PREVALENCE OF AND FACTORS ASSOCIATED WITH OCCUPATIONAL HEALTH PROBLEMS AMONG HILL FARMERS IN THAILAND

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Abstract. Hill farmers, those who work on land that is partly or completely hilly, may be at increased risk for occupational health problems. In this study, we aimed to determine the prevalence of and factors associated with occupational health complaints among hill farmers in northern Thailand. Participants were recruited from hill farmers using convenience random sampling. These subjects included ethnic Thais and Karen. Inclusion criteria for study subjects were: any farmer who worked on partially or completely hilly land for more than 6 months, being aged >18 years and being able to communicate with the researchers. The exclusion criterion was having a congenital physical disability. Study subjects were interviewed following a structured questionnaire containing 4 sections: 1) socioeconomic characteristics, 2) work characteristics, 3) occupational hazard exposures in the previous six months and 4) occupational health problems in the previous six months. We used univariate and multivariate binary logistic regression analysis to determine factors associated with occupational health problems. A total of 600 subjects were included in the study; 55% male. The mean (±standard deviation (SD)) age of subjects was 45.6 (±12.8) (range: 18-85) years; 51% were aged 30-49 years. Sixty-three percent of subjects self-identified as being ethnic Karen. The mean (±SD) number of years the subjects worked in agriculture were 23.8 (±14.8) years. Seven percent of subjects stated they worked on land that was completely hilly and the other 93% worked on land that was only partially hilly. The most prevalent occupational health problems were: low back pain (79%), shoulder and neck pain (78%) and heat exhaustion (74%). On multivariate analysis factors significantly associated with low back pain were: having to bend or twist during their work (adjusted odds ratio (aOR) = 7.3, 95% confidence interval (CI): 4.2-12.7; $p<0.001$) and work on a completely hill farming terrain (aOR = 4.0, 95%CI: 1.2-13.9; $p=0.027$).

The factor significantly associated with shoulder and neck pain was: having to lift heavy loads (aOR = 3.2, 95%CI: 1.8-5.6; p<0.001). The factors significantly associated with heat exhaustion was: expose to heat from working outdoors (aOR = 11.4, 95%CI: 4.9-26.9; p<0.001). In summary, the prevalences of back pain, shoulder and neck pain and heat exhaustion in our study population were high. The factors significantly associated with these complaints were working in a bent or twisted posture, work on a completely hilly farm, lift heavy loads and being exposed to heat working outdoors. We conclude there is need to develop methods to reduce these symptoms and apply them in this study population. Further studies are needed to determine if these developed interventions can reduce these symptoms in this study population.

Keywords: occupational health problem, hill, farmers, self-report

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INTRODUCTION

Agricultural work can be hazardous. Agricultural workers may be exposed to occupational hazards resulting in injuries or illnesses such as heat exhaustion, hearing impairment, musculoskeletal disorders, mental illnesses, respiratory diseases and skin diseases (Nordgren and Charavaryamath, 2018; Kaewthummnukul *et al*, 2020; Kongtip *et al*, 2018). This population may not be included in occupational safety, health and work environment regulations in Thailand (Kaewboonchoo *et al*, 2015). Inadequate occupational health data about agricultural workers may result in inadequate protection of this group.

Thirty-four percent of the Thai working population is engaged in agriculture and 47% of the land in Thailand is used for agriculture, including hilly areas (NSO Thailand, 2022). Twenty of the 76 provinces in Thailand have hilly agricultural areas, defined as a 35-degree slope or an elevation of >500 meters above sea level (HRDI, 2019). Hill farming, defined as farming in partially or completely hilly areas (Kunstadter and Chapman, 1978), is common in northern Thailand. Hill farming is more dangerous than regular farming on flat land due to the slippery nature of the terrain (Chaothaworn *et al*, 2014; Juntaracena *et al*, 2018).

The hill tribe people, such as the Karen, Hmong, Yao and Lahu tribes often live and work in hilly

areas (Thai Department of Social Development and Welfare, 2016). Previous studies of Hmong farmer exposures, such as frequently bending over and lifting heavy objects, can cause musculoskeletal problems (Neitzel *et al*, 2014; de Castro *et al*, 2014). Not using personal protective equipment can increase the risk of blade injuries and pesticide exposure (Neitzel *et al*, 2014). Previous studies of Thai hill tribe populations focused primarily on general health conditions, such as mental health problems, alcohol abuse and hepatitis B infection (Apidechkul, 2019; Detpitukyon *et al*, 2018; Singkhorn *et al*, 2021). None looked at occupational hazards and problems due to farming in hilly areas. It is important to understand the prevalence of occupational health problems and their associated factors among hill farmers in northern Thailand in order to develop programs to prevent these problems.

In this study, we aimed to determine the prevalence of and factors associated with occupational health complaints among hill farmers in northern Thailand in order to inform efforts to reduce these complaints.

MATERIALS AND METHODS

Study location

This cross-sectional study was conducted in Ban Cham Pui, Ban Klang and Ban Mae San Villages, Ban Dong Subdistrict, Mae Mo District, Lampang Province, Thailand during the growing season of May-September 2021. These 3 villages have partly or completely hilly agricultural land (Thai Department of Social Development and Welfare, 2016). These 3 villages are located at 542, 510 and 774 meters above sea level, respectively. They have steep slopes (Fig 1). Sixty percent of the population in these 3 villages are ethnic Karen and the remaining 40% are ethnic Thais.

Study population and recruitment

The minimum sample size calculated to be needed for the study using a method previously described (Daniel and Cross, 2019) was 542; a total of 600 subjects were recruited into the study to account for missing data.

The inclusion criteria for study subjects were: being a farmer who farmed partially or completely hilly land for more at least 6 months, being aged >18 years and being able to communicate with the researcher. The exclusion criterion was having a congenital physical disability. Subjects were chosen using convenience random sampling.

This study protocol was approved by the Ethics Review Committee for Human Research, Boromarajonani College of Nursing, Nakhon Lampang, Thailand (E 2564-010). Each subject gave written informed consent prior to inclusion in the study

Data collection tool and analysis

Each study subject was interviewed

by a qualified village health volunteer who had the subject complete a questionnaire developed after review of the literature (Chaothaworn *et al*, 2014; Kongtip *et al*, 2018; Nankongnab *et al*, 2020). The questionnaire consisted of 52 items divided into 4 sections: 1) socioeconomic characteristics (15 items), 2) work characteristics (7 items), 3) occupational hazards exposure in the previous six months (16 items) and 4) occupational health problems in the previous six months (14 items). Most of the questions were multiple-choice type but some were open-ended answer type. Our questionnaire was reviewed by 3 experts, 1 specialized in occupational health, 1 specialized in epidemiology and 1 specialized in nursing. The overall index of item–objective congruence (IOC) was 0.96. We pilot tested the questionnaire among 30 hill farmers from a non-study area to validate the instrument.

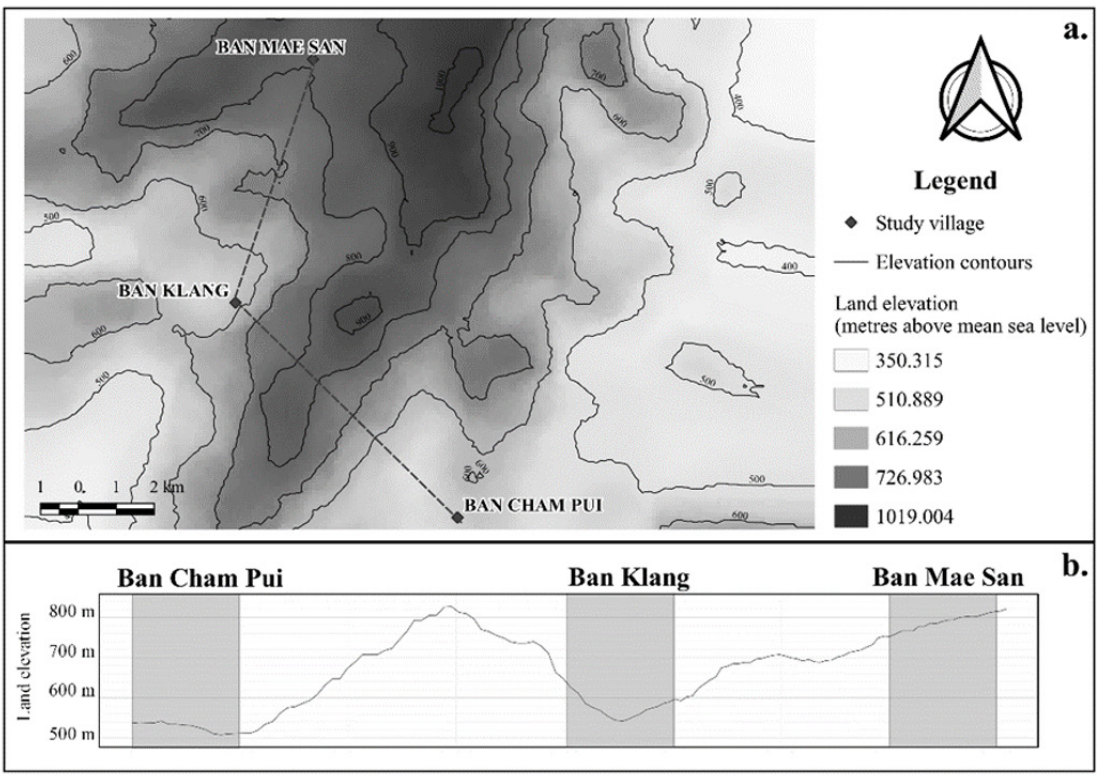

Fig 1 - Elevation contour map of the study area (a) and a cross section (b) of the study area

We used univariate and multivariate logistic regression analyses to determine associations between exposure to occupational hazards in the previous six months (yes/no) and self-reported occupational health problems (yes/no). A *p*-value <0.05 was considered statistically significant for both univariate and multivariate analyses. Variables included in the multivariate analysis were: study area, subject sex, subject age, whether the subject self-identified as an ethnic Karen, subject education level, household income, number of household members, subject history of cigarette smoking and alcohol consumption, physical activity level, being a community leader, health information and healthcare-seeking behavior. Crude odds ratios (OR) and adjusted odds ratios (aOR) with 95% confidence intervals (CIs) were used for univariate and multivariate analyses. Frequencies, percentages, means and standard deviations were used where applicable to describe characteristics, reported factors and occupational health problems. All analyses were performed using IBM Statistical Package for the Social Sciences (SPSS) for Windows, version 23 (IBM Corp, Armonk, NY).

RESULTS

General sociodemographic characteristics

A total of 600 subjects were included in the study, 55% male. The mean (±standard deviation (SD)) age of subjects was 46 (±13) (range: 18-85) years; 51% were aged 30-49 years. Sixty-three percent of study subjects self-identified as ethnic Karen. Fifty-four percent of subjects had a primary school education level. Sixty-three percent of subjects had a household income of <THB5,000 (USD150) per month and 67% of subject households had >3 members. Thirty-three percent of subjects were current smokers and 34% of subjects were current alcohol drinkers. Thirty-two percent of subjects had physical activity 6-7 days per week. Eighty-two percent of subjects had been to see a physician or health care worker due to a work-related condition. Fifty-four percent of subjects had seen occupational health-related information from the media (Table 1).

Work related characteristics

Ninety-three percent of subjects farmed on partially hilly land and 7% on completely hilly land. The mean (±SD) number of years the subjects worked in agriculture was 24 (±15) years; the mean (±SD) number of hours worked per day was 6.8 (±1.4) and the mean number of days worked per week was 5.3 (±1.3). Ninety percent of subjects worked in cultivation, 46% did wild foraging and 22% worked with livestock. Nineteen percent of subjects reported using at least one type of pesticide. The percentages of subjects who used

personal protective equipment were as follows: trousers (95%), boots (91%), long sleeve shirts (90%), hats (85%), gloves (62%) and a balaclava (56%) (Table 2).

Factors associated with occupational health problems

Among farmers who had to work outdoors and were exposed to heat (93%), 74% reported a history of heat

Table 1

Sociodemographic characteristics of study subjects (N = 600)

Characteristics	*n* (%)
Sex	
Male	330 (55.0)
Female	270 (45.0)
Age (years)	
<30	60 (10.0)
30-39	156 (26.0)
40-49	152 (25.3)
50-59	134 (22.3)
≥60	98 (16.4)
Self-identified as Karen	
No	225 (37.5)
Yes	375 (62.5)
Education level	
Illiterate	91 (15.2)
Primary school	325 (54.2)
Junior high school	97 (16.1)
Senior high school or vocational certificate	64 (10.7)
High vocational certificate or Bachelor's or higher degree	23 (3.8)
Monthly household income	
≤THB5,000 (USD150)	375 (62.5)
>THB5,000 (USD150)	225 (37.5)

Table 1 (cont)

Characteristics	*n* (%)
Number of household members	
≤3	201 (33.5)
>3	399 (66.5)
Smoking history	
Never	362 (60.3)
Former	40 (6.7)
Current	198 (33.0)
Alcohol drinking history	
Never	368 (61.3)
Former	31 (5.2)
Current	201 (33.5)
Frequency of physical activity	
None	102 (17.0)
1-3 days/week	157 (26.2)
4-5 days/week	149 (24.8)
6-7 days/week	192 (32.0)
Healthcare seeking history	
Physician or other healthcare worker	493 (82.2)
Self-medicating or no treatment	107 (17.8)
Source of occupational health information	
Television, radio, website or social media	322 (53.7)
Neighbor, acquaintance, or family member	20 (3.3)
Village health volunteer	258 (43.0)
Community leader role	
No	527 (87.8)
Yes	73 (12.2)

THB: Thai baht; USD: US dollar

Table 2

Characteristics of agricultural work among study subjects (N = 600)

Characteristics	*n* (%)*
Terrain	
Partially hilly	558 (93.0)
Completely hilly	42 (7.0)
Mean ± SD number of years worked in agriculture	23.8 ± 14.8
Mean ± SD number of hours worked per a day	6.8 ± 1.4
Mean ± SD number of days worked per week	5.3 ± 1.3
Farming activities in the previous 6 months	
Cultivation	543 (90.5)
Wild forage	275 (45.8)
Livestock	131 (21.8)
Used at least one type of pesticide	
No	485 (80.8)
Yes	115 (19.2)
Type of personal protective equipment used	
Balaclava	333 (55.5)
Gloves	373 (62.2)
Boots	546 (91.0)
Hat	509 (84.8)
Trousers	569 (94.8)
Long sleeve shirt	541 (90.2)

*Unless otherwise stated

SD: standard deviation

exhaustion, 27% had been sunburned and 6% reported having a history of syncope due to heat exposure (Table 3). Subjects who reported heat were significantly more likely to have a history of heat exhaustion (aOR = 11.4; 95% CI: 4.9-26.9; $p<0.001$) but heat exposure was not significantly

Table 3

Self-reported occupational hazard exposures and occupational health problems among study subjects (N = 600)

Characteristics	No *n* (%)	Yes *n* (%)
Occupational hazard exposures		
Heat exposure from the working outdoors	40 (6.7)	560 (93.3)
Agricultural machinery use	293 (48.8)	307 (51.2)
Sharped machinery or tools use	53 (8.8)	547 (91.2)
Broken machine or tool use	451 (75.2)	149 (24.8)
Worked on a slippery surface	261 (43.5)	339 (56.5)
Lifted heavy loads	407 (67.8)	193 (32.2)
Body bending or twisting	119 (19.8)	481 (80.2)
Work-related stress	157 (26.2)	443 (73.8)
Insecticide use	558 (93.0)	42 (7.0)
Herbicide use	496 (82.7)	104 (17.3)
Fungicide use	570 (95.0)	30 (5.0)
Occupational health problems		
Heat exhaustion	159 (26.5)	441 (73.5)
Heat syncope	565 (94.2)	35 (5.8)
Sunburn	438 (73.0)	162 (27.0)
Hearing difficulty	526 (87.7)	74 (12.3)
Work-related accident	537 (89.5)	63 (10.5)
Slip, trip, or fall	341 (56.8)	259 (43.2)
Shoulder or neck pain or injury	135 (22.5)	465 (77.5)
Low back pain or injury	128 (21.3)	472 (78.7)
Leg or foot pain or injury	169 (28.2)	431 (71.8)
Having >1 symptom of work-related stress	446 (74.3)	154 (25.7)
Respiratory symptoms after pesticides use	543 (90.5)	57 (9.5)
Skin symptoms after pesticide use	575 (95.8)	25 (4.2)

associated with having been sunburned or having had heat-induced syncope (Table 4).

Fifty-one percent of the subjects used at least one type of agricultural machinery (Table 3). The types of agricultural machinery used reported by subjects were: hand mower (46%), hand tractor (17%), mechanized water pump (12%), battery backpack sprayer (9%) and motorized backpack sprayer (4%). Subjects who used agricultural machinery were significantly more likely to have had a work-related accident (aOR = 2.3, 95%CI: 1.1-4.6; p = 0.020). Twelve percent of subjects reported having hearing difficulty but we found no significant association between hearing loss and using agricultural machinery (Table 4). Ninety-one percent of subjects had used sharp machines or tools; 25% had used broken machines or tools (Table 3). The subjects who had used broken machines or tools were significantly more likely to have had a work-related accident (aOR = 7.9, 95%CI: 4.1-15.5; p<0.001) but we found no significant association between using a sharp tool and having a work-related accident (Table 4).

Working on a slippery surface was reported by 57% of subjects and 43% of subjects reported having had a slip, trip or fall (Table 3). Those who had worked on a slippery surface were significantly more likely to have had a slip, trip or fall than those who had not (aOR = 4.4, 95%CI: 2.8-6.9; p<0.001) (Table 4).

Eighty percent of subjects reported having to bend or twist during work and 32% reported having to lift heavy loads. Seventy-none percent of subjected reported having an injury or pain in the low back, 78% in the shoulder or neck and 72% in the leg or foot. Skeletomuscular problems were the most frequently reported type of work-related health problem among study subjects (Table 3). Subjects who had to lift heavy loads as part of their work (32%) were significantly more likely to report shoulder or neck pain or injury (aOR = 3.2, 95%CI: 1.8-5.6; p<0.001), low back pain or injury (aOR = 2.5, 95%CI: 1.4-4.3; p = 0.002) or leg or foot pain or injury (aOR = 2.0, 95%CI: 1.3-3.3; p = 0.004). Those who had to bend or twist during work were significantly more likely to have low back pain or injury (aOR = 7.3, 95%CI: 4.2-12.7; p<0.001), have leg or foot pain or injury (aOR = 4.2, 95%CI: 2.5-7.0; p<0.001) or have shoulder or neck pain or injury (aOR = 2.9, 95%CI: 1.8-4.8; p<0.001) (Table 4).

Seventy-four percent of subjects were stressed about work and 26% had stress related symptoms, such as insomnia, anorexia, concentration difficulties or irritability (Table 3). We found a significant association between having work related stress and having at least one stress-related symptom (aOR = 4.7, 96%CI: 2.6-8.6, p<0.001) (Table 4).

Table 4

The association between self-reported occupational hazard exposure and occupational health problems among study subjects

Factors	Crude OR (95% CI)	*p*-value	*Adjusted OR (95% CI)	*p*-value
Heat exposure due to working outdoors (yes/no)				
Heat exhaustion	11.6 (5.4-25.1)	<0.001	11.4 (4.9-26.9)	<0.001
Heat syncope	0.8 (0.2-2.6)	0.643	1.2 (0.3-5.3)	0.784
Sunburn	3.5 (1.2-10.1)	0.018	2.7 (0.9-7.9)	0.080
Agricultural machinery use (yes/no)				
Hearing difficulty	1.1 (0.7-1.9)	0.596	1.1 (0.6-2.2)	0.676
Work-related accident	2.2 (1.3-3.9)	0.005	2.3 (1.1-4.6)	0.020
Sharp machine or tool use (yes/no)				
Work-related accident	2.1 (0.6-6.8)	0.238	2.4 (0.6-9.1)	0.197
Broken machine or tool use (yes/no)				
Work-related accident	5.8 (3.4-10.1)	<0.001	7.9 (4.1-15.5)	<0.001
Worked on a slippery surface (yes/no)				
Slip, trip, or fall	5.3 (3.7-7.6)	<0.001	4.4 (2.8-6.9)	<0.001
Low back pain or injury	1.6 (1.1-2.3)	0.023	1.2 (0.8-2.0)	0.383
Leg or foot pain or injury	1.1 (0.7-1.5)	0.786	0.9 (0.6-1.5)	0.859

Table 4 (cont)

Factors	Crude OR (95% CI)	*p*-value	*Adjusted OR (95% CI)	*p*-value
Lifted heavy load (yes/no)				
Shoulder or neck pain or injury	3.0 (1.8-4.9)	<0.001	3.2 (1.8-5.6)	<0.001
Low back pain or injury	2.4 (1.5-3.9)	<0.001	2.5 (1.4-4.3)	0.002
Leg or foot pain or injury	1.9 (1.3-2.9)	0.002	2.0 (1.3-3.3)	0.004
Body bending or twisting (yes/no)				
Shoulder or neck pain or injury	3.4 (2.2-5.2)	<0.001	2.9 (1.8-4.8)	<0.001
Low back pain or injury	5.3 (3.4-8.2)	<0.001	7.3 (4.2-12.7)	<0.001
Leg or foot pain or injury	3.2 (2.1-4.8)	<0.001	4.2 (2.5-7.0)	<0.001
Work-related stress (yes/no)				
Having >1 symptom of work-related stress	3.7 (2.1-6.3)	<0.001	4.7 (2.6-8.6)	<0.001
Insecticide use (yes/no)				
Respiratory symptoms after pesticide use	42.2 (19.8-90.0)	<0.001	20.1 (7.2-55.7)	<0.001
Skin symptoms after pesticide use	37.5 (15.2-92.9)	<0.001	27.3 (7.3-101.1)	<0.001
Hearing difficulty	2.8 (1.3-5.8)	0.006	4.6 (1.8-11.8)	0.002
Herbicide use (yes/no)				
Respiratory symptoms after pesticides use	78.6 (32.2-191.8)	<0.001	130.3 (31.4-541.7)	<0.001
Skin symptoms after pesticide use	70.1 (16.2-303.2)	<0.001	82.0 (13.2-508.3)	<0.001
Hearing difficulty	1.9 (1.1-3.4)	0.020	2.9 (1.3-6.6)	0.011

Table 4 (cont)

Factors	Crude OR (95% CI)	*p*-value	*Adjusted OR (95% CI)	*p*-value
Fungicide use (yes/no)				
Respiratory symptoms after pesticide use	24.2 (10.7-54.5)	<0.001	10.9 (3.9-31.0)	<0.001
Skin symptoms after pesticide use	9.3 (3.6-24.6)	<0.001	4.1 (1.2-13.4)	0.021
Hearing difficulty	2.3 (0.9-5.5)	0.067	2.9 (1.1-8.4)	0.043

CI: confidence interval; OR: odds ratio

*Adjusted for the study area, sex, self-identifying as Karen, age, education, household income, number of household members, cigarette smoking, alcohol consumption, physical activity frequency, community leader role, health information and healthcare-seeking

Seventeen percent of subjects reported using herbicide on their farm, 7% reported using insecticide and 5% reported using fungicide. The most common symptoms reported by those after using pesticide were respiratory symptoms (10%) and skin symptoms (4%) (Table 3). Those who reported respiratory or skin symptoms were most likely to have used an herbicide followed by an insecticide and a fungicide (Table 4). Having used an insecticide (aOR = 4.6, 95%CI: 1.8-11.8; p = 0.002), an herbicide (aOR = 2.9, 95%CI: 1.3-6.6; p = 0.011) or a fungicide (aOR = 2.9, 95%CI: 1.1-8.4; p = 0.043) were significantly positively associated with hearing loss (Tables 3 and 4).

The factors significantly associated with working on a completely hilly area among subjects were: having a sunburn (aOR = 3.7, 95%CI: 1.8-7.5; p<0.001), slipping, tripping or falling (aOR = 2.7, 95%CI: 1.3-5.6; p = 0.010), having low back pain or injury (aOR = 4.0, 95%CI: 1.2-13.9; p =0.027) and having work-related stress (aOR = 2.9, 95%CI: 1.5-5.9; p = 0.003) (Table 5).

DISCUSSION

In our study, most of our subjects were exposed to heat outdoors, increasing their risk for heat-related illness, similar to previous studies from India (Venugopal *et al*, 2015) and Iran (Heidari *et al*, 2015). We found a significant association between heat exhaustion and heat exposure working outdoors similar to the findings of

Table 5

Association between type of terrain, partially or completely hilly, and selected problems among study subjects

Factors	Crude OR (95%CI)	*p*-value	*Adjusted OR (95%CI)	*p*-value
Heat exhaustion	2.8 (1.1-7.3)	0.033	2.6 (0.9-7.0)	0.068
Heat syncope	1.3 (0.4-1.3)	0.708	0.9 (0.2-3.5)	0.826
Sunburn	2.9 (1.6-5.6)	0.001	3.7 (1.8-7.5)	<0.001
Hearing difficulty	1.8 (0.8-3.9)	0.175	1.8 (0.7-4.3)	0.199
Work-related accident	0.9 (0.3-2.6)	0.831	0.8 (0.2-2.5)	0.662
Slip, trip, or fall	1.8 (0.97-3.5)	0.061	2.7 (1.3-5.6)	0.010
Shoulder or neck pain or injury	0.9 (0.4-1.9)	0.833	0.8 (0.4-1.9)	0.680
Low back pain or injury	3.8 (1.1-12.4)	0.030	4.0 (1.2-13.9)	0.027
Leg or foot pain or injury	1.0 (0.5-1.9)	0.952	0.7 (0.3-1.5)	0.356
Having >1 symptom of work-related stress	3.2 (1.7-6.0)	<0.001	2.9 (1.5-5.9)	0.003
Respiratory symptoms after pesticides use	1.0 (0.4-2.9)	0.996	2.1 (0.6-8.1)	0.280
Skin symptoms after pesticides use	1.2 (0.3-5.1)	0.841	2.2 (0.4-13.6)	0.402

CI: confidence interval; OR: odds ratio

*Adjusted for the study area, sex, self-identifying as Karen, age, education, household income, number of household members, cigarette smoking, alcohol consumption, physical activity frequency, community leader role, health information and healthcare-seeking

a previous study from Kamphaeng Phet Province, Thailand (Kiatkitroj *et al*, 2021). In our study we found a significant association between working on completely hilly land and having sunburn but not between exposure to heat and having a sunburn. Higher altitudes have thinner atmosphere to absorb solar radiation increasing sunburn risk (WHO, 2016). Working at higher elevations increases risk for sunburns (Singh, 2017).

Heavy machinery has less of a role in hilly country and this may explain the relatively low proportion of subjects who had machinery associated injuries in our study. We did see a significant association between broken machinery and injuries in our study, similar to a previous study from Phayao Province, Thailand (Chaothaworn *et al*, 2014). This suggests keeping machinery in good repair may be important for preventing injuries in our study population. Many of our subjects reported slips, trips and falls, similar to the results of a study from a hilly part of Trinidad (Baksh *et al*, 2015). More of our subjects reported slips, trips or falls than subjects in other studies from Nan and Pathum Thani Provinces, Thailand (Arphorn *et al*, 2021; Kaewdok *et al*, 2020), possibly due to more hilly country in our study area than in those studies.

In our study, a common skeletomuscular complaint among study subjects was low back pain, similar to a study from Lampang Province, Thailand (Manothum and Arphorn, 2018). In our study we found a significant association between heavy lifting, bending or body-twisting while working on completely hilly land and lower back pain or injuries, similar to a study Chiang Rai Province, Thailand (Tonchoy and Suta, 2020). Since the use of machinery is difficult in completely hilly land, much of the labor has to be done by hand increasing the risk for skeletomuscular problems.

In our study, most of the subjects complained of work-related stress, similar to studies from Chiang Rai Province, Thailand (Pintakham *et al*, 2019) and a study of multiple provinces in northern Thailand (Sapbamrer *et al*, 2022).

In our study, most of the ethnic Thai subjects used pesticides and most of the ethic Karen subjects did not, similar to a study from the USA in which most of the Hmong farmers did not use pesticides (Neitzel *et al*, 2014) but in contrast to a study among Lahu farmers in Chiang Rai Province, Thailand who did use pesticides (Nambunmee *et al*, 2021).

In our study, we found a significant association between pesticide use and the presence of respiratory and skin symptoms, similar to a study from Phayao Province, Thailand (Chaothaworn *et al*, 2014) but in contrast to a study from Chiang Rai Province, Thailand, in which no association was seen (Nambunmee *et al*, 2021).

In our study, pesticide exposure was associated with hearing problems, similar to studies from Thailand (Choochouy *et al*, 2019), the United States (Crawford *et al*, 2008), and Brazil (Delecrode *et al*, 2012). In our subjects we found no significant association between exposure to agricultural machinery and hearing loss, similar to previous studies Thailand (Suwanno *et al*, 2008), the United States (Humann *et al*, 2012) and New Zealand (McBride *et al*, 2003). Our questionnaire was not designed to determine the frequency and loudness of noise exposure to agricultural machinery; therefore, could not accurately determine an association between machinery exposure and hearing loss.

A limitation of our study was that it was retrospective and subject to recall bias. Further prospective studies are needed to eliminate this bias.

In summary, the prevalences of back pain, shoulder and neck pain and heat exhaustion in our study population were high. The factors significantly associated with these complaints were working in a bent or twisted posture, work on a completely hilly farm, lift heavy loads and being exposed to heat working outdoors. We conclude there is need to develop methods to reduce these symptoms and apply them in this study population. Further studies are needed to determine if these developed interventions can reduce these symptoms in this study population.

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CONFLICT OF INTEREST DISCLOSURE

The authors declare no conflicts of interest.

REFERENCES

Apidechkul T. Seroprevalence and factors associated with hepatitis B virus infection among the hill tribe youths, northern Thailand. *BMC Infect Dis* 2019; 19: 125.

Arphorn S, Lertvarayut T, Kiatkitroj K, *et al*. Association between physical capacity and occupational falls among middle-aged and older farmers in Thailand: using the self-check risk assessment tool in Japan. *J Occup Health* 2021; 63: e12287.

Baksh KS, Ganpat W, Narine LK. Occupational health and safety issues among vegetable farmers in Trinidad and the implications for extension. *J Agric Saf Health* 2015; 21: 159-71.

Chaothaworn C, Chanprasit C, Jongrungrotsakul W. Health status related to risk at work among shallot farmers, Cham Pa Wai Subdistrict, Mueang District, Phayao Province. *Nursing J* 2014; 41: 35-47. [in Thai]

Choochouy N, Kongtip P, Chantanakul S, Nankongnab N, Sujirarat D, Woskie SR. Hearing loss in agricultural workers exposed to pesticides and noise. *Ann Work Expo Health* 2019; 63: 707-18.

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 :817-26.

Daniel WW, Cross CL. Biostatistics: a foundation of analysis in the health sciences. 10th ed. Hoboken, NJ: John Wiley & Sons, Inc; 2019.

de Castro AB, Krenz J, Neitzel RL. Assessing Hmong farmers' safety and health. *Workplace Health Saf* 2014; 62: 178-85.

Delecrode CR, de Freitas TD, Frizzo AC, Cardoso AC. Prevalence of tinnitus in workers exposed to noise and organophosphates. *Int Arch Otorhinolaryngol* 2012; 16: 328-34.

Detpitukyon S, Apidechkul T, Sunsern R, *et al*. Patterns and perception of alcohol drinking among the Lahu people, Northern Thailand. *J Health Res* 2018; 32: 185-97.

Heidari H, Golbabaei F, Shamsipour A, Rahimi Forushani A, Gaeini A. Evaluation of heat stress among farmers using environmental and biological monitoring: a study in north of Iran, 2015 [cited 2022 Apr 13]. Available from: URL: https://www.researchgate.net/profile/Aliakbar-Shamsipour/publication/278149813_Evaluation_of_Heat_Stress_Among_Farmers_Using_Environmental_and_Biological_Monitoring_A_study_in_North_of_Iran/links/557c285e08aeb61eae236046/Evaluation-of-Heat-Stress-Among-Farmers-Using-Environmental-and-Biological-Monitoring-A-study-in-North-of-Iran.pdf

Highland Research and Development Institute (HRDI). About Highland, 2019 [cited 2022 Apr 13] Available from: URL: https://www.hrdi.or.th/About/Highland [in Thai]

Humann MJ, Sanderson WT, Gerr F, Kelly KM, Merchant JA. Effects of common agricultural tasks on measures of hearing loss. *Am J Ind Med* 2012; 55: 904-16.

Juntaracena K, Neubert MS, Puntumetakul R. Effects of muddy terrain on lower extremity muscle activity and discomfort during the rice planting process. *Int J Ind Ergon* 2018; 66: 187-93.

Kaewboonchoo O, Kongtip P, Woskie S. Occupational health and safety for agricultural workers in Thailand: gaps and recommendations, with a focus on pesticide use. *New Solut* 2015; 25: 102-20.

Kaewdok T, Sirisawasd S, Taptagaporn S. Working conditions related to slip, trip and fall injuries among elderly workers in the agricultural sector, Nong Suea District, Pathum Thani Province. *Dis Control J* 2020; 46: 115-27. [in Thai]

Kaewthummnukul T, Suthakorn W, Tantranont K. Situation analysis of occupational and environmental health among rice farmers: health status and work behavior. *Nursing J* 2020; 47: 100-13. [in Thai]

Kongtip P, Nankongnab N, Mahaboonpeeti R, *et al*. Differences among Thai agricultural workers' health, working conditions, and pesticide use by farm type. *Ann Work Expo Health* 2018; 62: 167-81.

Kiatkitroj K, Arphorn S, Tangtong C, Maruo SJ, Ishimaru T. Risk factors associated with heat-related illness among sugarcane farmers in Thailand, 2021 [cited 2022 Apr 13]. Available from: URL: https://www.jstage.jst.go.jp/article/indhealth/advpub/0/advpub_2021-0161/_pdf/-char/en

Kunstadter P, Chapman EC. Problems of shifting cultivation and economic development in Northern Thailand. In: Kunstadter P, Chapman EC, Sabhasri S, editors. Farmers in the Forest. Honolulu, HI: University of Hawai'I Press; 1978. p. 12-42.

Manothum A, Arphorn S. Study of ergonomic risks of maize farmers in Lampang, Thailand. *J Ind Technol* 2018; 14: 73-81.

McBride DI, Firth HM, Herbison GP. Noise exposure and hearing loss in agriculture: a survey of farmers and farm workers in the Southland region of New Zealand. *J Occup Environ Med* 2003; 45: 1281-8.

Nambunmee K, Kawiya T, Neitzel RL, Seeprasert P. Pesticide spraying and reduced cholinesterase activity among hill tribe farmers in Thailand. *J Health Pollut* 2021; 11: 210908.

Nankongnab N, Kongtip P, Tipayamongkholgul M, Bunngamchairat A, Sitthisak S, Woskie S. Difference in accidents, health symptoms, and ergonomic problems between conventional farmers using pesticides and organic farmers. *J Agromedicine* 2020; 25: 158-65.

National Statistical Office of Thailand (NSO Thailand). The informal employment survey 2021, 2022 [cited 2022 Apr 13] Available from: URL: http://www.nso.go.th/sites/2014en/Survey/social/labour/informalEmployment/2021/Report_IES2021.pdf

Neitzel RL, Krenz J, de Castro AB. Safety and health hazard observations in Hmong farming operations. *J Agromedicine* 2014; 19: 130-49.

Nordgren TM, Charavaryamath C. Agriculture occupational exposures and factors affecting health effects. *Curr Allergy Asthma Rep* 2018; 18: 65.

Pintakham K, Jitkham P, Khamthiang T. Stress and coping with stress level of rice farmers in Ban Du Sub-District Muang District, Chiang Rai Province. *Phetchabun Rajabhat J* 2019; 21: 49-53. [in Thai]

Sapbamrer R, Chittrakul J, Sirikul W, *et al*. Impact of COVID-19 pandemic on daily lives, agricultural working lives, and mental health of farmers in northern Thailand. *Sustainability* 2022; 14: 1189.

Singh LC. High altitude dermatology. *Indian J Dermatol* 2017; 62: 59-65.

Singkhorn O, Apidechkul T, Pitchalard K, *et al*. Prevalence of and factors associated with depression in the hill tribe population aged 40 years and older in northern Thailand. *Int J Ment Health Syst* 2021; 15: 62.

Suwanno S, Pongmuttasaya P, Jankhonkaen S, Chamnasuan S, Hancherngchai S. Prevalence of accident and hearing loss of machine handing by agricultural workers in responsible area of the Office of Disease Prevention and Control 7th Ubonratchatani Province, 2008 [cited 2022 Apr 13]. Available from: URL: https://dric.nrct.go.th/Search/ShowFulltext/2/295678 [in Thai]

Thai Department of Social Development and Welfare. Highland community covering and area of 20 provinces of Thailand 2559 BE. Bangkok, Thailand: Thai Ministry of Social Development and Human Security; 2016. [in Thai]

Tonchoy P, Suta P. Ergonomic risk factors of musculoskeletal disorders among ethnical maize farmer groups, Chiang Rai Province, 2020 [cited 2022 Apr 13]. Available from: URL: https://he01.tci-thaijo.org/index.php/jdpc7kk/article/view/188512 [in Thai]

Venugopal V, Chinnadurai JS, Lucas RA, Kjellstrom T. Occupational heat stress profiles in selected workplaces in India. *Int J Environ Res Public Health* 2015; 13: 89.

World Health Organization (WHO). Radiation: Ultraviolet (UV) radiation, 2016 [cited 2022 Apr 13]. Available from: URL: https://www.who.int/news-room/questions-and-answers/item/radiation-ultraviolet-(uv)