

*Review Article*

## Work-related diseases among agriculturists in Thailand: A systematic review

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**Abstract**

This systematic review aimed to summarize the prevalence of work-related diseases among agriculturists in Thailand. A meta-analysis of prespecified subgroups of health hazards and effects from primary studies was conducted. The articles were searched for by using the following electronic databases: PubMed, TCI, and ThaiLIS published between 2007 and 2017. Heterogeneity between studies was assessed by using the  $I^2$  and Chi-square test. Data from 34 articles were analyzed using STATA and a comprehensive meta-analysis on the prevalence of diseases performed. The highest estimated pooled prevalence (random effects model) was that of musculoskeletal disorders (MSDs) at 67.8% (95%CI 66.3-69.3), followed by those of chemical hazard at 52.8% (95%CI 50.5-55.1), and other health effects, including heat effects, skin irritation and injuries, at 53.1% (95%CI 51.7-54.4). This review shows that a health surveillance program using big data management to show work-related diseases and Thai government support in strategic planning to decrease the prevalence of MSDs and pesticide exposure among agriculturists are a priority.

**Keywords:** agriculture, health effect, hazard, occupational disease, injuries, meta-analysis

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**1. Introduction**

The National Statistical Office (NSO) of Thailand collected informal employment data in 2017. It was revealed that 55.6% of the 38.3 million workforce were informally employed (NSO, 2017). The agricultural sector had a majority of informal workers and almost all of them were engaged in crops cultivation (NSO, 2013). They lacked employee status as defined under the Labor Protection Act (LPA). Typically, they were not working in the status of an employee; they were working at home or maybe self-employed, or were temporary workers. Epidemiological studies of adverse health effects among agriculturists have been reported with regard to health risk and risk factors of exposure to health hazards, and injuries

caused by agricultural activities (Suggaravetsiri & Chaiklieng, 2017; Veerast, Suggaravetsiri & Chaiklieng, 2013).

According to a global report on work-related diseases, the highest prevalence of the work-related diseases of agriculturists was work-related musculoskeletal disorders (MSDs) at 43.2% to 91.3% (Dong, Li, & Yu, 2012; Jo *et al.*, 2016; Kearney, Allen, Balanay, & Barry, 2016; McMillan, Trask, Dosman, Hagel, & Pickett, 2015; Osborne *et al.*, 2010; Yee, Tamrin, Yik, Yusoff, & Mori, 2014), followed by skin irritation at 86.0% (Oesterlund *et al.*, 2014) to 87.3% (Kim *et al.*, 2013), injuries caused by all kinds of accidents at 26.3% to 60.0% (Browning, Westneat, & Reed, 2016; Kim, Lee, & Räsänen, 2016; Mayrhofer, Quendler, & Boxberger, 2014; Prasanna & Dewangan, 2009), heat-related illness at 4.0% (Banerjee, 1993) to 50.0% (Sahu, Sett, & Kjellstrom, 2013), toxicity from pesticide at 10% (Kamel *et al.*, 2007) to 22.5% (Zare *et al.*, 2015), infectious diseases at 0.7% to 28.6% (Adesiyun *et al.*, 2010; Dahal *et al.*, 2016; Fiecek,

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Grochowalska, Chmielewski, & Tylewska-Wierzbanska, 2012), and lower respiratory tract complaints at 2.7% to 26.0% (Hoppin *et al.*, 2008; 2009; Kim *et al.*, 2013), respectively.

In Thailand, occupational and environmental diseases among the Thai population visiting public hospitals are reported to the Health Data Center (HDC). It was reported between 2013 and 2016 that the highest prevalence among agriculturists was injuries (0.6%), followed by MSDs (0.3%), hearing loss and diseases caused by heat (0.2%), and pesticide toxicity (0.1%) (Health Data Center, 2017). The statistics were compiled from diagnosed cases of the passive surveillance report in Thailand and largely contradicted the global statistics mentioned in the research, which were mostly based on the complaints or health screening data reports of the study participants. Some work-related diseases were indicated in the previous studies, but there was no general report from the HDC on cases as occupational diseases, such as skin diseases and infectious diseases. One cross-sectional study indicated the prevalence of skin diseases, calculated from the self-reported symptoms of the agriculturists, at 71.5% (Lueangektin & Wongvigitsuk, 2010); this was much higher than the incidence rate calculated from diagnosed cases of skin diseases (6.2%) and infectious diseases (3.5%) in a retrospective cohort study of agriculturists (Phuengsangpaen & Chaiklieng, 2017). There was a higher incidence of MSDs (39.2%) and pesticide toxicity (0.4%) among the agriculturists of the previous study report (Phuengsangpaen & Chaiklieng, 2017) when compared to those reports from the passive surveillance database of HDC. Although there have been studies on the prevalence of work-related diseases, they are not representative of the national prevalence of occupational diseases of agriculturists according to the surveillance report of health data and its studies. Therefore, the aim of this meta-analysis was to summarize the prevalence of work-related diseases among agriculturists in Thailand.

## 2. Materials and Methods

### 2.1 Search strategy

This review was carried out by searching the following electronic databases for primary studies: PubMed, TCI (Thai Journal Citation Index Centre), and ThaiLIS (Thailand Library Integrated System), published between January 2007 and September 2017. The search strategy included incorporation of the following terms: agriculture, agriculturist, farmers, planter, grower, prevalence, injuries, work-related, occupational diseases, health hazard, health effect, and Thailand.

### 2.2 Study selection

The search strategy aimed to identify all the available publications in Thai or English language that reported data on the prevalence of work-related diseases, including injuries among agriculturists in Thailand. Two reviewers independently reviewed titles and abstracts to identify acceptable studies from all sources which met the inclusion criteria: 1) there was a full-text article available, 2) the type of agriculture was presented and located in Thailand, and 3) the sample size of agriculturists and the prevalence of

disease were identifiable enough to be classified according to health hazard, MSDs and other health effects groups.

### 2.3 Data extraction

Two reviewers independently extracted data from the acceptable studies. Any differences of opinion were discussed and the cases of disagreement were resolved by a third reviewer, who was an epidemiologist, to meet the eligibility criteria of a cross-sectional study designed for agriculturists. The data were extracted from 34 acceptable studies of cross-sectional design, and included the names of the authors and the year of article publication. The recorded parameters were province of study (from the following regions of Thailand: North, Northeast, Central, East and South) or locality, survey year, number of participants, type of agriculture, type of health hazard or health effects of exposure, and prevalence of work-related diseases and injuries according to the complaints or health screening data of the participants. Studies that used only diagnosis data from the health care service were excluded from the data analysis.

### 2.4 Data analysis

Studies were heterogeneous in many aspects, including the baseline of prevalence in the population, agricultural types of agriculturist, and self-prevention against hazards. Heterogeneity between studies was assessed using the  $I^2$  and Chi-square tests. Hence, we analyzed the studies in prespecified subgroups of health hazards of chemical hazards, and health effects, such as MSDs or other effects from different area-based studies in Thailand of agriculturists. We computed the prevalence in these studies according to a random effects model for data synthesis (the meta-analysis). Data were analyzed using Stata (version 10.0) and comprehensive meta-analysis (version 3) software.

## 3. Results

### 3.1 Description of included studies

Of the 503 unique citations identified in the literature search, 38 articles describing results were selected, but there were only 34 articles which met the requirements of cross-sectional studies and eligibility criteria (Figure 1). The articles were classified into one health hazard group of chemical hazards (13 articles), and three health effect groups, which were musculoskeletal disorders, or MSDs (15 articles) and other health effects, i.e. heat effects (two articles), skin irritation (two articles), and injuries (two articles).

### 3.2 Prevalence of work-related diseases and injuries

The pooled prevalence of work-related diseases was classified by the health hazard group of chemical exposure hazards as 52.8% (95% CI 50.5 to 55.1). The reported prevalence ranged from 5.6 (95% CI 3.6 to 8.4) (Khobjai, Dumrongsut, Punta, & Dokpoung, 2010) to 95.1% (95% CI 83.5 to 99.4) (Wongsakoonkan, Nguiyai, Phomngam, & Deelap, 2016) in various studies conducted at different provinces across five regions of Thailand (North, Northeast, Central, East, and South). Further detail on the types of

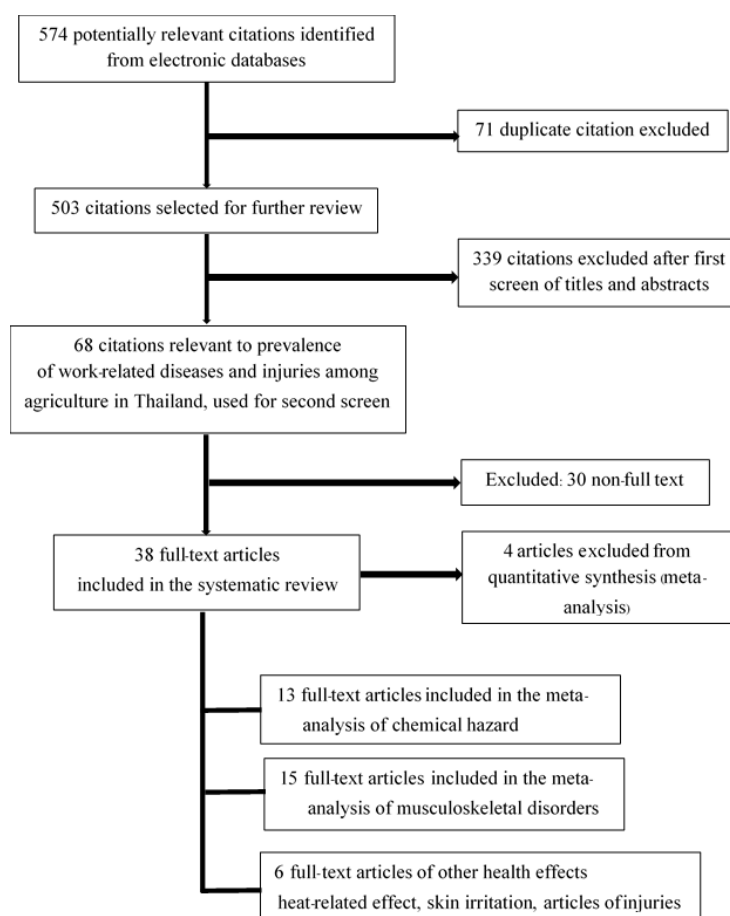


Figure 1. Study flow chart

agriculture and the chemical hazards, which were classified as organophosphate and carbamate hazard, and paraquat hazard, are presented in Table 1 and the forest plot is shown in Figure 2.  $I^2$ , showing the heterogeneity of the reviewed studies was 41.94%, while the Chi-square value was 20.67, at a p-value <0.001.

The highest pooled prevalence estimates of work-related diseases classified according to health effects was MSDs at 67.8% (95% CI 66.3 - 69.3) which ranged from 41.3 (95% CI 38.0 - 44.7) to 91.9% (95% CI 87.6 - 95.0) in studies conducted in different provinces in only four regions of Thailand (North, Northeast, East and South), followed by heat-related effects or illness at 59.0% (95% CI 53.8 - 63.9), skin irritation at 54.4% (95% CI 48.2 - 60.6), and injuries at 23.1% (95% CI 19.7 - 27.0), respectively. Further detail for types of agriculture are presented in Table 2 and Table 3, and the forest plot for musculoskeletal disorders is shown in Figure 3.  $I^2$ , showing the heterogeneity of the musculoskeletal disorders, was 72.38%; Chi-square = 8.12, p-value <0.001. Other health effects subgroups were highly heterogeneous in the reviewed studies ( $I^2 = 99.81$ , p-value <0.001). The random-effects pooled prevalence of the subgroup was 53.09% (95%CI = 51.7-54.4) as shown in Table 4. The overall pooled prevalence of the random-effects estimate of work-related diseases among agriculturists was 64.8% (95%CI 46.1-83.5) and its forest plot is shown in Figure 4.

#### 4. Discussion and Conclusions

The pooled prevalence rate in the health hazard group classified as chemical hazard was 52.8%. This prevalence rate was seemingly higher than the prevalence reported among the registered rice farmers of Roi-Et province in the northeastern region of Thailand, which was evaluated from secondary data of 43 files of the health database on agriculturists. Moreover, those rates were higher than the prevalence among the general Roi-Et population and the trend of increasing prevalence was illustrated every year between 2012 and 2015 (Thongbu, Suggaravetsiri, & Chaiklieng, 2017). Several articles have shown that agriculturists are exposed to pesticides, such as organophosphate and carbamate. The exposure can be monitored by screening of cholinesterase enzyme activity. The highest prevalence was found at 95.1% in chili planters (Wongsakoonkan *et al.*, 2016). Lack of personal protective equipment (PPE) use was the basic cause of pesticide exposure. Skin contact was the primary route of pesticide exposure causing chronic health effects and cancer (Hoppin *et al.*, 2008). Although pesticide toxicity was not the most prevalent work-related health effect in this review, the previous study analysing 43 files from the health database indicated the highest rate for case fatality was from pesticide poisoning (8.5%) in rice farmers of the Northeast. In addition, our previous study found that skin

Table 1. Prevalence of work-related diseases considering chemicals exposure hazard

Type of chemicals and references	Province, Region (survey year)	Type of agriculture	Participants (N)	Prevalence rate (95%CI)
Organophosphate and carbamate				
Kachaiyaphum <i>et al.</i> , 2010	Chaiyaphum, NE (2009)	Chili	350	32.0 (27.1-37.2)
Khobjai <i>et al.</i> , 2010	Phayao, N (2010)	Corn, Cabbage	389	5.6 (3.6-8.4)
Chaiklieng & Praengkrathok, 2013	Nakhonratchasima, NE (2012)	Rice	110	90.9 (83.9-95.6)
Kaewka, 2014	Nong Bua Lam Phu, NE (2013)	Crops	63	87.3 (76.5-94.4)
Ueng-udonpukdee <i>et al.</i> , 2014	Phitsanulok, N (2013)	Rice	140	35.5 (27.8-44.2)
Paipard <i>et al.</i> , 2014	Kalasin, NE (2014)	Vegetables	50	86.0 (73.3-94.2)
Kudting & Khanatho, 2015	Nong Bua Lam Phu, NE (2014)	Sugarcane	291	78.7 (73.5-83.2)
Pluemchan & Khansakorn, 2015	Chonburi, E (2014)	Crops	310	79.7 (74.8-84.0)
Wongsakoonkan <i>et al.</i> , 2016	Phetchabun, C (2015)	Chili	41	95.1 (83.5-99.4)
Yaruang & Sukonthasarn, 2016	Chiang Rai, N (2015)	Rice	401	50.6 (45.6-55.6)
Teerarattanasoontorn & Parnsaneh, 2016	Nakhon Si Thammarat, S (2015)	Pomelo	50	80.0 (66.3-90.0)
Suebsimma <i>et al.</i> , 2017	Sisaket, NE (2015)	Chili	165	37.7 (30.2-45.4)
Paraquat				
Phetphung, 2015	Nan, N (2014)	Corn	147	54.4 (46.0-62.6)

Note: C= Central, E=East, NE = Northeast, N=North, S= South region of Thailand

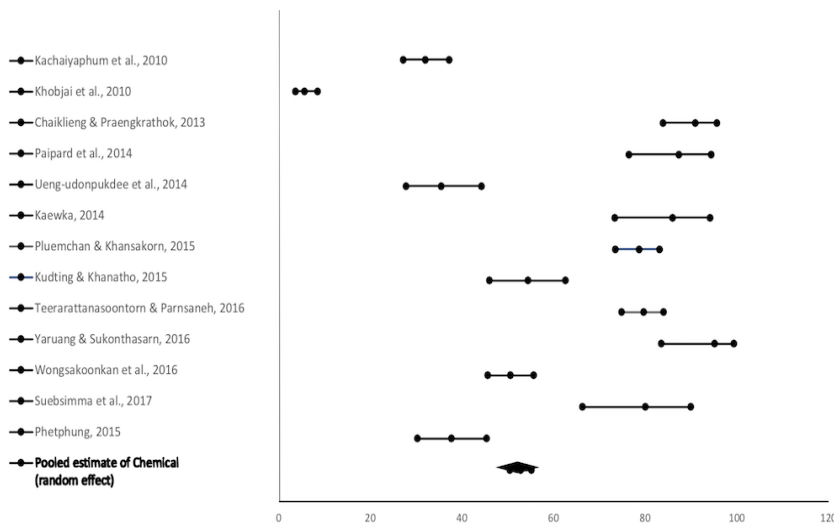


Figure 2. Forest plot of chemical hazard prevalence was pooled estimate by random effects model (heterogeneity:  $I^2 = 41.94$ , Chi-square = 20.67, p-value <0.001).

Table 2. Prevalence of work-related diseases considering musculoskeletal disorders (MSDs)

References	Province, Region (survey year)	Type of agriculture	Participants (N)	Prevalence rate (95% CI)
Chanprasit & Kaewthummanukul, 2010	Chiang Mai, N (2009)	Baby corn	130	69.2 (60.5-77.0)
Puntumetakul <i>et al.</i> , 2011	Khon Kaen, NE (2009)	Rice	311	73.3 (68.0-78.1)
Taechasubamorn <i>et al.</i> , 2011	Phitsanulok, N (2009)	Rice	283	77.4 (72.1-82.1)
Plykaew <i>et al.</i> , 2013	Nakhon Si Thammarat, S (2011)	Para-rubber	235	87.7 (82.7-91.6)
Sriwong & Inmuong, 2013	Nongbua Lampu, NE (2012)	Sugarcane	146	78.4 (70.5-84.5)
Settheetham & Nathapindhu, 2013	Mukdahan, N (2012)	Rice	233	91.9 (87.6-95.0)
Chaothaworn <i>et al.</i> , 2014	Phayao, N (2012)	Shallot	288	84.0 (79.3-88.1)
Phajan <i>et al.</i> , 2014	Khon Kaen, Udon Thani, Nakhon Ratchasima, NE (2012)	Sugarcane	540	88.7 (85.7-91.2)
Luangwilai <i>et al.</i> , 2014	Nakhonratchasima, NE (2014)	Rice	290	71.7 (66.2-76.8)
Phucharoen & Karoonsupcharoen, 2015	Nakhon Nayok, E (2014)	Ornamental flowers	222	82.9 (77.3-87.6)
Yaruang & Sukonthasarn, 2016	Chiang Rai, N (2014)	Rice	401	81.3 (77.1-85.0)
Udom <i>et al.</i> , 2016	Nakhon Si Thammarat, S (2015)	Para-rubber	433	55.7 (50.8-60.4)
Joomjee <i>et al.</i> , 2017	Ubon Ratchathani, NE (2015)	Para-rubber	238	47.1 (40.6-53.6)
Choomthi <i>et al.</i> , 2017	Chiang Mai, N (2015)	Baby corn	249	88.4 (83.7-90.1)
Thetkathuek <i>et al.</i> , 2017	Chonburi, Rayong, Chanthaburi, E (2015)	Crop	861	41.3 (38.0-44.7)

Note: E=East, NE = Northeast, N=North, S= South region of Thailand

Table 3. Prevalence of work-related diseases considering other health effects

Health effect (references)	Province, Region (survey year)	Type of agriculture	Participants (N)	Prevalence rate (95% CI)
Heat effect (Chakreng <i>et al.</i> , 2010)	Samutsongkram, C (2009)	Rice	171	35.7 (28.5-43.3)
Heat effect (Thammachak, 2012)	Phrae, N (2010)	Rice	265	75.5 (69.8-80.5)
Skin irritation (Lueangektin & Wongvigitsuk, 2010)	Samutprakarn, E (2008)	Rice	123	71.5 (62.7-79.3)
Skin irritation (Phetphung, 2015)	Nan, N (2014)	Baby corn	147	41.5 (33.3-49.9)
Injuries (Chaothaworn <i>et al.</i> , 2014)	Phayao, N (2012)	Shallot	288	20.1 (15.7-25.2)
Injuries (Promphonjorn & Kuhirunyaratn, 2016)	Udon Thani, NE (2014)	Para-rubber	230	26.5 (20.9-32.7)

Note: C= Central, E=East, NE = Northeast, N=North region of Thailand

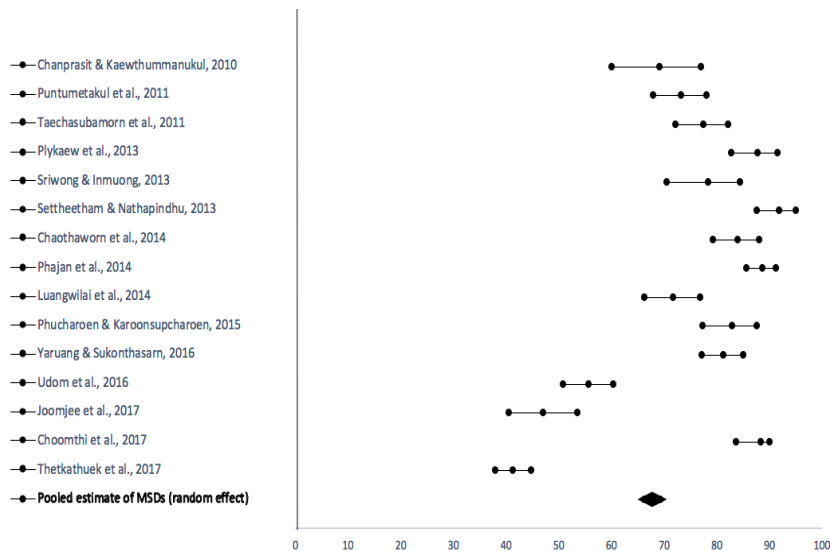
Figure 3. Forest plot of the random-effects pooled estimate of MSDs prevalence (heterogeneity:  $I^2=72.38\%$ , Chi-square = 8.12, p-value <0.001)

Table 4. The summary of pooled prevalence estimation for work-related diseases among agriculturalists

Work-related diseases	Number of studies	Prevalence rate	S.E.	95% CI
Chemical hazard	13	52.8	0.14	50.5 - 55.1
Heterogeneity: Chi-square = 20.67, d.f. = 12 (p-value <0.001); $I^2 = 41.94$				
Pooled prevalence (random effect model) = 61.6%, 95%CI = 36.4-83.8, S.E.= 12.08				
Musculoskeletal disorders (MSDs)	15	67.8	0.12	66.3 - 69.3
Heterogeneity: Chi-square = 8.12, d.f. = 14 (p-value <0.001); $I^2 = 72.38$				
Pooled prevalence (random effect model) = 74.6%, 95%CI = 47.0-87.5, S.E.= 9.28				
Other health effects group				
- Heat effects	2	59.0	0.35	53.8 - 63.9
- Skin irritations	2	54.4	0.35	48.2 - 60.6
- Injuries	2	23.1	0.29	19.7 - 27.0
Heterogeneity: Chi-square = 2,567.64, d.f. = 5 (-p-value <0.001); $I^2 = 99.81$				
Pooled prevalence (random effect model) = 53.1%, 95%CI = 51.7-54.4, S.E.= 0.69				
Work-related diseases (34 studies)				
Heterogeneity: Chi-square = 19.74, d.f. = 33 (P <0.001); $I^2 = 67.12$				
Pooled prevalence (random effect model) = 64.8%, 95%CI = 46.1-83.5, S.E.= 9.54				

irritation related to pesticide toxicity was highly prevalent among agriculturalists (Chaiklieng, Phuengsangpaen, Suggaravetsiri, & Trinwootpong, 2019). This review confirms the high prevalence of pesticide toxicity in crop and vegetable agriculturalists in the northeastern region of Thailand and that the pooled prevalence estimate (random effects model) of other related health effects, including skin irritation, was as high as that of chemical hazard (53.1%).

The skin irritation, such as rash, was possibly caused by pesticides (Lueangektin & Wongvigitsuk, 2010) but this problem was not reported to the HDC for work-related diseases. However, all cases with skin problems were an adverse health effect of chemical use (Phetphung, 2015). In addition, more than 50.0% of agriculturalists exposed to the chemical hazards of insecticides such as organophosphate and carbamate, or herbicides such as paraquat, had adverse effects

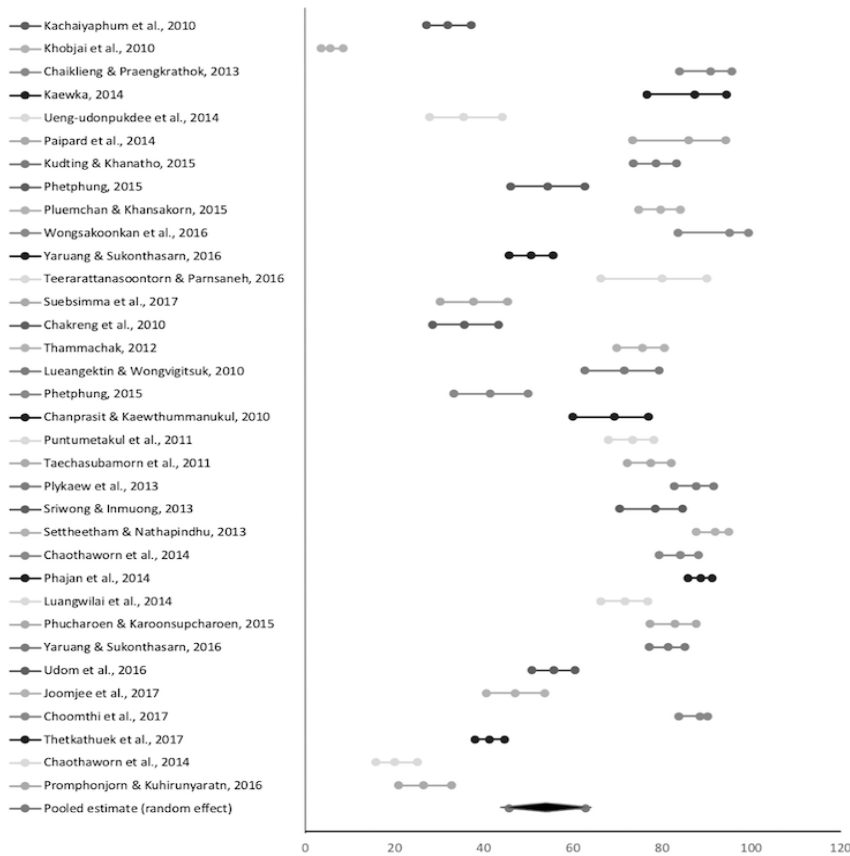


Figure 4. Forest plot of overall prevalence of work-related diseases pooled estimate by the random effects (heterogeneity:  $I^2 = 67.12$ , Chi-square = 19.74, p-value <0.001)

(Kaewka, 2014; Wongsakoonkan, Nguiyai, Phomngam, & Deelap, 2016). Moreover, health problems such as those seen in the asthma clinic of Srinagarind Hospital, Khon Kaen, Thailand, have been reported; in this clinic, it was shown that 33.3% of asthmatic patients were in farmers (Worton, Chaiear, & Boonsawad, 2014). The effects of pesticide-related toxicity on the respiratory system have also previously been reported as complaint symptoms of paraquat sprayers (Chagkornburee, Chaiklieng, & Preuktharatikul, 2019).

The highest pooled prevalence of work-related diseases classified according to health effects was that of MSDs at 67.8%. Agriculturists have had pains in different areas of their body, particularly the lower back (Chanprasit & Kaewthummanukul, 2010; Joomjee *et al.*, 2017; Phajan, Nilvarangkul, Settheetham, & Laohasiriwong, 2014; Puntumetakul *et al.*, 2011; Settheetham *et al.*, 2013; Sriwong & Inmuong, 2013; Taechasubamorn, Nopkesorn, & Pannarunothai, 2011; Yaruang, & Sukonthasarn, 2016). Lower back pain is a common adverse symptom among agriculturists who perform dynamic exertion work. One study showed that 55 percent of agriculturists had suffered with chronic lower back pain during the last 12 weeks (Taechasubamorn, Nopkesorn, & Pannarunothai, 2011). This study suggests that MSDs were prevalent in non-specific types of agriculture with regard to the major concern of disease surveillance among agriculturists in Thailand. The ergonomics risk assessment and occupational health risk assessment matrix should be applied as per the previous guidelines

(Chaiklieng, 2019) in parallel with ergonomics training and implementation following assessment of risk levels in order to prevent MSDs among agriculturists.

The highest pooled prevalence estimate of other health effects in the subgroup was heat-related effects (59.0%). The effects of heat in agriculturists' exposure were heat exhaustion, heat rash, and heat cramp, which were significantly correlated with heat in the working environment ( $r=0.76$ , p-value <0.001) (Chakreng, Phadungtet, & Aekpanyasakul, 2010). That study suggested resting-time management during the workday, which would reduce the adverse heat-related effects on the agriculturists. Hence, there were only two studies regarding heat-related illness among rice farmers; there should be further studies to confirm the representative prevalence of physical hazards affecting agriculturists' health.

The last health effect subgroup is occupational injuries. A previous report showed that informal workers had an accident rate 10 times (62.6%) higher than that of formal employees (Kongtip *et al.*, 2015). In addition, the agriculturist group had the highest incidence of severe injury due to transport accidents between 2005 and 2010 (Department of Disease Control, 2012). A limitation in this review is that there were only two studies which mentioned injuries related to cultivation activities; there should be further analysis of occupational injuries to cover the periods of cultivation hours and transportation between the workers' residential place and the plantation or field workplace.

This systematic review had several strengths. Firstly, it used a comprehensive bilingual search strategy using multiple sources and databases in Thai and English to retrieve relevant studies of agriculturists in Thailand. Secondly, data were pooled only when studies were reasonably consistent in their methods. This review had certain limitations, in that various types of agriculture were not related to the prevalence of ill health from chemical hazards and MSDs. Each type of agriculture is a subset of agricultural cultivation; therefore, all agriculturists have a chance to be exposed to similar health hazards, and neither the regions of the area-based research nor agriculture types have been correlated to adverse effects. In addition, unavailable full-text publications from some local study reports led to the inclusion of small numbers of participants in the analysis, so the conclusion for prevalence of disease caused by heat-related illness, skin irritation, and injuries should be confirmed with analysis of big data from the HDC database.

Even though this review pooled prevalence estimates because of methodological similarity between studies on prevalence in each hazard exposure, the pooled averages will need to be interpreted with caution because of heterogeneity in the study results. In conclusion, this review shows that the health care management of agriculturists in Thailand should be a priority. The government should support occupational health services for agriculturists who are in the informal sector. A health surveillance program using big health data analysis from the HDC and active health surveillance in the risk group of the cohort study should be vigorously used to reduce MSDs and prevent pesticide toxicity by making risk assessments and implementing prevalence programs.

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