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Pesticide safe use practice and acute health symptoms, and associated factors among farmers in developing countries: a systematic review and meta-analysis of an epidemiological evidence

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Abstract

Background The increasing use of pesticides has become a global public health concern. The problem is more devastating in developing countries, which deters the implementation of effective intervention strategies. Moreover, the existing evidences are inconsistent and not comprehensive. Therefore, this study aimed to determine the pooled pesticide safe use practices and acute health symptoms, and identify factors among farmers in developing countries.

Methods A comprehensive search using databases such as PubMed, HINARI, Google Scholar, and Epistemonikos, as well as grey literature, was searched up to June 30, 2023. The updated preferred reporting items for systematic reviews and meta-analysis guidelines were used. Data were extracted using Microsoft Excel, and it was exported to STATA 14/SE software for analysis. The Joanna Briggs Institute's quality appraisal tool was used to assure the quality of the included articles. A random-effects model was used during analysis. The funnel plot and Egger's regression test were used to assess the publication bias, and sensitivity analysis was conducted to assess the effect of a single study.

Results The pooled pesticide safe use practice was 43.1% (95% CI: 31.01–55.2), and the prevalence of acute health symptoms was 30.36% (95% CI: 19.61–41.1). Farmers with good knowledge (OR = 3.83, 95% CI: 2.36–5.29), good attitudes (OR = 2.16, 95% CI: 1.46–2.86), being educated (OR = 5.11, 95% CI: 2.96–7.26), and having more than five years of experience (OR = 6.13, 95% CI: 2.56–9.71) were found to be the identified factors associated with pesticide safe use practice.

Conclusions This study highlighted a significant gap in pesticide safe use practices and a high prevalence of acute health symptoms among farmers. Therefore, comprehensive intervention measures such as providing educational and safety training programs are required for pesticide users among farmers.

Keywords Pesticide, Practice, Acute health symptoms, Farmers, And developing countries

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Introduction

Pesticides are chemical compounds that are used in public health to control and kill pests, including insects, fungi, rodents, and weeds [1, 2]. According to the World Health Organization (WHO), over 1000 different pesticides are used globally [3]. Farmers use pesticides widely in agriculture to control pests, which may enhance their productivity. However, the misuse of these pesticides is becoming more apparent, and they can pose a serious risk to humans and the environment [4, 5]. At the global level, there was a 30% increase in the total traded quantities of pesticides between 2019 and 2020. This increase is largely attributed to a rise in the traded quantities of disinfectants, which grew from 4.0 million tons in 2019 to 8.7 million tons in 2020 [6]. For each country, pesticides may be imported legally or illegally [7].

The negative effects of exposure to pesticide chemicals in agricultural activities are more devastating among farmers because they may be exposed during their occupational activity [8–10]. In addition to agricultural farm workers, others, such as infants, young children, pregnant women, and pesticide applicators, are more susceptible to pesticides [11]. Moreover, pesticide residues in foods and the proximity of agricultural fields were also possible mechanisms of exposure to pesticides by farmers [12–15]. The level of exposure depends on the type, time, and route of exposure [16].

According to the Environmental Protection Agency (EPA), the health risks of pesticides depend on the type of pesticide [17]. Chronic health problems such as cognitive, motor, sensory, and neurological deficiencies [18] and Acute Health Symptoms (AHS) such as nausea, headaches, and respiratory problems are widely experienced among farmers due to pesticides [8, 18, 19]. Moreover, the improper use of pesticides affects the components of the natural environment [20]. Indirectly, environmental contamination can lead to human exposure through the consumption of foods and drinking water [20].

The increasing usage of pesticides in farming has become a worldwide public health issue, especially in developing countries [21]. Globally, a significant number of people die annually due to pesticide exposure [22]. In rural areas of developing countries, the WHO reports that 200,000 people are killed from pesticide poisoning every year. In addition, 3 million farmers are affected by serious pesticide poisoning and 25 million by mild poisoning, resulting in approximately 180,000 fatalities among farm workers per year [23]. Every year, approximately 3,000,000 cases of pesticide poisoning and 22,000 deaths are reported in developing countries [11].

The pesticide-safe use practice among farmers in developing countries is between 12.5% in Tanzania [24] and 87.2% in Iran [25]. Whereas the prevalence of AHS among farmers in developing countries ranged from 1.59% in Ethiopia [26] to 55.76% in Kuwait [27]. The adverse health effects of exposure to pesticides are increasing in developing countries due to poor working conditions, inadequate occupational safety standards and hygienic facilities, a lack of use of Personal Protective Equipment (PPE), and low educational levels [28–31]. Furthermore, a lack of training and unintentional application errors, such as poor handling of pesticides, can pose serious health risks to farmers [32, 33]. Evidence suggests that the possible reasons for these factors are that farmers who receive pesticide safety training will improve their awareness, knowledge, and practices more effectively [34–36]. Hence, farmers' knowledge, practice, and attitude levels towards potential pesticide hazards are essential in preventing and controlling pesticide exposure [26, 29].

Even though there are multiple guidelines and legislation on pesticide safe use practices globally [37–39], due to malpractice in developing countries, exposure to pesticides is one of the most important occupational risks among farmers [40]. In addition, there is a gap in the availability of updated and comprehensive evidence on the level of pesticide safe use practice and AHS, and predictors among farmers in developing countries. Hence, the findings of this study could be crucial for concerned bodies, such as the health and agricultural sectors, to design specific strategies for mitigation and intervention activities, like training programs about the safe use of pesticides. Moreover, this study is invaluable for the protection of public health and the environment and has implications for future researchers. Therefore, this study aimed to determine the pooled level of pesticide safe use practices and the prevalence of AHS, and identify factors among farmers in developing countries.

Methods

Study setting, registration, and protocol

In this study, the updated Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines were used [41] (Fig. 1). This review protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) with record id CRD42023426076. This study was conducted in developing countries, according to the list of World Bank data.

Information sources and search strategies

A comprehensive systematic literature search was undertaken using PubMed, HINARI, Google Scholar, and Epistemonikos, which were searched up to June 30, 2023. For the PubMed search, the following key terms were used in combination with the Boolean operators "AND" and "OR". ((((pesticides AND (fha[Filter])) AND (practice AND (fha[Filter]))) AND (acute health symptoms AND

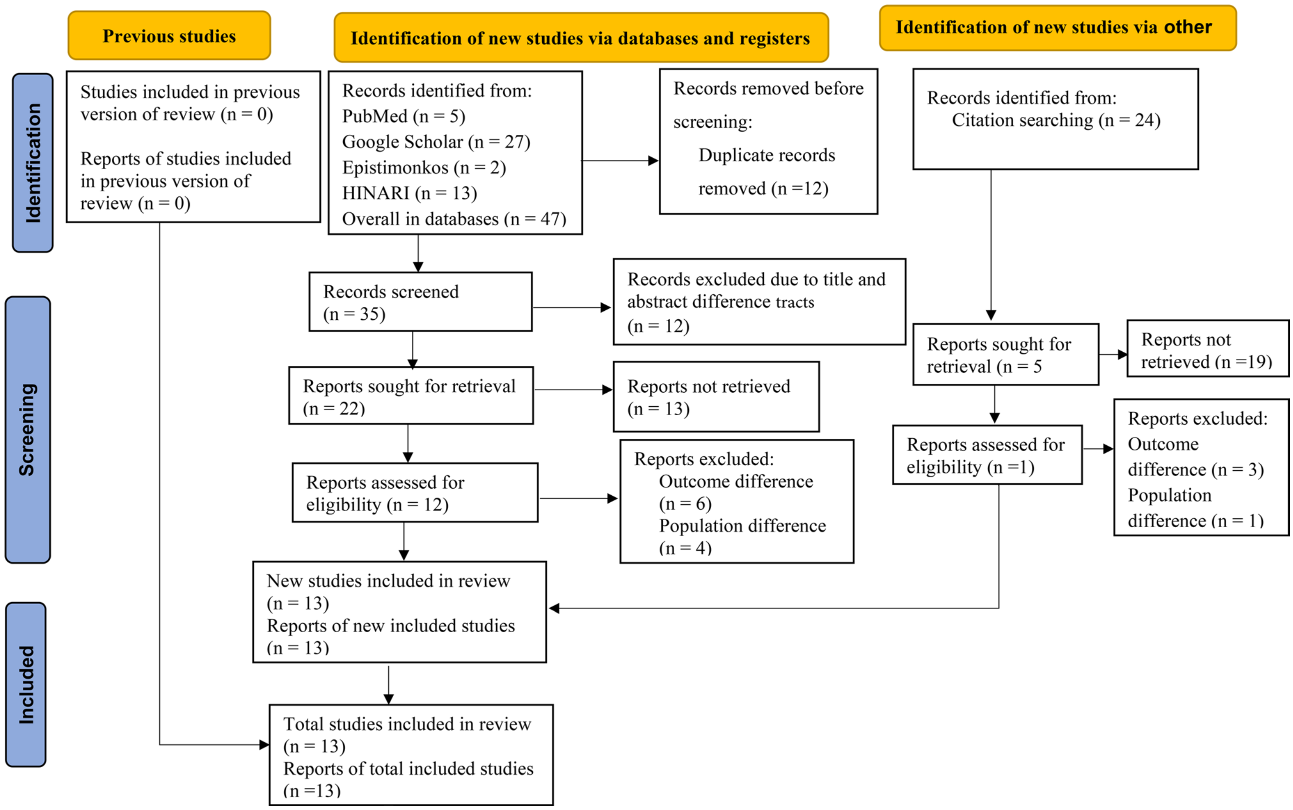

Fig. 1 PRISMA flow diagram of this study, 2023

(fha[Filter]))) AND (farmers AND (fha[Filter]))) AND (developing countries AND (fha[Filter])).

In addition to the electronic database search, to obtain additional articles, the gray literature was searched using a direct Google search and reference lists (bibliography) of the included studies.

Eligibility criteria

Inclusion criteria

Articles that fulfilled the following criteria were considered for inclusion in this review.

- Population: farmers.
- Outcomes: articles reported the quantitative outcome of pesticide safe use practice and AHS, and associated factors.
- Study design: all observational studies (cross-sectional, cohort, and case control).
- Study setting: Studies conducted in developing countries.
- Time frame: All studies reported up to June 30, 2023, were considered.
- Language of published articles: articles written in English.
- Publication issue: both published and unpublished articles were included.

Exclusion criteria

In this study, research articles such as systematic reviews, qualitative studies, letters to editors, short communications, and commentaries were excluded. In addition, articles that were not fully accessible after three personal email contacts with the corresponding author and articles that did not indicate the outcome interest of this study were all excluded.

Operational definitions

Acute health symptoms

Short-term exposure effects that appear immediately and are often reversible. Farmers experienced one or more AHS including coughing, headache, dizziness, vomiting, fatigue, skin irritation, nausea, and blurred vision [42, 43].

Pesticide safety use practices

Include wearing PPE (goggles, hats, facemasks, gloves, long-sleeved shirts and trousers, and boots), storing pesticides separately, and properly disposing of empty pesticide containers during pesticide handling [44].

Study selection

Two investigators (BD and AHT) independently screened articles by their title, abstract, and full text to identify eligible articles using predetermined inclusion and exclusion criteria. The screened articles were compiled together by two investigators, and the disagreement between investigators that arose during data abstraction and selection was solved based on evidence-based discussion and the involvement of the third investigator (CD).

Data extraction and management

The data extraction format was included (name of the author, publication year, study country, study design, method of data collection, sample size, safe practice, prevalence of AHS, and risk of bias) (Table 1). Zotero reference manager software was used to collect and organize search outcomes and remove duplicate articles. The updated PRISMA checklist was used to summarize the study conditions [41] (Table S1).

Quality assessment of the studies

The quality of the included articles was assessed using the Joanna Briggs Institute (JBI) quality appraisal tools for analytical cross-sectional studies [45]. Two reviewers (BD and AHT) independently assessed the quality of the included articles. The assessment tool contains eight criteria: (1) clear inclusion and exclusion criteria; (2) description of the study subject and study setting; (3) use of a valid and reliable method to measure the exposure; (4) standard criteria used for measurement of the condition; (5) identification of confounding factors; (6) development of strategies to deal with confounding factors; (7) use of a valid and reliable method to measure the outcomes; and (8) use of appropriate statistical analysis. Finally, articles scored more than 50% were considered in this study [46, 47], detailed assessment in (Table S2).

Outcome of interest

In this study, there are three main outcomes. The primary outcome of this study was the pooled.

pesticide safe use practice. The second outcome of this study was the prevalence of AHS. Each study was expressed as a percentage. The third outcome of this study was the pooled measure of the association between pesticide safe use practices. It was determined using the pooled odds ratio (OR) with a 95% confidence interval.

Statistical methods and data analysis

The extracted data were exported from a Microsoft Excel spreadsheet to STATA version 14 for further analysis. Heterogeneity among the included studies was quantitatively measured by the index of heterogeneity (I^2 statistics), in which 25–50%, 50–75%, and >75% represented low, moderate, and high heterogeneity, respectively [48]. The overall pooled estimate of pesticide safe use practices and the prevalence of AHS among farmers was computed using the metaprop STATA command. To assess and handle the potential difference, a subgroup analysis was conducted using the study country variable. To ensure that the overall pooled estimate was not influenced by a single study, a sensitivity analysis was conducted. Furthermore, the small-study effect was evaluated using the funnel plot test and Egger's regression test, with a p-value < 0.05 as a cutoff point to declare the presence of publication bias. The results were presented using graphs, tables, texts, and a forest plot.

Table 1 Summary of included articles on pesticide safe use practice and acute health symptoms, and associated factors in developing countries, 2023

Author	Year of study	Study country	Study design	Methods of data collection	Sample size	Safe practice (%)	Prevalence of AHS (%)	Levels of risk of biases (%)
Jallow et al. [36]	2017	Kuwait	CS	SQ & OC	250	42	55.76	62.5
Afata et al. [37]	2022	Ethiopia	CS	SQ	300	50.2	48.7	87.5
Lekei et al. [38]	2014	Tanzania	CS	SQ & OC	121	33.06	35.06	62.5
Manyilizu et al. [39]	2017	Tanzania	CS	SQ	128	12.5	38.75	87.5
Sharafi et al. [40]	2018	Iran	CS	SQ	311	87.2	50.8	75
Nwadike et al. [41]	2021	Nigeria	CS	SQ	524	76.24	34.7	62.5
Jambari et al. [42]	2020	Malaysia	CS	SQ	144	21.15	15.1	75
Kangkhetkron and Juntarawijit [43]	2021	Thailand	CS	SQ	680	39.85	20	100
Kafle et al. [32]	2021	Nepal	CS	SQ	663	43.1	5.25	87.5
Gesesew et al. [28]	2016	Ethiopia	CS	SQ	719	58	1.59	87.5
Lelamo et al. [44]	2023	Ethiopia	CS	SQ	549	35.15	-	75
Mequanint et al. [8]	2019	Ethiopia	CS	Semi -SQ	148	36.19	-	87.5
Alebachew et al. [45]	2018	Ethiopia	CS	Semi –SQ, IDI & KI	430	24.4	-	75

Keys: SQ = Structured Questionnaire, OC = Observation Checklist, CS = Cross-Sectional, IDI = In-depth interview, KI = Key-Informant, and - = Not found

Results

Search process

In this study, using a database and gray literature search, a total of 71 studies were identified. After duplicate records were removed, 35 records were screened for this review. Following the records, only 27 reports were sought for retrieval. After being identified for retrieval, 13 reports were evaluated for eligibility. Following eligibility, a total of 14 studies were excluded due to differences in outcome interest and study participants. Ultimately, a total of 12 studies were included in this study from database sources. In addition to the database sources, 1 study was included in this review from citation searching. Finally, a total of 13 studies were included in this review.

Characteristics of the included articles

All the included studies were cross-sectional studies. In this review, a total of 5,177 study participants were included. The included studies were conducted between 2014 and 2023. The pesticides safety use practice of the included articles ranged from 12.5 to 87.2%, and the prevalence of AHS ranged from 1.59 to 55.76%. The majority of the included studies collected data using structured questionnaires. The included articles risk of bias were determined using percentage.

Meta-analysis

Pesticide safe use practices

The pooled pesticide safe use practice was found to be 43.1% (95% CI: 31.01–55.2). Extreme heterogeneity was observed among the included studies (I^2=98.9%, p<0.001). A random-effects model was used to determine pooled safe use practice. The possible reason for the high heterogeneity might be that, since this study was conducted in different developing countries, there can be variation in the knowledge and awareness of farmers towards pesticide safe use practices. In this analysis, the lowest pesticide safe use practice was found at 12.5% (95% CI: 6.77–18.23) in Tanzania, and the highest pesticide safe use practice was found at 87.2 (95% CI: 83.49–90.91) in Iran [25] (Fig. 2).

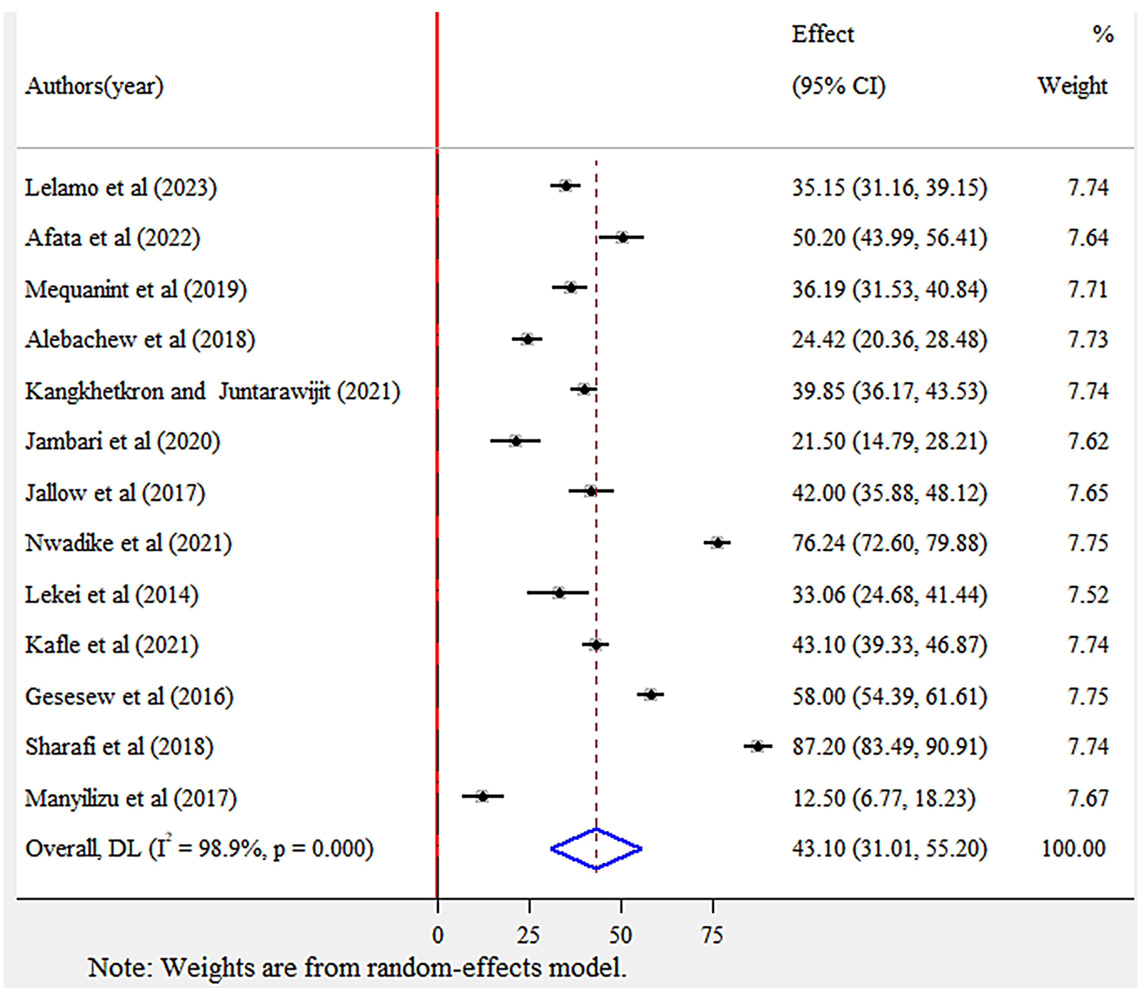

Fig. 2 Forest plot of pesticide safe use practices among farmers in developing countries, 2023

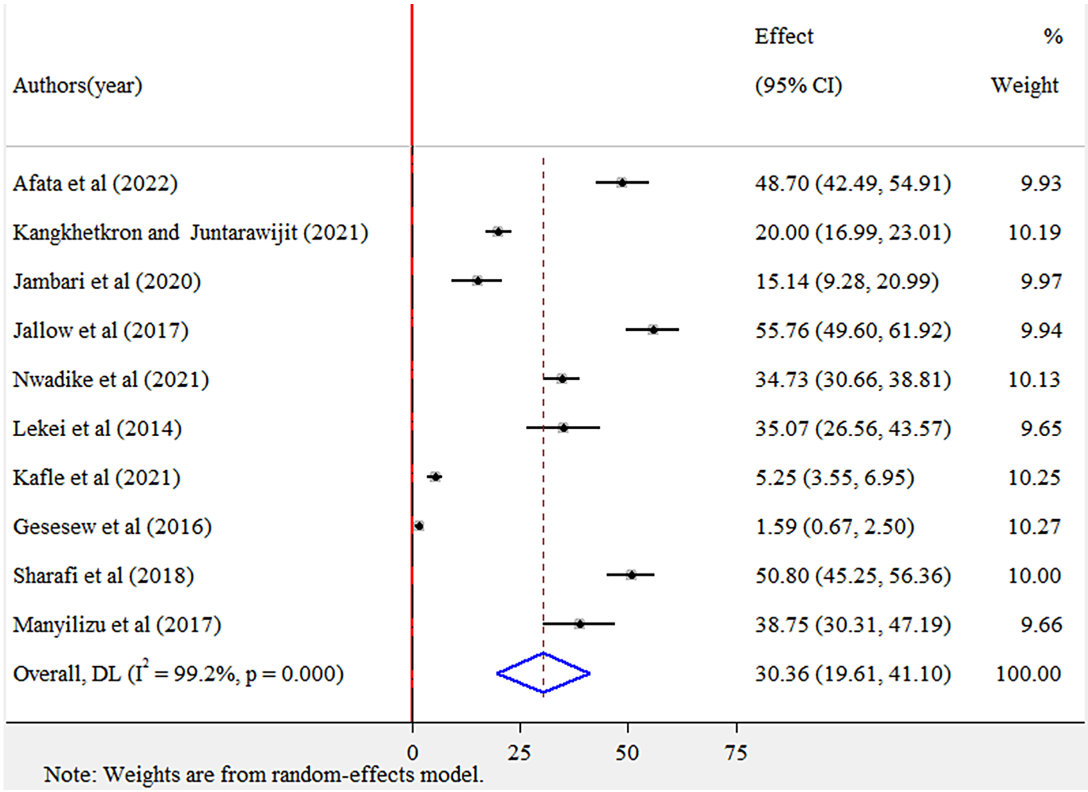

Fig. 3 Forest plot of the pooled prevalence of acute health symptoms among farmers in developing countries, 2023

Table 2 Subgroup analysis of the pooled pesticide safe use practice and prevalence of acute health symptoms among farmers in developing countries, 2023

Variables	Characteristics	Included studies	Pooled pesticides safe use practice
Pesticide safe use practice			
Study country	Ethiopia	5	41% (95%CI: 28–53)
	Thailand	1	40% (95%CI: 36–44)
	Malaysia	1	22% (95%CI: 15–28)
	Kuwait	1	42% (95%CI: 36–48)
	Nigeria	1	76% (95%CI: 73–80)
	Tanzania	2	23% (95%CI: 2–43)
	Nepal	1	43% (95%CI: 39–47)
	Iran	1	87% (95%CI: 83–91)
Acute health symptoms			
Variables	Characteristics	Included studies	Pooled prevalence of AHS
Study country	Ethiopia	2	25% (95%CI: -21–71)
	Thailand	1	20% (95%CI: 17–23)
	Malaysia	1	15% (95%CI: 9.3–21)
	Kuwait	1	56% (95%CI: 50–62)
	Nigeria	1	35% (95% CI: 31–39)
	Tanzania	2	37% (95% CI: 31–43)
	Nepal	1	5% (95% CI: 4–7)
	Iran	1	51% (95% CI: 45–56)

Prevalence of AHS among farmers

The pooled prevalence of AHS among farmers was found to be 30.36% (95% CI: 19.61–41.1), with extreme heterogeneity among the included studies (I^2=99.2%, p<0.001). In the same way, like pesticide safe use practices, the possible reason for the high heterogeneity in the prevalence of AHS in this study might be due to the fact that data was retrieved from different developing countries. In this review, the lowest prevalence of AHS was 1.59% (95% CI: 0.67–2.5) in Ethiopia [26], and the highest was 55.76 (95% CI: 49.6–61.92) in Kuwait [27] (Fig. 3).

Subgroup analysis

To perform a subgroup analysis in this study, a study country was used. As a result, the study subgroup analysis of pesticide safe use practices among farmers was 87% (95% CI: 83–91) in Iran and 22% (95% CI: 15–28) in Malaysia, which had the highest and lowest, respectively. Subgroup analysis of the AHS found 56% (95% CI: 49.6–61.92) in Kuwait and 5% (95% CI: 3.55–6.95) in Nepal, from the highest to the lowest, respectively, as depicted in (Table 2).

Sensitivity analysis

A sensitivity analysis was conducted to evaluate the effect of each study on pooled safe pesticide use practices and the prevalence of AHS among farmers. After a stepwise exclusion of each study from a meta-analysis, the pooled safe pesticide use practices of farmers in developing countries were close to the actual effect size, it implied that there was no single study effect on the pooled pesticide safe use practice (Figure S1). However, the sensitivity analysis for the AHS among farmers in developing countries revealed that there is the effect of a single study (Figure S2).

Heterogeneity and publication bias

In this study, the included studies had a high level of heterogeneity for pesticide safe use practices (I^2=98.9%, p<0.001) and AHS (I^2=99.2%, p<0.001). The presence of publication bias was assessed using a funnel plot and the Egger regression test at a p-value<0.05. A funnel plot for pesticide safe use practice (Fig. 4 was found to have a symmetrical distribution, and Egger's regression test was found to be not statistically significant (p=0.381). On the other hand, a funnel plot for AHS was found to have an asymmetrical distribution, and the Egger regression test was found to be statistically significant (p<0.001) (Fig. 5). Therefore, according to the findings, there is no strong evidence for the presence of publication bias in pesticide safe use practices. However, the findings for AHS revealed the presence of publication bias. Hence, Duval and Tweedie's "trim and fill" method was performed to account for publication bias for AHS. The findings revealed that there was a significant difference; before adjustment, it was found to be 2.8 (95% CI: 1.7–3.9), and after adjustment, it was found to be 1.58 (95% CI: 0.57–2.58) (Fig. 6).

Factors associated with pesticide safe use practices

In this study, factors associated with pesticide safe use practice were assessed using 4 studies [10, 34, 43, 49]. The findings of 3 studies [10, 34, 43] revealed that farmers with good knowledge of pesticides were approximately 4 times more likely to have better safety practices (OR=3.83, 95% CI: 2.36–5.29). Farmers with good attitudes toward pesticides were two times more likely to have a better safe practice (OR=2.16, 95% CI: 1.46–2.86), according to 2 studies [10, 43]. Similarly, the findings of 4 studies [10, 34, 43, 49] revealed that farmers having education were 5 times more likely to have better safety practices than illiterate farmers (OR: 5.11, 95% CI: 2.96–7.26). According to 2 studies [34, 49], farmers with >5 years of pesticide use experience were 6 times more likely to have a better safe practice (OR: 6.13, 95% CI: 2.56–9.71), as depicted in (Fig. 7).

Discussion

This systematic review and meta-analysis aimed to estimate the pooled safe pesticide use practices and the prevalence of AHS, and its associated factors among farmers in developing countries. The use of pesticides has steadily increased globally over the past decades. However, it causes serious health risks among farmers, and the problem is more devastating in developing countries due to their malpractice [4, 5, 21]. In developing countries, there

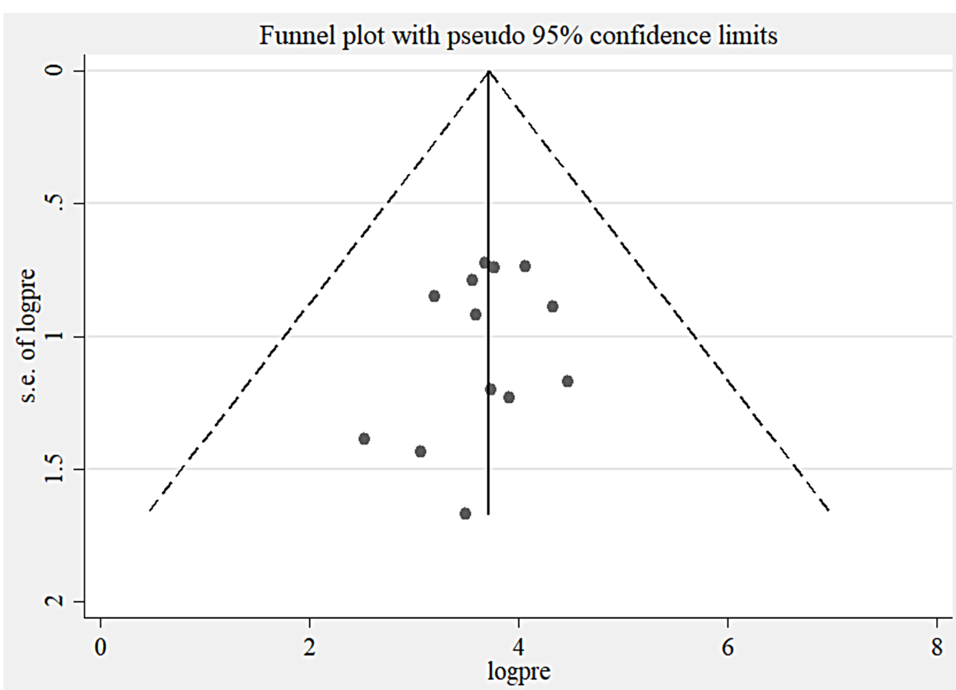

Fig. 4 Funnel plot for pesticide safe use practice among farmers in developing countries, 2023

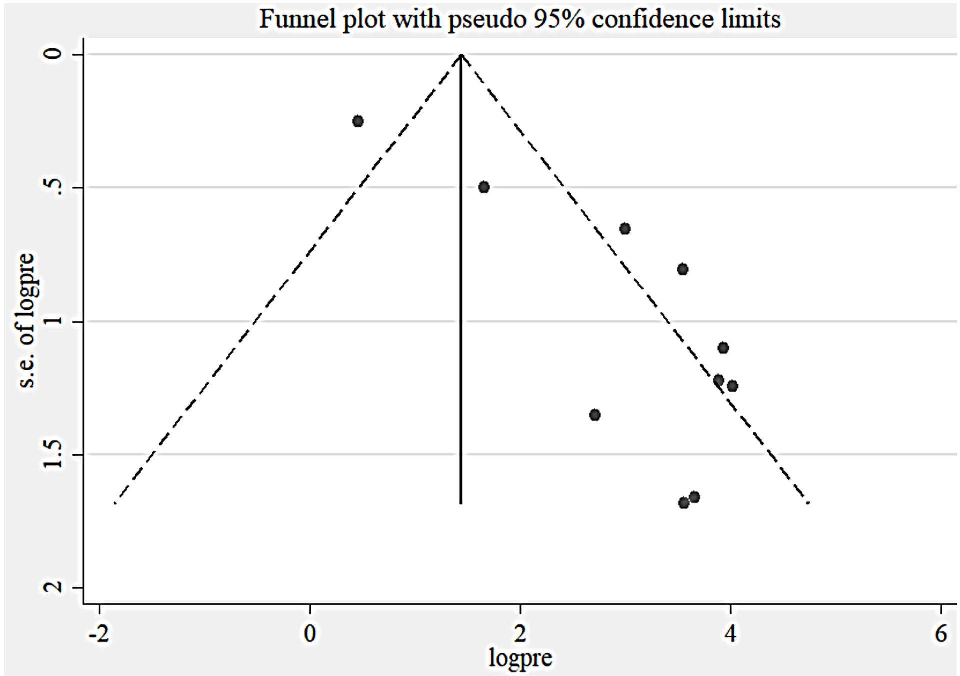

Fig. 5 Funnel plot for acute health symptoms among farmers in developing countries, 2023

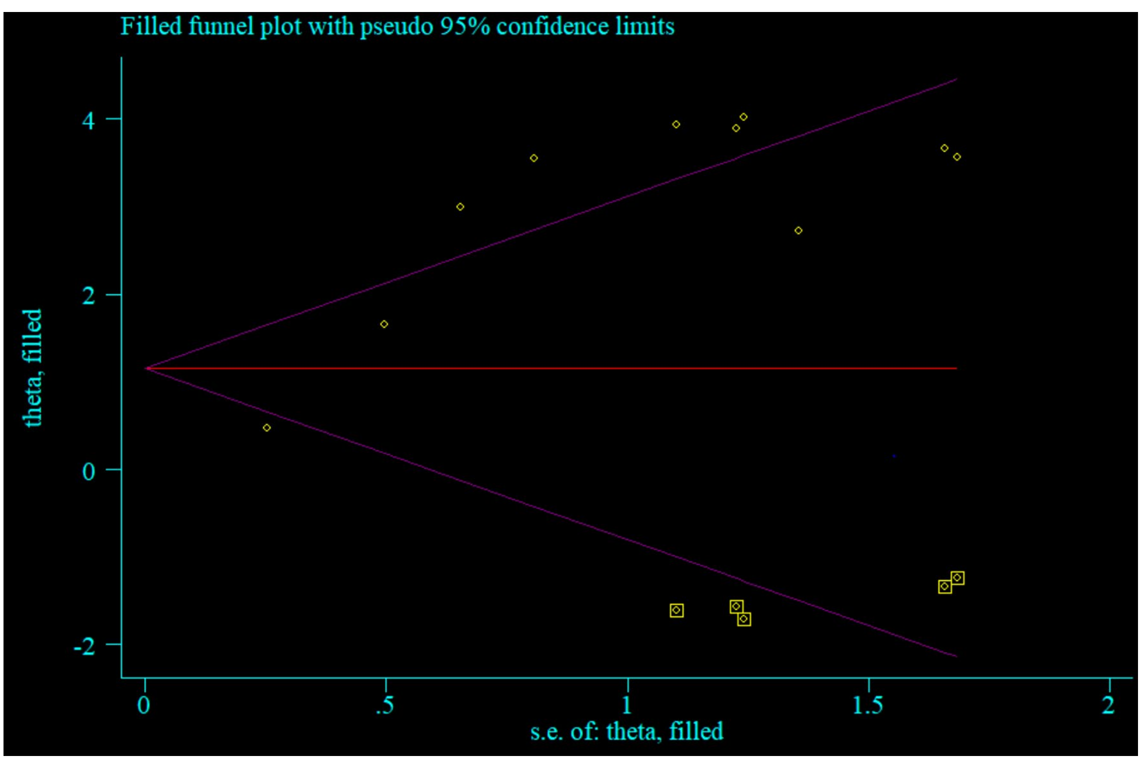

Fig. 6 Funnel plot with 95% CI of a simulated meta-analysis for acute health symptoms among farmers in developing countries, 2023

is limited evidence of the pooled level of pesticide safe use practices and AHS, and its associated factors. Hence, this study could be a contribution for concerned bodies to design specific strategies for the protection of the environment and public health. In addition, this study has invaluable implications for further researchers.

According to this study, the pooled pesticide safe use practice among farmers was found to be 43.1% (95% CI:

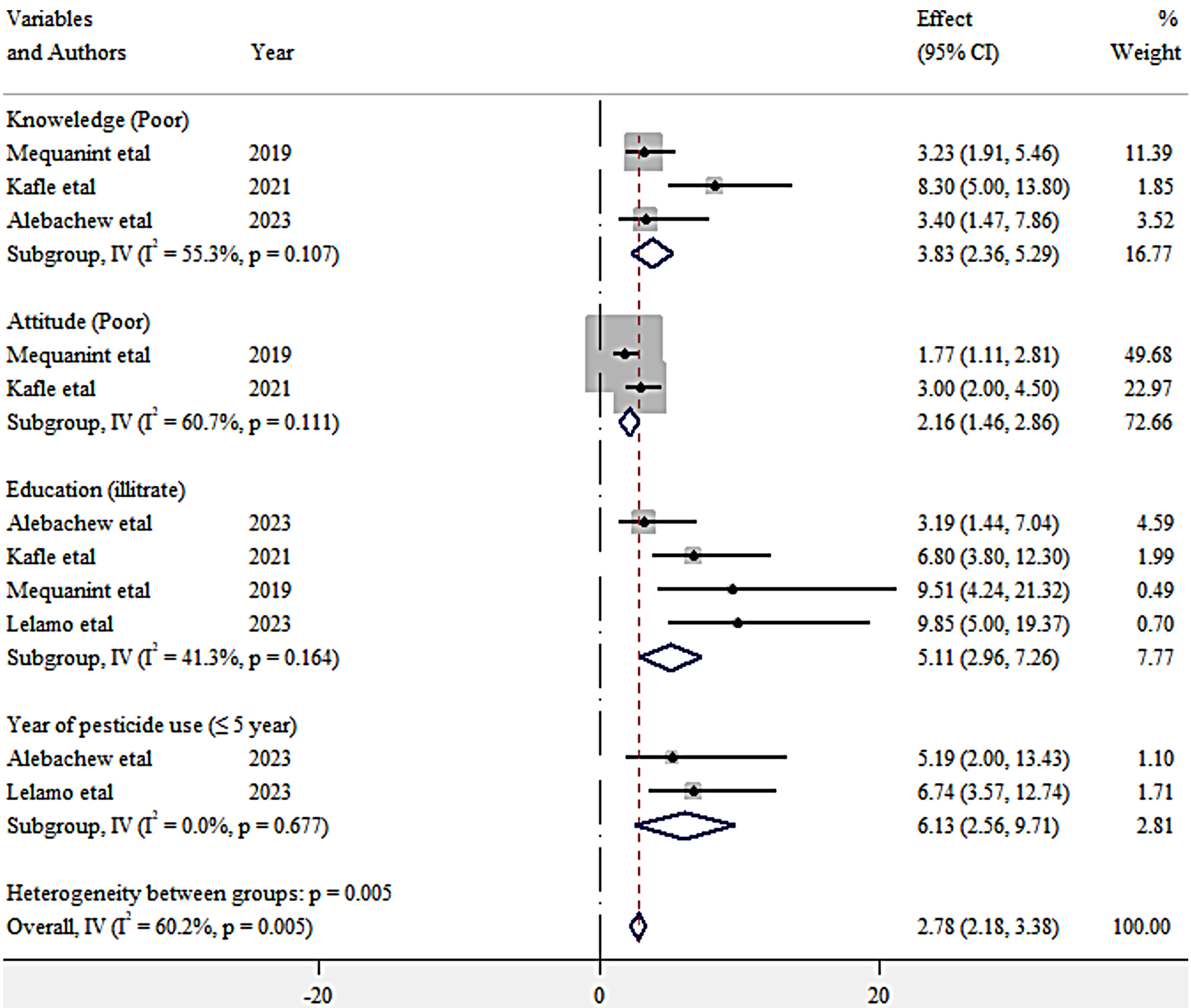

Fig. 7 The pooled effect size of factors associated with pesticide safe use practice among farmers in developing countries, 2023

31.01–55.2). This finding is supported by WHO [5] and Endalew et al. [50], who reported that pesticide safe use practices are low in developing countries. This low pesticide safe use practice might be linked to a lack of knowledge, safety awareness, and training [51]. This finding implies that farmers have a high possibility of being exposed to many health-related risks [52, 53]. Hence, farmers' exposure to pesticides needs to be reduced through the correct usage of PPE [4, 5]. Moreover, pesticide safe use practices can be promoted by designing specific strategies, like educational programs, to enhance the awareness level of farmers.

In this review, the pooled prevalence of AHS among farmers was found to be 30.36% (95% CI: 19.61–41.1). This finding is supported by many studies [4, 54, 55] who suggested that unsafe use of pesticides may cause a range of adverse health-related symptoms among farmers. Moreover, this study is also supported by a systematic review conducted by Boedeker et al. [56], who reported that acute pesticide poisoning is an ongoing major global public health challenge. In developing countries, a high percentage of farmers experience AHS due to occupational exposure to pesticides, according to Jørs et al. [57]. The present finding implies that there are weak public health safety measures and limited regulation and surveillance systems. Therefore, urgent interventions are required for farmers to reduce and prevent occupational exposure to pesticides [5].

In this study, a subgroup analysis was conducted by the country to determine whether thereis variation in pesticide safe use practices and the prevalence of AHS among farmers. The present findings suggest that there is variation from country to country. The variation might be due to differences in the nature of the pesticides they used and sociodemographic characteristics of the farmers, such as sex, age, educational status, etc [10, 49]. The present finding is supported by a systematic review and meta-analysis study that showed that there are differences regarding countries in terms of pesticide poisoning and depression [58].

This study also identified factors associated with pesticide safe use practices among farmers in developing countries. Hence, good knowledge and attitudes, being educated, and having more than five years of pesticide use experience were all found to be associated with pesticide safe use practices among farmers.

Farmers with good knowledge and attitudes toward pesticides were significantly more likely to practice safe pesticide use. This finding is supported by Endalew et al. [50], Moradhaseli et al. [59], and Mequanint et al. [10]. The knowledge and attitude level of farmers about pesticides is of utmost significance to protect themselves and to use comprehensive strategies to reduce human health risks [50, 60]. Pesticide handlers with good knowledge and attitudes have better pesticide safety practices and lower health risks [61]. However, some farmers having good knowledge and attitudes toward pesticides may not be guaranteed because they may not implement them in practice [29, 62]. Evidence suggests that there is a need to improve the knowledge and attitude levels of farmers about pesticide safety practices through various strategies such as capacity building and training [10, 29].

This study also showed that farmers who were educated were found to have better pesticide safe use practices. This study, supported by different studies [29, 63, 64], implies that having education is crucial to understanding the instructions regarding safety issues and the harmful effects of pesticides. Moreover, the present finding, also supported by Khanal and Singh [11], implied that farmers who read the label on pesticide bottles had higher pesticide safe use practices than farmers who could not read the labels. In this context, the finding implied that illiterate farmers were at a higher risk of using pesticides because they were unable to understand the instructions regarding safety concerns and health effects [11, 29, 63, 65], suggesting that education has a significant impact on the utilization of pesticide technology. In addition, educated farmers are more likely to implement the training they receive. Therefore, to improve pesticide safety use practices for farmers, providing and promoting education programs is crucial.

Similarly, this study also showed that farmers with better pesticide use experience were found to have pesticide safe use practices. This finding is supported by Taghdisi et al. [29] and Aldosari et al. [66]. The possible reason for this finding might be that farmers who have more experience could use PPE appropriately during the preparation, handling, storage, and spraying of pesticides. In addition, farmers who have experience could understand the effects of unsafe pesticide practices. They may obtain information about the importance of safe pesticide use, and consequently, they protect themselves and their environments from their experiences [34, 49]. Moreover, the present finding, also supported by Memon et al. [67], shows that there is a positive association between PPE use and experience.

Limitations of the study

The studies included in this systematic review and meta-analysis were cross-sectional, which limits the ability to establish cause-and-effect relationships or accurately identify true determinants that could influence the outcomes of this study. Additionally, the assessment of pesticide safe use practices and AHS among farmers relied on self-reported data, which may impact the generalizability of the findings. Moreover, the study was unable to identify the most commonly used types of pesticides, as each study used a different pesticide nature, making it difficult to aggregate the data.

Conclusion

The findings of this study indicated that only less than half of the farmers practiced safe pesticide use, and approximately one-third reported experiencing AHS. Factors associated with pesticide safe use practices included good knowledge and attitudes, being educated, and over five years of pesticide use experiences. To enhance pesticide safety practices among farmers and protect their health, the concerned bodies and organizations better implement comprehensive intervention measures. These could include educational and safety training programs, as well as providing occupational safety materials like PPE. For future researchers, it is recommended that more robust and evidence-based study designs be employed to accurately assess pesticide safety use practices and AHS among farmers. Additionally, future studies should aim to identify the most commonly used types of pesticides among farmers.

Abbreviations

AHS	Acute Health Symptoms
EPA	Environmental Protection Agency
JBI	Johnna Briggs Institute
PPE	Personal Protection Equipment
PRISMA	Preferred Reporting Items for Systematic Review and Meta-Analysis
PROSPERO	Prospective Register of Systematic Reviews
WHO	World Health Organization

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-024-20817-x.

Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

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BD: originated the research idea, analyzed the data and write the manuscript. AHT, CD, TN, SH, EAA, YA, AME, and LW analyzed the data and reviewed the manuscript. All authors have read and approved the manuscript.

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Consent for publication
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Competing interests
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