Journal of Agromedicine

ISSN: 1059-924X (Print) 1545-0813 (Online) Journal homepage: https://www.tandfonline.com/loi/wagr20

Difference in Accidents, Health Symptoms, and Ergonomic Problems between Conventional Farmers Using Pesticides and Organic Farmers

Noppanun Nankongnab, Pornpimol Kongtip, Mathuros Tipayamongkholgul, Ariya Bunngamchairat, Suthart Sitthisak & Susan Woskie

To cite this article: Noppanun Nankongnab, Pornpimol Kongtip, Mathuros Tipayamongkholgul, Ariya Bunngamchairat, Suthart Sitthisak & Susan Woskie (2020) Difference in Accidents, Health Symptoms, and Ergonomic Problems between Conventional Farmers Using Pesticides and Organic Farmers, Journal of Agromedicine, 25:2, 158-165, DOI: 10.1080/1059924X.2019.1607793

To link to this article: https://doi.org/10.1080/1059924X.2019.1607793

Published online: 26 Apr 2019.

JOURNAL OF AGROMEDICINE
2020, VOL. 25, NO. 2, 158–165
https://doi.org/10.1080/1059924X.2019.1607793

Taylor & Francis
Taylor & Francis Group

ORIGINAL RESEARCH

Difference in Accidents, Health Symptoms, and Ergonomic Problems between Conventional Farmers Using Pesticides and Organic Farmers

Noppanun Nankongnab [a], Pornpimol Kongtip[a], Mathuros Tipayamongkholgul[b], Ariya Bunngamchairat[a], Suthart Sitthisak[c], and Susan Woskie[d]

[a]Department of Occupational Health and Safety, Faculty of Public Health, Mahidol University, Center of Excellence on Environmental Health and Toxicology, Commission on Higher Education, Ministry of Education, Bangkok, Thailand; [b]Department of Epidemiology, Faculty of Public Health, Mahidol University, Bangkok, Thailand; [c]Phitsanulok Provincial Public Health Office, Phitsanulok, Thailand; [d]Department of Public Health, University of Massachusetts Lowell, Lowell, MA, USA

ABSTRACT

Organic farming has been promoted in Thailand by King Rama the ninth. In addition to being healthier for consumers, organic farming is healthier for agricultural workers. The cross-sectional study was conducted to investigate the frequency of chronic disease conditions, accidents, health symptoms, and ergonomic problems among 243 conventional (pesticide using) farmers and 235 organic farmers. Data were collected using questionnaires in face-to-face interviews. The results indicated symptoms that could be related to pesticide exposure (skin rashes, water blisters, headache, dizziness, and loss of appetite) were significantly higher among conventional farmers than organic farmers. The organic farmers reported significantly more health symptoms such as hives, chest pain, mild fever, flatulence, and frequent urination than the conventional farmers. The organic farmers reported significantly more pain, numbness, or weakness in the wrists/hands, fingers, upper back, hips, and ankles/feet than conventional farmers.

KEYWORDS

Organic farmers; ergonomics; health symptoms; accident; pesticide

Introduction

Agriculture is one of the most hazardous occupations worldwide. Workers in agriculture have at least twice the risk of dying on the job as workers in other sectors.[1] The International Labour Office estimates that at least 170,000 agricultural workers are killed each year. The World Health Organization estimates the total cases of pesticide poisoning worldwide at between 2 and 5 million workers annually, of which 40,000 are fatal.[1] From 2002 to 2010 in Thailand, 17,481 agricultural injuries (16.9% of all injuries) were reported to the National Injury Surveillance (NIS) System of Thailand. Leading causes of occupational injuries in Thai agriculture were being struck by a thrown or falling object (12.2%), contact with agricultural machinery (9.6%), and foreign body entering the eye or skin (8.0%).[2] In addition to injuries, other potential agricultural-related health problems include pesticide-related illnesses, musculoskeletal disorders, dermatitis, respiratory conditions, reproductive health problems, climate-caused illnesses, communicable diseases, bladder and kidney disorders, eye and ear problems, and cancers.[3–5] Exposure to pesticides constitutes a major occupational risk that may result in poisoning and death, work-related cancer, and reproductive impairments.[6] Few studies of musculoskeletal disorders among agricultural workers have been conducted in Thailand. Maize farmers experienced work-related musculoskeletal disorders attributed to inappropriate work postures, repetitive movements, and long hours of working.[7] Maize farmers reported pain in the lower back (44.1%) and in their hands (39.1%).[8] Rice farmers reported musculoskeletal problems from lifting heavy pumping hoses (66%), carrying heavy seed containers (76%), carrying pesticide sprayers (69.6%), incorrect postures (16.6%), and lifting heavy rice sacks (75.1%).[9]

Organic farming is being accepted and promoted worldwide, including in Thailand.[10] HRH King Bhumibol Adulyadej offered a model of small farm management based on the Sufficiency Economy Philosophy (SEP).[11] The SEP principles

CONTACT Noppanun Nankongnab noppanun.nan@mahidol.ac.th Department of Occupational Health and Safety, Faculty of Public Health, Mahidol University, Center of Excellence on Environmental Health and Toxicology, Commission on Higher Education, Ministry of Education, 420/1 Rajvithi Road, Rajthavee, Bangkok, 10400, Thailand

focus on moderation, self-reliance, and care for the environment. Organic farmers have started producing their own organic fertilizer for their own use and later for sale.[11] The issues of reducing synthetic fertilizers and pesticides, efficiently using farm-based resources,[12] and expecting better health outcomes are some of the reasons behind the shift from conventional farming to organic farming.[10] In the urban areas of Thailand, organic products are becoming more popular among consumers who believe such produce is healthier and more environmentally friendly.[13] The benefits of organic farming include higher soil organic matter and nitrogen, lower fossil energy inputs, yields similar to those of conventional systems, and conservation of soil moisture and water resources. Organic farms plant crops to feed livestock and use manure as nitrogen sources for fertilizers.[14] The current Thai government supports expanding organic farms to 800,000 hectares by 2021.[15] To date, little research has been conducted on the benefits of organic farming in Thailand. One study compared the opinions and attitudes toward organic vs. conventional rice Farming,[10] and another compared environmental awareness, economic orientation, and farming practices between US organic and conventional farmers.[16] Our study focused on comparing the health and safety experience of farmers using conventional pesticides and organic farmers in Thailand and examined the self-reported frequencies of farm injuries, health symptoms, and musculoskeletal disorders to determine whether these groups differed significantly in these work-related outcomes.

Material and method

Subject recruitment

Subjects were recruited through the local health-promoting hospitals/primary care units (HPH/PCUs) and community leaders in the designated study areas. We hired a site officer from the local community to work with the HPH/PCU and community leaders in each area to recruit and interview subjects. The sample size was calculated for our longitudinal study, which consists of four interviews within 2 years and accounts for loss to follow-up. Exclusions included being treated for diabetes, high blood pressure, and thyroid and heart diseases at recruitment. Conventional farmers were recruited from two provinces – Nakhon Sawan and Phitsanulok – and organic farmers from one province – Yasothorn. Conventional farmers were recruited from vegetable farmers in Bung Pra Subdistrict, Phitsanulok province and rice farmers from Soa Hin Subdistrict, Phitsanulok province. Sugarcane farmers were recruited in Kaothong subdistrict, Nakorn Sawan province. One farmer who sprayed pesticides was selected in each household. The organic farmers were certified organic farmers who were mainly rice farmers, but they also grew vegetables, fruits, and some other plants to improve soil quality. Subjects were recruited from five villages in Yasothon province, including Kham Mad, Na So, Nong Yor, Bark Reou, and Loeng Nok Tha. At recruitment, we enrolled 261 conventional farmers and 235 organic farmers. When the second interview was conducted 8 months later, the cohort declined to 243 conventional farmers and 235 organic farmers, with response rates of 93.1% and 100.0%, respectively. The group loss to follow-up was mainly from vegetable farmers, because they had a lot of work to do and did not have time to participate in the study. The study protocol of this research was approved by the Ethics Committee of Human Research, Faculty of Public Health, Mahidol University (MUPH 2015–146).

Questionnaires

The questionnaires consisted of several sections including general characteristics, chronic health problems, health behaviour, injury, machinery use, musculoskeletal problems, and agricultural activities. Questionnaire content validity was reviewed with three experts in this field. A trial of the questionnaire was run with agricultural workers in different areas and readjusted according to the suggestions of the subjects and interviewers, after review by content experts. The questionnaire interviews, which took about 30 minutes, were conducted at the subject's home by field site staff, who were trained by the research team.

Data analysis

All data were analyzed using SPSS, Version 18 (SPSS Co., Ltd., Bangkok, Thailand). The descriptive results were analyzed as mean, standard deviation, minimum, and maximum. The Chi square test, Fisher's exact test, and independent t-test were used to measure the differences between the two groups. A Poisson generalized log-linear model was used to compare organic and conventional farmers for the risk of reporting health symptoms, injuries, and musculoskeletal disorders (MSD) in the past 3 months, as well as to compare patterns of agricultural machinery use between these groups. Due to the high percentage of the population with the outcomes of interest, we used a Poisson log-linear function to investigate the factors, such as farm type, that increased the risk of an adverse outcome.[17–19] In the case of MSDs, the adjusted relative risks were also estimated using a model that controlled for all other risk factors that were significant in univariate analyses.

Results

Characteristics of conventional and organic farmers

In this study, the average age of the organic farmers was significantly higher than the conventional pesticide using farmers (50.2 vs. 53.1 years). More male participants were identified among the conventional farmers compared with organic farmers (74.4% vs. 50.4%). Most farmers in both groups had low education (elementary school only) (Table 1). Conventional farmers grew rice (76.2%), sugarcane (37.4%), bananas (6.5%), vegetables (37.9%), and fruit (5.1%). Most conventional farmers did not do all farming processes themselves (64.5%). Many reported not doing rice harvesting, soil preparation, and sowing rice seeds themselves. The second/extra jobs (besides farming) reported by conventional farmers included agricultural laborer on other farms, office work, construction, hair dresser, etc. Most organic farmers used to be conventional farmers. Only 29 (12%) of the organic farmers never worked with pesticides. Organic farmers grew rice (96.8%), sugarcane (6.6%), bananas (55.7%), vegetables (84.5%), and fruit (48.3%). Like conventional farmers, most organic farmers did not do all the farming processes themselves (61.5%). They reported not doing rice harvesting or soil preparation using tractors, rather hiring others to do this.

Table 1. Characteristics of conventional pesticide using and organic farmers.

Variables	Conventional farmers (n = 243) n (%)	Organic farmers (n = 235) n (%)	p-value
Age			
Min-max	18–69	28–79	
Mean(SD)	50.2(11.0)	53.1(10.3)	0.005†
Sex			
Male	160(74.4)	115(50.4)	<0.001†
Female	55(25.6)	113(49.6)	
Educational level			
Elementary or lower	136(63.8)	126(57.0)	0.182
High school	72 (33.8)	84(38.0)	
Bachelor or higher	5(2.3)	11(5.0)	
Marital status			
Single	21(10)	13(6)	0.051
Married	179(85.6)	185(84.9)	
Widowed/divorced	9(4.3)	20(9.2)	
Pesticide use (year)			
1–10 years	33(15.4)	62(31.8)	<0.001*
11–20 years	31(14.5)	77(39.5)	
21–30 years	59(27.6)	32(16.4)	
>30 years	91(42.5)	24(12.3)	
Agricultural work time (hour/day)			
Min-max	1–10	1–12	
Mean (SD)	4.6(2.0)	4.5(2.4)	0.591
Second/Extra current job	50(23.6)	127(57.2)	<0.001*
Blood glucose (mg/dl)			
Normal (≤125)	188(86.6)	209(90.5)	0.201
Abnormal(>126)	29(13.4)	22(9.5)	
Blood pressure (mmHg)			
Normal (<140&<90)	127(61.4)	147(69)	0.099
Abnormal (>140&≥90)	80(38.6)	66(31)	
Metabolic syndrome**			
Nonmetabolic syndrome	132(61.7)	137(59.6)	0.648
Metabolic syndrome	82(38.3)	93(40.4)	

Significant differences at $p < 0.05$ (t-test (†), Chi-square (*) and Fisher's exact test (ǂ))

** metabolic syndrome is defined as the presence of three or more of these risk factors: (1) abnormal BMI; (2) abnormal blood triglycerides; (3) abnormal HDL cholesterol; (4) elevated blood pressure (5) and abnormal blood glucose

Table 2. Comparison of types of machine used for farming in the past three months for conventional (n = 243) versus organic farmers (n = 235).

Types of machine used	Conventional vs organic farmers Crude RR (95%CI)	p-value
Hand tractors	1.60(1.29–2.00)	<0.001*
Riding tractors	3.02(1.98–4.61)	<0.001*
Backpack spraying	22.89(12.04–43.51)	<0.001*
Water pump	2.08(1.55–2.79)	<0.001*
Thai farm truck (rot i-taen)	3.39(0.71–16.13)	0.126
Truck	1.21(0.49–3.01)	0.684

*Significant differences at P < 0.05

The second/extra jobs reported by organic farmers included agricultural laborer on other farms, office work, construction, drivers, house keepers, etc. Conventional farmers used machinery at a higher frequency than organic farmers (Table 2). They had a significantly higher rate of use of hand tractors (RR 1.60), tractors (RR 3.02), water pumps (RR 2.08), and backpack sprayers (RR 22.89) than organic farmers. There was no significant difference in their use of Thai farm trucks (rot i-taen) or trucks.

Injuries among conventional and organic farmers

Most injuries, including cuts from machinery or sharp knives, falls from high places, electric shock, slips and falls, animal bites, and crushing by machine or injuries from overturned machines were not significantly different between conventional and organic farmers (Table 3). Among conventional farmers, several types of accidents were significantly more likely to be reported, including substances/pesticides splashed in the eyes or on the body (RR 147.59) and struck by machinery/tools (RR 2.97)

Table 3. Comparison of injuries in the past three months for conventional (n = 243) versus organic farmers (n = 235).

Type of Injuries	Conventional vs organic farmers Crude RR (95%CI)	p-value
Cut from sharp machine or knife	1.16(0.84–1.59)	0.364
Fall from a high place	0.42(0.08–2.14)	0.295
Electric shock	0.17(0.02–1.44)	0.105
Slips and falls	1.27(0.86–1.87)	0.230
Substance/pesticides splashed into the eyes/on body	147.59(20.83–1045.65)	<0.001*
Snake, rat or reptile bites	0.26(0.03–2.32)	0.229
Struck by machine/tool	2.97(1.19–7.38)	0.019*
Injury from overturned machine	2.62(0.83–8.22)	0.099
Crushed by the machine	3.14(0.64–15.39)	0.158

*Significant differences at P < 0.05

Table 4. Comparison of health symptoms reported over the past three months by conventional (n = 243) versus organic farmers (n = 235).

Type of health problem	Conventional vs organic farmers Crude RR (95%CI)	p-value
Skin itchy	1.00(0.82–1.22)	0.986
Skin rash	1.36(1.04–1.77)	0.023*
Urticarial skin (hives with red, raised, itchy bumps)	0.09(0.04–0.22)	<0.001*
Skin dry and cracked	0.91(0.52–1.62)	0.758
Water blister	2.02(1.31–3.13)	0.002*
Chest pain	0.42(0.21–0.86)	0.017*
Mild fever in the afternoon/ evening	0.38(0.19–0.75)	0.006*
Loss of appetite/Weight loss	2.38(1.43–3.95)	0.001*
Flatulence	0.36(0.23–0.55)	<0.001*
Eye pain	0.87(0.57–1.33)	0.522
Blurred vision	1.07(0.85–1.35)	0.577
Irritated eyes	1.18(0.85–1.64)	0.335
Reduced hearing ability	1.75(1.27–2.41)	0.001*
Headache	1.60(1.24–2.07)	<0.001*
Dizziness	1.43(1.08–1.90)	0.013*
Upper and lower limb weakness	0.66(0.41–1.04)	0.076
Frequent urination	0.56(0.33–0.94)	0.027*
Jaundice	1.05(0.27–4.15)	0.943
Runny nose	1.03(0.81–1.30)	0.825
Cough	1.05(0.84–1.31)	0.687
Short breath	1.21(0.68–2.14)	0.513
Wheezing	0.78(0.40–1.51)	0.452
Depression	0.60(0.18–2.02)	0.411

*Significant differences at p < 0.05

Health symptoms reported by conventional and organic farmers

Symptoms reported in the past 3 months could be either acute events or a more chronic condition. The relative risk of skin rash (RR 1.36) or water blisters (2.02) was higher for conventional farmers than for organic farmers (Table 4). Although, urticarial skin (hives) (RR 0.09), chest pain (RR 0.42), and mild fever in the afternoon or evening (RR 0.38) were significantly more common among organic farmers than conventional farmers. Conventional farmers complained of loss of appetite/weight loss (RR 2.38) significantly more frequently than organic farmers, but significantly more organic farmers reported flatulence (RR 0.36) and frequent urination (RR 0.56) than conventional farmers. A significantly higher frequency of conventional farmers reported hearing loss (RR 1.75), headaches (RR 1.6), and dizziness (RR 1.43) than organic farmers. The two groups reported similar

Table 5. Comparison of musculoskeletal disorders (MSD) over the past three months reported by conventional (n = 243) versus organic farmers (n = 235).

	Conventional vs organic farmers		Conventional vs organic farmers	
MSD	Crude RR (95%CI)	p-value	Adjusted[a] RR(95%CI)	p-value
Neck	0.62(0.39–0.98)	0.039*	0.73(0.45–1.20)	0.211
Shoulder	0.59(0.31–1.10)	0.095	0.78(0.39–1.56)	0.483
Elbow	0.26(0.03–2.31)	0.227	0.47(0.04–5.64)	0.549
Wrist/hand	0.08(0.01–0.61)	0.014*	0.08(0.02–0.33)	<0.001*
Fingers	0.06(0.01–0.46)	0.006*	0.08(0.01–0.93)	0.044*
Upper back	0.17(0.08–0.37)	<0.001*	0.22(0.10–0.52)	<0.001*
Lower back	0.92(0.69–1.22)	0.540	1.03(0.72–1.48)	0.854
Hip	0.30(0.17–0.52)	<0.001*	0.33(0.17–0.64)	0.001*
Knee	0.87(0.52–1.44)	0.579	0.98(0.52–1.85)	0.956
Ankle/feet	0.17(0.05–0.55)	0.003*	0.17(0.05–0.55)	0.003*

[a]Poisson general log linear model adjusted for sex, age, BMI, using hand tractor, riding tractor and having a second/extra job
*Significant difference at $p < 0.05$

frequencies of eye pain, blurred vision, eye irritation, upper and lower limb weakness, jaundice, runny nose, cough, being short of breath, and wheezing.

MSD of conventional and organic farmers

In crude analyses, organic farmers reported significantly more musculoskeletal pain, numbness, or weakness in the past 3 months in the neck, wrists/hands, fingers, upper back, hips, and ankles/feet compared to conventional farmers (Table 5). These two groups reported similar rates of MSDs for the shoulders, elbows, lower back, and knees. After controlling for other factors significantly associated with reporting an MSD in the past 3 months (sex, age, body mass index, using hand tractor, using riding tractor and having a second/extra job), organic farmers still had a significantly higher risk of MSDs of the wrists/hands, fingers, upper back, hip, and ankle/feet (Table 5).

Discussion

The rapid development of the organic market and consumer concerns for greener and safer agricultural practices is leading to the promotion of organic farming in developing countries.[20] Thailand is at an early stage in organic farming; organic production is dominated by food products such as rice and fresh vegetables. The main reasons for converting to organic farming include better health for agricultural workers, a more promising market with greater profits,[20] and environmental protection.[21]

Regarding injuries, farming remains the most dangerous occupation in the United States, with an annual death rate of 24.9/100,000 persons compared with 3.5/100,000 persons for all workers.[22–24] In Thailand, the mortality rate among injured farmers was 0.5 deaths per 100 workers during 2002–2010.[2] In this study, significantly more conventional farmers (65.9%) reported chemical splashes in the eyes or on the body than organic farmers (0.4%). These injuries can occur when mixing or spraying pesticides, which organic farmers do not use.[25] Organic farmers use manure from animals raised in their area to fertilize plants. They used fermented extracts or herbs mixed with water to prevent pests.

Significantly more conventional farmers reported being hit by machinery or tools than organic farmers, and although not significant, they also reported more injuries from overturned machinery. This may be explained by the significantly higher frequency of machinery use (hand tractors, riding tractors, water pumps) by conventional farmers. The number of farmers hit by machinery/tools (7.9%) was similar to the number reported by the National Injury Surveillance (NIS) System of Thailand for injury by contact with agricultural machinery (9.6%).[2] Ensuring that everyone has had proper training when operating a piece of machinery is important to prevent farm injuries and fatalities. In addition, every farm family should be trained in life-saving techniques, including first aid and CPR.[26]

Both conventional and organic famers reported similar rates of health symptoms such as skin itching and dry/cracked skin, but conventional farmers

reported more skin rash and water blisters, while organic farmers reported more urticarial skin rash (hives). Occupational irritant dermatitis is an inflammation caused by the direct contact of a substance with the skin. Signs of contact dermatitis include redness, blisters, scales, or crusts. Plants and agricultural pesticides are the main causative agents of skin conditions.[27,28] In addition, farmers are exposed to outdoor environments with high levels of solar radiation, which increases the risk of skin irritation and disease.[27] Urticaria may be caused by an allergy to urine and protein from farm animals such as buffalos, cows, and chickens or the use of manure in fertilizing plants.

Conventional farmers (20.1%) reported a significantly higher rate of loss of appetite/weight than organic farmers (8.4%). Loss of appetite/weight loss could be caused by chronic exposure to organophosphate and carbamate pesticides.[29] Headache and dizziness were also reported significantly more frequently in conventional farmers. This could also be attributed to exposure to organophosphate and carbamate pesticides.[29] Organic farmers reported considerably higher flatulence than that of conventional farmers (30.2% vs. 10.7%). Flatulence could be caused by eating more vegetables high in fiber which cannot be digested solely by the stomach, requiring the bacteria in the intestines to digest it.[30]

Both conventional and organic farmers reported similar frequencies of eye pain, blurred vision, and irritated eyes. This study reported slightly fewer eye problems than a study of seasonal and migrant farm workers in North Carolina who reported having eye pain and redness (40%) after working all day exposed to agricultural chemicals, wind, dust, and UV rays.[31] Conventional farmers (35%) reported hearing loss more frequently than organic farmers (20%), most likely because conventional farmers reported more frequent use of farm machinery and tools than organic farmers. Previous measurements of the noise level on farms reported levels of 85–106 dBA for orchard spraying and 74–112 dBA for tractor use.[32] Use of ototoxic organophosphate insecticides by conventional farmers may also contribute to their higher rates of self-reported hearing loss.[33,34]

Farmers face many respiratory hazards such as organic and inorganic dust, chemical fertilizers and pesticides, and bacteria and fungi.[35] In the United States, farmers reported a higher prevalence of current respiratory symptoms (wheezing, cough, and phlegm) than the general population.[36] In this study, we did not find any difference in the frequency of respiratory symptoms between conventional and organic farmers. Depression was scarcely reported by either conventional or organic farmers in this study. This result differs from one study covering 567 farmers aged 37 to 78 years in France, where 14.6% self-reported treatment or hospitalization for depression.[37]

Regarding the overall number of health problems reported by both groups of farmers, conventional farmers reported slightly more health problems than organic farmers. Similar results were found by Setboonsarng and Lavado who reported that organic households experienced less illness than conventional households, most likely due to a combination of reduced exposure to pesticides, improved food security, better nutrition, and better sanitation conditions in general.[38]

This study shows that organic farmers have a significantly higher frequency of reporting MSDs in most areas of the body compared to conventional farmers. An MSD study of eastern Cambodian fruit farm workers in Thailand also found that farmers commonly reported pain in the neck (23.9%), shoulders (21.6%), wrists and hands (11.7%), upper back (28.2%), lower back (41.3%), hips and thighs (17.1%), knees (13.5%), and ankles (11.1%).[39] Examples of activities or environments leading to occupational MSDs include rapid or repetitive motion, forceful exertion, excessive mechanical force, awkward or non-natural postures, and vibration.[40,41] The higher frequency of MSDs among organic farmers is probably caused by the hard work entailed in taking care of plants without using chemical pesticides, including squatting near the plants and using their hands to remove weeds. Organic farmers also expressed concern about reducing the costs of farming by performing most agricultural chores by themselves, hiring only some helpers for tasks that they cannot do alone, such as harvesting rice. They make organic fertilizer using manure by themselves and bio-ferment water for use for spraying as a pesticide to inhibit small animals and insects. Also, although controlled for in the full model, the age of the organic farmers was

significantly higher than that of the chemical farmers. Older workers are known to have less physical strength and endurance.[42]

Limitation of this study

This was a cross-sectional study involving baseline data from a longitudinal study. The information regarding injuries, health symptoms, and MSDs was collected using a questionnaire, and no medical verification of these outcomes was conducted. This study may have recall bias, because farmers may not be able to recall all of their health symptoms for the 3-month lookback period. The age and gender of the conventional farmers and organic farmers were significantly different, which could have influenced machine use, injury risk, or health symptoms.

Conclusion

A higher percentage of conventional farmers had substances/pesticides splashed into their eyes or on their bodies, and more were struck by machines/tools than organic farmers. The conventional farmers had a higher risk of health symptoms that could be related to pesticide exposure (skin rash, blisters, headaches, dizziness) than organic farmers. Finally, organic farmers who did not use pesticides may be at increased risk of ergonomic problems due to the strenuous manual labor involved in organic farming. Future research should employ a longitudinal study to investigate the difference in the incidence rate of these outcomes between conventional and organic farmers

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The research was supported by the NIH Fogarty International Center, National Institutes of Environmental Health Sciences, Center for Disease Control and the NIH under Award Number [U01TW010091 and U2RTW010088].

ORCID

Noppanun Nankongnab http://orcid.org/0000-0002-7256-3385

References

1. ILO. ILO warns on farm safety agriculture mortality rates remain high pesticides pose major health risks to global workforce. http://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_008027/lang–en/index.htm. 2018. Accessed April 8, 2018.
2. Sangchom S, Meanpoung P, Sangchatip A. Trends and characteristics of occupational injuries in thailand, 2002–2010. *Osir*. 2014;7:8–15.
3. Kirkhorn SR, Schenker MB. Current health effects of agricultural work: respiratory disease, cancer, reproductive effects, musculoskeletal injuries, and pesticide-related illnesses. *J Agric Saf Health*. 2002;8:199–214.
4. Mobed K, Gold EB, Schenker MB. Occupational health problems among migrant and seasonal farm workers. *West J Med*. 1992;157:367–373.
5. Rainbird G, O'Neill D. Occupational disorders affecting agricultural workers in tropical developing countries: results of a literature review. *Appl Ergon*. 1995;26:187–193.
6. ILO. Safety and health in agriculture. http://www.ilo.org/wcmsp5/groups/public/—ed_protect/—protrav/—safework/documents/publication/wcms_110193.pdf. 2000. Accessed April 8, 2018
7. Chanprasit C, Kaewthummanukul T. Occupational health hazards, work-related illness and injury, work behaviors among informal workforce: case study in baby corn planting farmer group. *Public Health J Burapha Univ*. 2010;5:40–50.
8. Manothum A, Arphorn S. Study of ergonomic risks of maize farmers in Lampang. *J Ind Technol*. 2018;14:73–81.
9. Buranatrevedh S, Sweatsriskul P. Model development for health promotion and control of agricultural occupational health hazards and accidents in Pathumthani, Thailand. *Ind Health*. 2005;43:669–676.
10. Chouichom S, Yamao M. Comparing opinions and attitudes of organic and non-organic farmers towards organic rice farming system in north-eastern thailand. *J Org Syst*. 2010;5:25–35.
11. Ministry of Foreign Affairs Kingdom of Thailand. Sufficiency economy philosophy: Thailand's path towards sustainable development goals. http://www.mfa.go.th/SEPforSDGs/SEPThailandsPathtowardsSDGS/SEP_Thailands_Path_towards_SDGs.pdf. 2015. Accessed April 8, 2018.
12. Ramesh P, Singh M, Rao A Organic farming: its relevance to the indian context. 2005.
13. Roitner-Schobesberger B, Darnhofer I, Somsook S, Vogl CR. Consumer perceptions of organic foods in bangkok, thailand. *Food Policy*. 2008;33(2):112–121. doi:10.1016/j.foodpol.2007.09.004.
14. Pimentel D, Hepperly P, Hanson J, Douds D, Seidel R. Environmental, energetic, and economic comparisons of organic and conventional farming systems.

BioScience. 2005;55(7):573–582. doi:10.1641/0006-3568(2005)055[0573:EEAECO]2.0.CO;2.
15. Biodiversity Sustainable Agriculture Food Sovereignty Action Thailand. Agricultural development in strategic plan 12 to increase sustainable agricultural areas of 800,000 hectare. http://www.biothai.net/node/30498. 2018. Accessed April 8, 2018.
16. McCann E, Sullivan S, Erickson D, De Young R. Environmental awareness, economic orientation, and farming practices: a comparison of organic and conventional farmers. *Environ Manage*. 1997;21:747–758.
17. McNutt LA, Wu C, Xue X, Hafner JP. Estimating the relative risk in cohort studies and clinical trials of common outcomes. *Am J Epidemiol*. 2003;157:940–943.
18. Zou G. A modified poisson regression approach to prospective studies with binary data. *Am J Epidemiol*. 2004;159:702–706.
19. Greenland S. Model-based estimation of relative risks and other epidemiologic measures in studies of common outcomes in case-control studies. *Am J Epidemiol*. 2004;160(4):301–305. doi:10.1093/aje/kwh221.
20. FAO. Organic vegetable farming supported by the royal project foundation: Thailand. http://www.fao.org/fileadmin/user_upload/ivc/PDF/Asia/05_Vidyarthi_organic_vegetables_Thailand.pdf. 2015. Accessed April, 8 2018.
21. Tipraqsa P, Craswell ET, Noble AD, Schmidt-Vogt D. Resource integration for multiple benefits: multifunctionality of integrated farming systems in northeast thailand. *Agric Syst*. 2007;94(3):694–703. doi:10.1016/j.agsy.2007.02.009.
22. Meyers JM, Miles JA, Faucett J, et al. Priority risk factors for back injury in agricultural field work: vineyard ergonomics. *J Agromedicine*. 2004;9:433–448.
23. United States Department of Labor. Agricultural operations. https://www.osha.gov/dsg/topics/agriculturaloperations/. 2013. Accessed April 8, 2018.
24. Wibowo RKK, Soni P. Farmers'injuries, discomfort and its use in design of agricultural hand tools: A case study from east java, indonesia. *Agric Agric Sci Procedia*. 2016;9:323–327. doi:10.1016/j.aaspro.2016.02.142.
25. Damalas CA, Eleftherohorinos IG. Pesticide exposure, safety issues, and risk assessment indicators. *Int J Environ Res Public Health*. 2011;8(5):1402–1419. doi:10.3390/ijerph8051402.
26. Rains GC Agricultural safety: Preventing injuries. https://secure.caes.uga.edu/extension/publications/files/pdf/B%201255_4.PDF. 2017. Accessed April 8, 2018.
27. Brueggeman M, Rosenthal E Agricultural skin diseases. http://worh.org/files/AgHealth/skin.pdf. 2001. Accessed April 8, 2018.
28. Spiewak R. Pesticides as a cause of occupational skin diseases in farmers. *Ann Agric Environ Med*. 2001;8:1–5.
29. Extension. Symptoms of pesticide poisoning. https://articles.extension.org/pages/17854/symptoms-of-pesticide-poisoning. 2012. Accessed December 3, 2018.
30. Honestdoc. Bloating: cause and treatment by yourself. https://www.honestdocs.co/bloating-treatment-causes. 2018. Accessed April 8, 2018.
31. Quandt SA, Elmore RC, Arcury TA, Norton D. Eye symptoms and use of eye protection among seasonal and migrant farmworkers. *South Med J*. 2001;94:603–607.
32. Durgut MR, Celen IH. Noise levels of various agricultural machineries. *Pak J Biol Sci*. 2004;7(6):895–901. doi:10.3923/pjbs.2004.895.901.
33. Crawford JM, Hoppin JA, Alavanja MC, Blair A, Sandler DP, Kamel F. Hearing loss among licensed pesticide applicators in the agricultural health study. *J Occup Environ Med*. 2008;50(7):817–826. doi:10.1097/JOM.0b013e31816a8caf.
34. Hoshino ACH, Pacheco-Ferreira H, Taguchi CK, Tomita S, de Fatima Miranda M. Ototoxicity study in workers exposed to organophosphate. *Braz J Otorhinolaryngol*. 2008;74(6):912–918. doi:10.1016/S1808-8694(15)30153-1.
35. Linaker C, Smedley J. Respiratory illness in agricultural workers. *Occup Med*. 2002;52(8):451–459. doi:10.1093/occmed/52.8.451.
36. Hoppin JA, Umbach DM, Long S, Rinsky JL. Respiratory disease in united states farmers. *Occup Environ Med*. 2014;71(7):484–491. doi:10.1136/oemed-2013-101983.
37. Weisskopf MG, Moisan F, Tzourio C, Rathouz PJ, Elbaz A. Pesticide exposure and depression among agricultural workers in france. *Am J Epidemiol*. 2013;178(7):1051–1058. doi:10.1093/aje/kwt089.
38. Setboonsarng S, Lavado RF Does organic agriculture lead to better health among organic and conventional farmers in thailand? An investigation of health expenditure among organic and conventional farmers in thailand. https://www.adb.org/sites/default/files/publication/155984/adbi-wp129.pdf. 2008. Accessed April 8, 2018.
39. Thetkathuek A, Meepradit P, Sa-Ngiamsak T. A cross-sectional study of musculoskeletal symptoms and risk factors in cambodian fruit farm workers in eastern region, thailand. *Safety and Health at Work*. 2018;9(2):192–202. doi:10.1016/j.shaw.2017.06.009.
40. Fathallah FA. Musculoskeletal disorders in labor-intensive agriculture. *Appl Ergon*. 2010;41(6):738–743. doi:10.1016/j.apergo.2010.03.003.
41. Niu S. Ergonomics and occupational safety and health: an ILO perspective. *Appl Ergon*. 2010;41(6):744–753. doi:10.1016/j.apergo.2010.03.004.
42. Benjamin K, Wilson S Facts and misconceptions about age, health status and employability. http://www.hse.gov.uk/research/hsl_pdf/2005/hsl0520.pdf. 2005. Accessed December 3, 2018.