the questionnaire after they finished their spraying activity and the average time for the farmers to complete the questionnaire was 15 minutes. The most applied pesticides in the study area were selected as the target compounds in the study by Hamsan et al. (13) and the final list of target compounds contained a total of 13 compounds, which were azoxystrobin, buprofezin, chlorantraniliprole, difenoconazole, fipronil, imidacloprid, isoprothiolane, pretilachlor, propiconazole, pymetrozine, tebuconazole, tricyclazole and trifloxystrobin. The concentrations of pesticides in personal air samples of farmers were collected and analyzed as described by Hamsan et al. (13). The results of personal air sampling have already been reported in Hamsan et al. (13) and the data were subsequently applied for the statistical analysis in the following section. The wind speed and temperature were recorded using a thermo anemometer (Model 451104Vane

Thermo-Anemometer, Extech, USA) during the personal air sampling.

Statistical analysis

Statistical Package for the Social Sciences (SPSS) version 22 was used to perform the statistical analysis. A pre-test was conducted to ensure the reliability and validity of the questionnaire used in this study. The pre-test was carried out on 20 farmers (24% of total number of sample size) in Kampung Sri Gambut, Sungai Burung, Tanjung Karang which have the same inclusion criteria as the respondents in the study area. Cronbach's alpha value was used to indicate the internal consistency reliability of the questionnaire used in this study. Cronbach's alpha of the pre-test showed the questionnaire was in an acceptable reliability, $\alpha = 0.79$. The descriptive data was presented in a range values with means and standard deviations (SD) for continuous variables while, data for categorical variables is presented in frequency and percentages (%). In this study, the correlation between climatological conditions (wind speed and temperature) during the farmers spraying activity and the concentration of pesticides in personal air samples was determined by using Spearman's rank correlation coefficient (Spearman's rho). Simple logistic regression was done to study the association between concentration of pesticides (azoxystrobin, buprofezin, chlorantraniliprole, difenoconazole, fipronil, imidacloprid, isoprothiolane, pretilachlor, propiconazole, pymetrozine, tebuconazole, tricyclazole and trifloxystrobin) to the self-reported respiratory health symptoms.

RESULTS

Socio-demographic information

Eighty-three paddy farmers were participated in this study. All of the paddy farmers that participated in this study were male and Malay with mean age of 44 years old, ranged from 18 to 59 years old and most of them were married (78.3%). The weight of respondents ranged from 45 kg to 120 kg and the mean body weight of paddy farmers was 69.72 kg. The body mass index (BMI) for all the respondents showed that majority of the farmers were in the range of normal or healthy weight. The mean height of respondents was 1.67 m which ranged from 1.53 m to 1.85 m. Based on the questionnaire, 67.5% of the paddy farmers were reported as smokers. The socio-demographic information of respondents is summarized in Table I.

Job and occupational history information

Table II shows the job and occupational history of the farmers. The mean of the years farmers worked as pesticide sprayers was 21 years, which ranged from 1 to 45 years. Some of the farmers started to involve in paddy farming since they were young to help their family in agricultural business.

Most of the farmers (74.7%) had other full time jobs before becoming a pesticide sprayer. As this study focused on inhalation route of exposure, occupational history of exposure to dust, gas and chemical was surveyed among the farmers. 73.5% of farmers reported that they were not exposed to dust in the history of their occupation, while 85.5% of them reported that they were not exposed to gas and chemical. The results showed that majority of the farmers were previously worked in an environment that free from respiratory health hazards.

Hazard classification information of target compounds

Table III summarizes the hazard classification and endocrine disruptor classification of pesticides for all the target compounds. The hazard classifications of all the target compounds in this study range from "unlikely to present acute hazard" to "moderately hazardous". Among all the 13 compounds, none was classified as "extremely hazardous" or "highly hazardous pesticides" because most of the farmers in the study area used subsidized pesticides by the government and government banned the practice of using class Ia and Ib pesticides in agriculture as it poses threats to human

Table I: Socio-demographic information of respondents

Variables	Mean ± SD	Minimum	Maximum
Age (years)	44.19 ± 12.28	18	59
Weight (kg)	69.72 ± 12.48	45	120
Height (m)	1.67 ± 0.07	1.53	1.85

Variables	Categories	Number of respondent (n)	Percentage (%)
Gender	Male	83	100
Race	Malay	83	100
Status	Single	18	21.7
	Married	65	78.3
BMI	Underweight	2	2.4
	Normal or Health weight	38	45.8
	Overweight	35	42.2
	Obese	8	9.6
Smokers	No	27	32.5
	Yes	56	67.5

Table II: Job and occupational history of respondents

Variables	Mean ± SD	Minimum	Maximum
Years as sprayer (years)	21.0 ± 13.8	1	45
Variables	**Categories**	**Frequency**	**Percentage (%)**
Other jobs before spraying pesticides	No	21	25.3
	Yes	62	74.7
Full time	No	25	30.1
	Yes	58	69.9
Exposure to dust	No	61	73.5
	Yes	22	26.5
Exposure to gas and chemical	No	71	85.5
	Yes	12	14.5

health (16). According to globally harmonized system (GHS) Hazard Statements, all the target compounds in this study have potential to cause inhalation, dermal and ingestion exposure to farmers and pymetrozine is listed as suspected of causing cancer, while tebuconazole is listed as suspected of damaging fertility or the unborn child. Some of the target compounds in this study were listed as either an endocrine disruptors compounds or suspected to possess an ability to disturb the endocrine system (Table III).

Pesticide exposure information of farmers

The pesticide exposure information was obtained by interviewing farmers using a set of questionnaire. The exposure time refers to the average number of hours spent by farmers in pesticides spraying activity daily. Exposure frequency is the number of days in a year the farmers exposed to pesticides. Exposure duration refers to the average number of years the paddy farmer exposed to pesticides. The average exposure time, exposure frequency and exposure duration of the farmers in the study area were 2 hours/day, 243 days/year and 21 years, respectively.

Self-reported respiratory health symptoms

Table IV summarized the self-reported respiratory health symptoms by the paddy farmers in this study. The self-reported respiratory health symptoms were breathing difficulty, chest pain, cough, phlegm, and wheezing. Among all the respiratory health symptoms, cough (41%) was the highest percentage of prevalence among the paddy farmers (Table IV). Cough is a symptom of acute exposure to pesticides (20). This finding is in line with a previous study by Dzulkifli et al. (21) who claimed that at least 72% of farmers from paddy growing area at Tanjung Karang had experienced acute poisoning symptoms when handling pesticides. The farmers were also asked in the questionnaire about the occurrence of self-reported respiratory health symptoms that they experienced throughout the year. All of them claimed that they experienced the symptoms not only during spraying season but also off of the spraying season.

Association between the concentration of pesticides and self-reported respiratory health symptoms

Simple logistic regression was applied to study the association of concentration of pesticides (azoxystrobin, buprofezin, chlorantraniliprole, difenoconazole, fipronil, imidacloprid, isoprothiolane, pretilachlor, propiconazole, pymetrozine, tebuconazole, tricyclazole and trifloxystrobin) to the self-reported respiratory

Table III: Hazard classification and endocrine disruptor classification of pesticides for all the target compounds

Target compounds	*WHO Classification	**GHS Hazard Statements	Endocrine disruptors (listed by EU and Colborn)
Azoxystrobin	U[a]	H331 [b]	NA[e]
Buprofezin	III[a]	H302; H320; H332; H373 [b]	NA[e]
Chlorantraniliprole	U[a]	H319; H335 [b]	NA[e]
Difenoconazole	II[a]	H302; H319; H332 [b]	Suspected (EU) [c]
Fipronil	II[a]	H301; H311; H330; H331; H372 [b]	Yes (Colborn) [d]
Imidacloprid	II[a]	H302 [b]	NA[e]
Isoprothiolane	II[a]	H302 [b]	NA[e]
Pretilachlor	U[a]	H315; H317; H331 [b]	NA[e]
Propiconazole	II[a]	H302; H317 [b]	Yes (EU) [c]
Pymetrozine	NA[e]	H332; H351 [b]	Yes (EU) [c]
Tebuconazole	II[a]	H320; H330; H361; H371; H373 [b]	Suspected (EU) [c]
Tricyclazole	II[a]	H301; H302 [b]	NA[e]
Trifloxystrobin	U[a]	H317; H319; H373 [b]	NA[e]

*Classification of active pesticide ingredients;
II = Moderately hazardous; III = Slightly hazardous; U = Unlikely to present acute hazard in normal use
**Globally Harmonized System of Classification and Labelling of Chemicals (GHS);
H301: Toxic if swallowed; H302: Harmful if swallowed; H311: Toxic in contact with skin; H315: Causes skin irritation; H317: May cause an allergic skin reaction; H319: Causes serious eye irritation; H320: Causes eye irritation; H330: Fatal if inhaled; H331: Toxic if inhaled; H332: Harmful if inhaled; H335: May cause respiratory irritation; H351: Suspected of causing cancer; H361: Suspected of damaging fertility or the unborn child; H371: May cause damage to organs; H372: Causes damage to organs through prolonged or repeated exposure; H373: May cause damage to organs through prolonged or repeated exposure
[a]WHO 2009 (16) [b]NCBI 2017 (17) [c]EU 2016 (18) [d]Colborn et al. 2005 (19) [e]Data were not available

Table IV: Self-reported respiratory health symptoms of the paddy farmers

Variables	Categories	Frequency	Percentage (%)
Breathing difficulty	No	69	83.1
	Yes	14	16.9
Chest pain	No	70	84.3
	Yes	13	15.7
Cough	No	49	59.0
	Yes	34	41.0
Phlegm	No	50	60.2
	Yes	33	39.8
Wheezing	No	68	81.9
	Yes	15	18.1
Asthma	No	83	100
	Yes	0	0
Serious respiratory diseases	No	83	100
	Yes	0	0

health symptoms. The p-value <0.25 showed that the concentrations of pesticides were a significant contributing factors to the self-reported respiratory health symptoms. Table V shows that the concentration of pretilachlor was a significant contributing factor of breathing difficulty symptom and concentration of isoprothiolane was a significant contributing factor of chest pain symptom. The concentrations of isoprothiolane, pretilachlor, propiconazole and tricyclazole were significant contributing factors to both cough and phlegm symptom. Lastly, the concentrations of azoxystrobin, buprofezin, chlorantraniliprole, fipronil, propiconazole and trifloxystrobin were significant contributing factors to wheezing symptom. Results showed that there was no significant association between the concentrations of difenoconazole, imidacloprid, pymetrozine, tebuconazole and all the self-reported respiratory symptoms in this study.

Table V: Relationship between the concentration of target pesticides in personal air samples, wind speed and temperature during sampling

Target compounds	Wind speed		Temperature	
	r	*p*-value	r	*p*-value
Azoxystrobin	-0.031	0.778	-0.191	0.084
Buprofezin	-0.014	0.901	-0.168	0.128
Chlorantraniliprole	-0.112	0.312	**-0.224***	**0.041**
Difenoconazole	-0.153	0.168	-0.185	0.094
Fipronil	**-0.231***	**0.036**	-0.191	0.083
Imidacloprid	-0.138	0.215	0.097	0.383
Isoprothiolane	0.054	0.629	-0.040	0.716
Pretilachlor	-0.047	0.671	-0.077	0.490
Propiconazole	0.018	0.875	0.030	0.788
Pymetrozine	**-0.217***	**0.049**	-0.024	0.827
Tebuconazole	-0.084	0.450	-0.194	0.079
Tricyclazole	-0.035	0.751	0.161	0.145
Trifloxystrobin	-0.013	0.910	-0.006	0.956

* Correlation is significant at the 0.05 level (2-tailed).

Correlations between climatological conditions and the concentrations of pesticides in personal air samples

The Spearman's correlation coefficient test was conducted to study the relationship between the concentration of target compounds in air samples, wind speed and temperature reading during the farmers spraying activity. Table VI shows the relationship between climatological conditions (wind speed and temperature reading) and all the concentration of the target compounds.

DISCUSSION

Association between the concentration of pesticides and self-reported respiratory health symptoms

Based on the results in this study, cough and phlegm symptoms were related to concentrations

Table VI: Association between the concentration of pesticides and the self-reported respiratory health symptoms

Concentration of pesticides	*p*-value[a]	*p*-value[b]	*p*-value[c]	*p*-value[d]	*p*-value[e]
Azoxystrobin	0.66	0.49	0.48	0.44	0.06*
Buprofezin	0.58	0.48	0.64	0.59	0.13*
Chlorantraniliprole	0.43	0.63	0.43	0.53	0.10*
Difenoconazole	0.81	0.33	1.00	0.50	0.58
Fipronil	0.33	0.33	0.93	0.88	0.20*
Imidacloprid	0.34	0.51	0.92	0.87	0.87
Isoprothiolane	0.28	0.02*	0.15*	0.09*	0.40
Pretilachlor	0.20*	0.87	0.19*	0.18*	0.55
Propiconazole	0.44	0.31	0.11*	0.07*	0.22*
Pymetrozine	0.98	0.81	0.34	0.72	0.65
Tebuconazole	0.26	0.30	0.63	0.27	0.87
Tricyclazole	0.75	0.70	0.06*	0.07*	0.72
Trifloxystrobin	0.60	0.31	0.59	0.47	0.12*

[a]Breathing difficulty, [b]Chest pain, [c]Cough, [d]Phlegm, [e]Wheezing. *Simple logistic regression is significant at the *p*-value <0.25 level.

of isoprothiolane, pretilachlor, propiconazole and tricyclazole. LeVan et al. (22) also reported a similar finding where an increase of cough and phlegm symptoms happened among farmers that applied pesticides. The inhalation of pesticides contaminated air during spraying activity of farmers could cause adverse effect to their respiratory health especially if the farmers do not obey the proper handling of pesticides procedure and also a prolonged duration of exposure to these pesticides (23). Another cross-sectional study in Southern Ghana showed that significant positive associations between: fumigants with wheezing; fungicides with wheezing and phlegm production; insecticides with chronic cough and wheezing; contact with pesticides with respiratory symptoms (24). Ye et al. (25) reported that there was strong evidence for an association between occupational pesticide exposure and asthma, especially in agricultural workers. Study by Hoppin et al. (26) reported private and commercial pesticides applicators were observed strong evidence of an association of organophosphates with wheeze. For private pesticides applicators in their study, the organophosphates chlorpyrifos, malathion, and parathion were positively associated with wheeze; for the commercial applicators, the organophosphates chlorpyrifos, dichlorvos, and phorate were positively associated with wheeze (26).

To summarize the results of simple logistic regression, the concentration of azoxystrobin, buprofezin, chlorantraniliprole, fipronil, isoprothiolane, pretilachlor, propiconazole, tricyclazole and trifloxystrobin were contributing factors that affect self-reported respiratory health symptoms in this study. From the results in this study, isoprothiolane, pretilachlor and propiconazole could affect most of the self-reported respiratory health symptoms, while wheezing was the most frequently reported symptom affected by pesticides.

Correlations between climatological conditions and the concentrations of pesticides in personal air samples

The relationship between the concentration of the target compounds in personal air samples and the wind speed reading during sampling was significant for fipronil (p=0.036) and pymetrozine (p=0.049). However there were weak relationships between the concentrations of pesticide and wind speed where r values for fipronil and pymetrozine were -0.231 and -0.217 respectively. The correlation coefficient was negative, indicating that when the wind speed increased, the concentration of fipronil and pymetrozine decreased. The results are in line with a study by Lov6sz et al. (27) which reported the concentration of chlorpyrifos-methyl in the air. To the best of author's knowledge, there is no study reported on the correlation of the target compounds in this study with the climatological conditions (wind speed and temperature reading). Therefore, the result was compared with Lov6sz et al. (27). The data obtained from the study Lov6sz et al. (27) showed that increased of wind speed decreased the measured chlorpyrifos-methyl concentrations in air. Such results could be due to the changing of wind direction during spraying activity, thus causing the sprayed pesticides drift from the spraying point and lead to the loss of a significant amount of concentration (28). This may pose health hazards for the population outside the spraying area (27). Besides that, the results also suggest that spraying activity should not be done during high wind speed as this may lead to less effective spraying of pesticide as the pesticide drift from the spraying area.

The relationship between the concentration of target compounds in air samples and the temperature reading during sampling was significant for chlorantraniliprole (p=0.041) but there was a weak relationship between the concentration of pesticide and temperature where the r value was -0.224 for chlorantraniliprole (Table V). The correlation coefficient was negative, indicating when the temperature increased, the concentration of chlorantraniliprole decreased. Same as wind speed, the results was also in line with the study by Lov6sz et al. (27) in which the results from the study showed that increasing temperature decreased the measured chlorpyrifos-methyl concentrations in air. This could be due to vapor drift, which occurs when the applied pesticide volatilize or evaporate and move off the application site, thus causing the significant loss of the concentration of pesticide (28). The volatility of some pesticides increases as temperatures rise and the highest potential for vapor drift is when conditions are hot and dry (29). From the results in this study the concentrations of pesticides of some target compounds (chlorantraniliprole, fipronil and pymetrozine) were affected by wind speed and temperature. Therefore, climatological conditions, such as wind speed and temperature should be considered during pesticides spraying activities.

Wind speed is the most important climatological factors influencing spray drift (30). According to Ontario (30), wind speed affects the distance a droplet will travel before it is deposited on the target site. Early morning often is the best times to apply pesticides. Windy conditions are more likely to occur around midday, when the temperature near the ground increases. This causes hot air to rise quickly and mix rapidly with the cooler air above it, favoring drift (30). Table VII describes various wind conditions and the potential for drift and advises whether or not to spray.

Hot and dry conditions increase the risk of spray drift because droplets rapidly evaporate and become fine droplets, vapour or particles of concentrated pesticide (31). In general, do not spray when air temperature is above 25°C. This reduces the chance of drift due to temperature inversions or evaporation. It also increases target deposition and coverage. Studies have shown that a sizable percentage of pesticides may never reach the intended target site because of spray drift (31). Significant

Table VII: Wind conditions and spraying recommendations

Wind speed	Description	Spraying
Still	May lead to vapour drift where finer droplets remain suspended in the air, prone to evaporation and drift long after spraying is completed	Do not spray
Light air	Suitable conditions	Spray
Light to gentle breeze	Ideal conditions	Spray
High	Higher wind speeds pose the most obvious risk of drift through, around or over target	Spray with caution or Do not spray

Source: Ontario, 2016 (30)

spray drift can damage or contaminate sensitive crops, poison bees, pose health risks to humans and animals, and/or contaminate nearby soil, water and air. It is impossible to eliminate drift, but it is possible to reduce it to a tolerable level.

CONCLUSION

The concentrations of pesticides of some target compounds in this study (chlorantraniliprole, fipronil and pymetrozine) were affected by wind speed and temperature. Therefore, climatological conditions, such as wind speed and temperature should be considered during pesticides spraying activities. The self-reported respiratory health symptoms reported by the paddy farmers in this study were as follows: cough (41.0%), phlegm (39.8%), wheezing (18.1%), breathing difficulty (16.9%), and chest pain (15.7%). The concentrations of azoxystrobin, buprofezin, chlorantraniliprole, fipronil, isoprothiolane, pretilachlor, propiconazole, tricyclazole and trifloxystrobin were contributing factors that affect self-reported respiratory health symptoms in this study. The results obtained in this study suggest that the farmers (i) should consider climatological conditions during the spraying activities to reduce the exposure of pesticides and (ii) should be aware that certain pesticides could deteriorate the respiratory health and (iii) should be equipped with proper PPE to reduce the exposure of pesticides through inhalation.

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REFERENCES

1. Lah K. Effects of Pesticides on Human Health. Toxipedia; 2011 [cited 2017 May 1]. Available from: http://www.toxipedia.org/display/toxipedia/Effects+of+Pesticides+on+Human+Health
2. Hu R, Huang X, Huang J, Li Y, Zhang C, Yin Y, et al. Long- and Short-Term Health Effects of Pesticide Exposure: A Cohort Study from China. PLoS One. 2015; 10:1–13.
3. Kim K-H, Kabir E, Jahan SA. Exposure to pesticides and the associated human health effects. Science of The Total Environment. 2017; 575:525–535.
4. Mercola J. Farm Workers Bear the Brunt of Pesticide Poisoning. DrMercola; 2015 [cited 2017 May 1]. Available from: http://articles.mercola.com/sites/articles/archive/2015/08/26/pesticide-poisoning.aspx
5. ANSES. Occupational exposure to pesticides. French Agency Food, Environ Occupational Health & Safety.; 2014 [cited 2017 May 1]. Available from: https://www.anses.fr/en/content/occupational-exposure-pesticides
6. Mamane A, Baldi I, Tessier J-F, Raherison C, Bouvier G. Occupational exposure to pesticides and respiratory health. European Respiratory Review. 2015; 24:306–319.
7. Faria NMX, Facchini LA, Fassa AG, Tomasi E. Pesticides and respiratory symptoms among farmers. Revista De Saude Publica. 2005; 39:973–981.
8. USEPA. Common Causes of Pesticide Incidents. United States Environ Protection Agency; 2016 [cited 2017 May 1]. Available from: https://www.epa.gov/pesticide-incidents/common-causes-pesticide-incidents
9. Hansen P, Walker T. Agricultural Pesticide Protective Equipment. Colorado State University Extension.; 2017 [cited 2017 May 1]. Available from: http://extension.colostate.edu/topic-areas/agriculture/agricultural-pesticide-protective-equipment-5-021/
10. DOS. The safe handling of agricultural pesticides - Code of recommended practice (Malaysian Standard; MS 479:2012).Department of Standards Malaysia; 2012 [cited 2017 May 31]:1–28. Available from: http://stg.jsm.gov.my/documents/372014/372056/MS+4792012+The+safe+handling+of+agricultural+pesticides+-+Code+of+recommended+practice+(First+revision)-723228.pdf/b6caea23-1e34-4c85-bd76-af4112d4a454?version=1.0&previewFileIndex=
11. USEPA. Human Health Issues Related to Pesticides. United States Environ Protection Agency; 2017 [cited 2017 May 1]. Available from: https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/human-health-issues-related-pesticides
12. Hoppin JA, Umbach DM, London SJ, Alavanja MCR, Sandler DP. Chemical Predictors of Wheeze among Farmer Pesticide Applicators in the Agricultural Health Study. American Journal of Respiratory and Critical Care Medicine. 2002; 165:683–689.
13. Hamsan H, Ho Y Bin, Zaidon SZ, Hashim Z,

Saari N, Karami A. Occurrence of commonly used pesticides in personal air samples and their associated health risk among paddy farmers. Science of The Total Environment. 2017; 603–604:381–389.
14. Ferris B. Epidemiology standardization project II: Recommended respiratory disease questionnaires for use with adults and children in epidemiological research. American Journal of Respiratory and Critical Care Medicine. 1978; 118:7–53.
15. Berg H. Pesticide use in rice and rice – fish farms in the Mekong Delta, Vietnam. Crop Protection. 2001; 20:897–905.
16. WHO. The WHO recommended classification of pesticides by hazard and guidelines to classification: 2009. World Health Organization.; 2009 [cited 2017 May 1]:1–78. Available from: http://www.who.int/ipcs/publications/pesticides_hazard_2009.pdf
17. NCBI. Pubchem. National Center for Biotechnology Information.; 2017 [cited 2017 May 1]. Available from: https://pubchem.ncbi.nlm.nih.gov/
18. EU. EU Endocrine disruptor priority list. European Union; 2016 [cited 2017 May 1]. Available from: http://ec.europa.eu/environment/chemicals/endocrine/strategy/substances_en.htm
19. Colborn T, Dumanoski D, Myers JP. Widespread Pollutants with Endocrine-disrupting Effects; 2005 [cited 2017 May 1]. Available from: http://www.ourstolenfuture.org/Basics/chemlist.htm
20. Roberts JR, Reigart JR. 2013. Recognition and Management of Pesticide Poisonings. 6th Edit. Washington, D.C.: U.S. Environmental Protection Agency.
21. Dzulkifli AR, Latiff AA, Majid MIA, Awang R. 2011. Case Study: Malaysian Information Service on Pesticide Toxicity. International Labour Organization. [cited 2017 May 1]. Available from: http://www.iloencyclopaedia.org/part-iii-48230/resources-information-and-osh/29-22-resources-information-and-osh/case-study-malaysian-information-service-on-pesticide-toxicity
22. LeVan TD, Essen S Von, Romberger DJ, Lambert GP, Martinez FD, Vasquez MM, et al. Polymorphisms in the CD14 gene associated with pulmonary function in farmers. American Journal of Respiratory and Critical Care Medicine. 2005; 171:773–779.
23. Woodruff TJ, Kyle AD, Bois FY. Evaluating Health Risks from Occupational Exposure to Pesticides and the Regulatory Response. Environmental Health Perspective. 1994; 102:1088–1096.
24. Quansah R, Bend JR, Abdul-Rahaman A, Armah FA, Luginaah I, Essumang DK, et al. Associations between pesticide use and respiratory symptoms: A cross-sectional study in Southern Ghana. Environmental Research. 1994; 150:245–254.
25. Ye M, Beach J, Martin JW, Senthilselvan A. Occupational pesticide exposures and respiratory health. International journal of environmental research and public health. 2013 Nov 28;10(12):6442-71.
26. Hoppin JA, Umbach DM, London SJ, Lynch CF, Alavanja MC, Sandler DP. Pesticides and adult respiratory outcomes in the agricultural health study. Annals of the New York Academy of Sciences. 2006 Sep 1;1076(1):343-54.
27. Lovбsz M-E, Dumitraşcu I, Gurzău ES. Human Exposure to an Organophosphate Pesticide During Spraying. Indian Journal of Applied Research. 2014; 4:44–46.
28. Fishel FM, Ferrell JA. Managing Pesticide Drift. Institute of Food and Agricultural Sciences.; 2016 [cited 2017 May 1]. Available from: http://edis.ifas.ufl.edu/pi232
29. Nicolai D, Stahl L. When is it too Windy to Spray? University of Minnesota; 2015 [cited 2017 May 1]. Available from: http://blog-crop-news.extension.umn.edu/2015/06/when-is-it-too-windy-to-spray.html
30. Ontario. How Weather Conditions Affect Spray Applications; 2016 [cited 2017 November 17]. Available from: http://www.omafra.gov.on.ca/english/crops/facts/09-037w.htm
31. Defra. Pesticides: Code of practice for using plant protection products; 2011 [cited 2017 November 17]. Available from: http://adlib.everysite.co.uk/adlib/defra/content.aspx?doc=155712&id=155848