

Analysis of Farmers' Compliance with PPE Use in Pesticide Use on Farms

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ABSTRACT

The use of pesticides in agriculture poses significant health risks to farmers, mainly when personal protective equipment (PPE) is not used correctly. Despite widespread pesticide application in farming practices, compliance with PPE usage remains low due to various individual, behavioral, and systemic factors. This study aims to evaluate the key determinants influencing farmers' compliance with PPE use during pesticide application. A literature review was conducted using sources from DOAJ, PubMed, and ScienceDirect published between 2020 and 2025, with search terms including "Personal Protective Equipment", "PPE compliance", "Protective behavior", "Farmers", and "Pesticide use". The review identified knowledge, risk perception, economic limitations, and institutional support as the main factors affecting PPE use. Low awareness, discomfort, limited accessibility, and weak regulatory enforcement contribute to unsafe pesticide-handling practices among farmers. Improving farmers' compliance with PPE requires a multidimensional approach that combines education, improved access to affordable PPE, behavior change strategies, and stronger institutional policies. Integrating these efforts can significantly reduce health risks and promote safer agricultural practices.

Keyword : PPE compliance, farmers, pesticide, farmer, agronursing

ABSTRAK

Penggunaan pestisida dalam pertanian menimbulkan risiko kesehatan yang signifikan bagi petani, terutama ketika alat pelindung diri (APD) tidak digunakan dengan benar. Meskipun penggunaan pestisida meluas dalam praktik pertanian, kepatuhan terhadap penggunaan APD tetap rendah karena berbagai faktor individu, perilaku, dan sistemik. Studi ini bertujuan untuk mengevaluasi faktor-faktor kunci yang memengaruhi kepatuhan petani terhadap penggunaan APD selama aplikasi pestisida. Tinjauan literatur dilakukan menggunakan sumber dari DOAJ, PubMed, dan ScienceDirect yang diterbitkan antara tahun 2020 dan 2025, dengan istilah pencarian termasuk "Alat Pelindung Diri", "Kepatuhan APD", "Perilaku Protektif", "Petani", dan "Penggunaan Pestisida". Tinjauan tersebut mengidentifikasi pengetahuan, persepsi risiko, keterbatasan ekonomi, dan dukungan kelembagaan sebagai faktor utama yang memengaruhi penggunaan APD. Kesadaran yang rendah, ketidaknyamanan, kurangnya aksesibilitas, dan penegakan peraturan yang lemah berkontribusi pada praktik penanganan pestisida yang tidak aman di kalangan petani. Meningkatkan kepatuhan petani terhadap APD membutuhkan pendekatan multidimensional yang menggabungkan pendidikan, peningkatan akses terhadap APD yang terjangkau, strategi perubahan perilaku, dan kebijakan kelembagaan yang lebih kuat. Mengintegrasikan upaya-upaya ini dapat secara signifikan mengurangi risiko kesehatan dan mendorong praktik pertanian yang lebih aman.

Kata kunci : Kepatuhan APD, petani, pestisida, petani, agronursing

1. INTRODUCTION

The use of pesticides in modern agricultural practices can significantly support crop productivity and ensure global food security. The role of chemicals has become essential in the implementation of contemporary agricultural processes due to their high efficacy and superior ability to protect crops from pests, thereby ensuring high yields (Chekol, 2025). In the last five decades, the use of pesticides has become an essential component of agricultural activities to help increase food production in developing countries. However, the high spread of pests, the rampant circulation of low-quality pesticides, and the tendency to gain more profit have led to a significant increase in pesticide use by farmers (Sookhtanlou & Allahyari, 2021)

However, there is still widespread reckless use of pesticides that pose risks to both the environment and human health, leading to acute and chronic health problems. Human and environmental exposure to pesticides can occur throughout the process, including mixing, loading, application, as well as through contact with the bargained crops during the return to the field. Unsafe pesticide use practices standard in developing countries include over-spraying, lack of personal protective equipment (PPE), improper storage of pesticides and their containers, and repeated use of washed pesticide containers for mice and beverages (Chekol, 2025). Therefore, proper use of personal protective equipment (PPE) during pesticide handling is important to protect farmers' health (Lari et al., 2023).

Pesticide exposure causes a range of acute and chronic health effects for farmers. An observational study in Tanzania found a high prevalence of neurological symptoms among sprayers: body weakness (57.1%), headache (40.7%), decreased appetite (29.3%), and skin irritation (26.4%) (Sapbamrer & Thammachai, 2020). As many as 27% of respondents even showed a decrease

in blood cholinesterase enzyme activity below normal limits, an indicator of organophosphate toxicity. These data confirm that pesticide exposure can trigger serious health effects, especially in the peripheral and central nervous systems. Other frequently reported effects include eye irritation, nausea, dizziness, and the risk of chronic diseases with repeated unprotected exposure. Therefore, not only are psychosocial factors important, but also the need for farmer health monitoring and education on the symptoms of pesticide poisoning (Sapbamrer & Thammachai, 2020).

International studies indicate that farmers' use of PPE when handling pesticides is low. For example, Sapbamrer & Thammachai (2020) systematic review reported basic PPE use: long-sleeved shirts were worn by ≈66% of farmers, long pants by 71%, but gloves by only ≈40.5% and masks by 43.2%. The percentage of complete PPE use was even lower. These results show that many farmers do not wear adequate protective gear during pesticide spraying. In contrast, formal training has been shown to improve such compliance (Sapbamrer & Thammachai, 2020). Farmers who have attended pesticide seminars or training show higher safety behaviors (including PPE use) than untrained farmers. In other words, practical educational interventions on the use of protective equipment can increase farmers' compliance with PPE requirements.

Although the importance of PPE use has been widely recognized, low levels of farmer knowledge about PPE remain standard across countries. For example, a study in Ethiopia found that most farmers did not use PPE due to high cost, limited availability, discomfort, and a lack of understanding of its importance (Chekol, 2025). Another study also expressed a similar opinion where in low-income countries (LICs) the majority of people chose not to use PPE during

farming activities due to factors such as lack of awareness, lack of access, unaffordability, discomfort due to heat and humidity, perceptions that considered PPE unnecessary, and the belief that it could cause disease (Lari, et al., 2023).

In a study by Bandanaa et al. (2024), it was noted that socio-demographic factors also affect compliance with PPE use. The study showed that age, education level, land ownership, and pesticide use training can significantly affect compliance with PPE use. In another study, it was mentioned that the level of knowledge and awareness, cultural conditions and prevailing norms, availability of costs and accessibility, regulatory control, gender, age, education level, and years of experience have a significant influence on compliance of farmers in implementing occupational safety (Ndirangu et al., 2025). Sookhtanlou & Allahyari (2021) state that farmers who receive training on work safety tend to have greater awareness of the importance of personal protection and higher levels of compliance than those who do not receive similar training. In addition to internal factors, external information support also plays an important role in shaping farmers' perceptions and behavior towards work safety. Farmers who receive information from agricultural extension workers and public institutions tend to be more compliant with the use of PPE when compared to farmers who only rely on information from pesticide retailers. In fact, it also affects farmers' decision-making regarding pesticide use. This is evidenced by farmers who obtain information from public extension services, who tend to use pest control measures, compared with those who receive private extension services, who tend to use synthetic insecticides (Tsakiris et al., 2023).

Efforts to increase farmers' compliance with PPE use are also evident through community-based interventions. In India, there was a positive impact on consistent PPE use, as evidenced by increased farmer participation in risk awareness programs and safety trainers, particularly regarding respirators, gloves, and eye protection (Lari et al., 2023). Therefore, a participatory training approach can be an effective strategy for improving work-safety behavior, especially the use of PPE among farmers (Sookhtanlou & Allahyari, 2021).

Various studies have shown that education and training programs are effective in improving farmers' occupational safety. For example, a quasi-experiment in Iran using the health belief model reported that after the educational intervention, farmers' attitude scores and safe behaviors improved significantly (Ahmadipour & Nakhei, 2024). These improvements included increased PPE use frequency and reduced risky behaviors. Similar results were reported in a study in Greece: farmers who had attended pesticide seminars showed greater knowledge and stronger hazard-control beliefs, followed by better safety behaviors (PPE use) than those who had not been trained (Kangavari et al., 2024). The study highlighted the importance of improving knowledge and compliance through structured training (educative intervention) as a priority to reduce pesticide exposure. Thus, educational programs designed according to audience characteristics (education, language, local customs) are a key strategy to improve PPE compliance and reduce farmers' health risks (Kangavari et al., 2024).

Therefore, it is important to review the literature on the factors and compliance rates associated with farmers' use of PPE when applying pesticides (Teysseire et al., 2020). This literature review focuses on identifying and analyzing findings from previous studies to understand better the challenges and

appropriate solutions to improve farmers' occupational safety. This is done to provide a scientific basis for efforts to improve farmer occupational safety across different geographical and socioeconomic contexts.

METHOD

This research uses the literature review method. Literature sources were collected from research journal databases and the Internet, focusing on PubMed, ScienceDirect, and DOAJ between 2020 and 2025. English keywords were used to identify relevant literature. The keywords used in the search were "Personal Protective Equipment", "PPE compliance", "Protective behavior", "Farmers", and "Pesticide use."

The journal search process began by identifying specific keywords. At the search stage, a total of 1,887 articles were identified as relevant to the keywords, comprising 1,327 from ScienceDirect, 201 from PubMed, and 359 from DOAJ. During the screening process, 216 articles were removed due to duplication, ineligibility determined by automated tools, or publication year. This left 1,671 articles for further screening.

At the next stage, 579 articles were excluded for failing to meet the predetermined criteria (review analysis). A total of 1,092 articles were selected for retrieval, but only 45 full-text articles were successfully obtained, while 1,047 could not be retrieved. These 45 articles were then assessed for eligibility based on inclusion and exclusion criteria. As a result, 33 articles were excluded due to reasons such as not being original research, lacking relevant outcomes, or having incomplete or unclear reporting. After this process, 12 articles were selected as eligible and were included in the final review. The results of this screening process are shown in the following PRISMA chart.

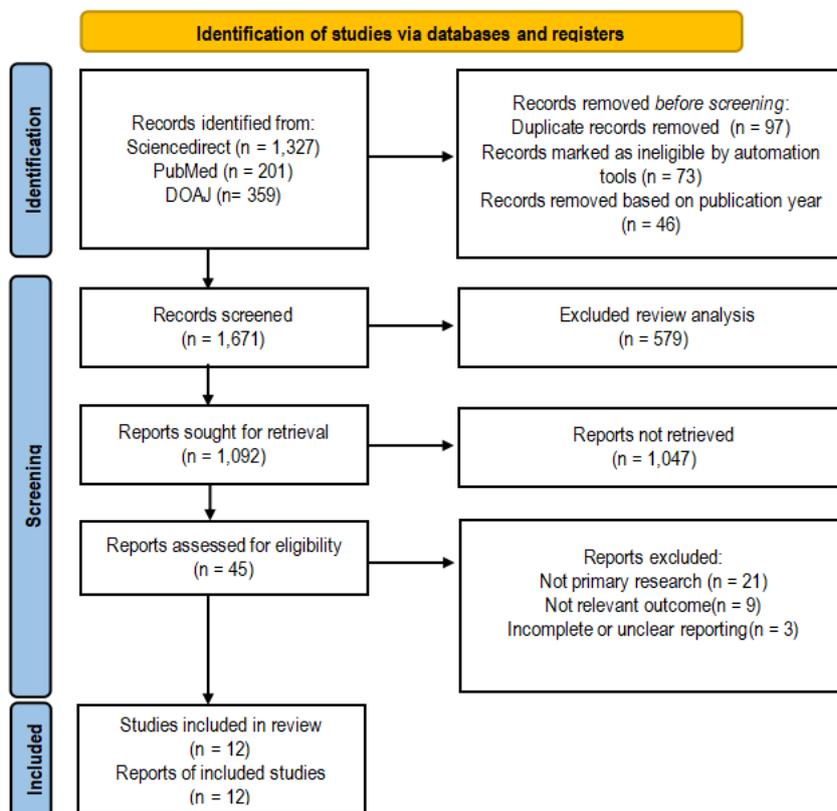


Figure 1. PRISMA Flowchart of The Literature Search

2. RESULT

After examining various studies and articles, twelve studies were found that showed differences in PPE Use Compliance Rates Among Farmers Who Use Pesticides. For more detailed information, see Table 1 for the results of the following literature analysis.

Table 1. Results of Literature Review

No	Author	Article Title/Journal Name/Volum e	Sample	Method	Result	Limitation	Objective
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1. Sookht anlou & Allahya ri (2021)	Farmers' health risk and the use of personal protective equipment (PPE) during pesticide application / Environment al Science and Pollution Research / Volume 28 / Number 22 https://doi.org/10.1007/s11356-021-12502-y	A total of 370 potato farmers were selected through a multi-stage sampling method from a population of 4,876 farmers in Ardabil Province, Iran. Samples were taken from three districts in Iran: 193 from Ardabil, 104 from Namin, and 73 from Nir, with 16 randomly selected villages. Samples were selected based on the criterion that farmers either use or are directly involved in the spraying of pesticides.	This study is quantitative descriptive (frequency, mean, percentage, standard deviation) and inferential (correlation between variables, Decision Tree in the form of CART Model, Composite Index) using a survey approach in the form of a structured questionnaire which is divided into three parts including demographic characteristics of farmers, use of pesticides and PPE, and health risk indices related to PPE use. Data were collected through direct interviews.	The findings of this study show that farmers are categorized into three groups of health risks related to PPE use based on the decision tree model: low (34.1%), medium (26.5%), and high (39.5%). In addition, important variables in predicting health risk include land size, perceived risk of pesticides, prior experience with pesticide-related adverse effects, attendance at bleaching, and farmers' ability to pay for PPE. On the other hand, it was found that farmers with small land sizes (less than 5.75 ha), especially those of the same size and less able to afford PPE, were at higher risk. About 67.3% of farmers in this group are at high risk, and 50.2% are at the highest risk. It is stated that farmers have a low perception of the hazards posed by the most toxic pesticides, with only 25.4% aware of the hazards of	This study has limitations in assessing health risks, as it was conducted only during the pesticide spraying stage and thus does not cover the entire process, including purchasing, storage, preparation, and post-use. In addition, there is a possibility of perception bias and less-than-optimal preventive behavior, in which risk perception does not always align with the level of pesticide toxicity, even though risk perception affects PPE use. Data on PPE use and perception may be subject to memory bias or social desirability, as they are collected through interviews and checklists	This study focuses on identifying the different types of pesticides applicable in the study area and the level of PPE use among farmers for each type. In addition, the study also assessed the level of health risks to farmers associated with PPE use in a composite manner and identified the most hazardous types of pesticides. Also, the study examined farmers' perceptions of pesticide health hazards and the influence of these perceptions on the level of health risk associated with PPE use. On the other hand, this study also identified the main predictive factors influencing farmers' health risk levels when using PPE during pesticide application.
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Paraquat and Chlorpyrifos. Most farmers use only a few types of PPE, such as boots and hats, while respirator masks and protective eyewear are less common. Overall, this study shows that variables such as experience, perception, economic capability, and land size strongly influence farmers' level of health risk in PPE use. Other factors, such as increased knowledge and economic support, could help reduce these risks.

that rely solely on farmer reports and direct observation. This study included only farmers who actively participated in the pesticide application process, so the results may not be fully applicable to all farmers in the area who use different methods. Also, the decision tree model and the variables used were unable to fully capture the complex social, economic, and educational factors that influence farmers' behavior and health risks.

2.	Aye et al. (2023)	Pesticide safety behaviors among agricultural workers and farmers: A cross-sectional study / International Journal of Nursing Practice,	195 cabbage farmers from Kalaw Township, Myanmar, who had at least 2 years of experience growing cabbage and used pesticides at least once.	Cross-sectional study with data collection using a questionnaire developed based on the PRECEDE-PROCEED model, followed by bivariate and multivariate logistic	72.1% of farmers exhibited low safety behaviors; brass and masks were rarely used; all experienced adverse health effects from pesticides; and influential factors included attitudes towards poisoning, support from	The study was cross-sectional and showed only an association, not a cause-and-effect relationship. The sample was limited to one region, so the results	To investigate pesticide safety behavior and its factors, including predisposing, reinforcing, and barrier factors that influence such behavior among cabbage farmers in Myanmar.
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		2024, Vol. 30, e13222. https://doi.org/10.1111/ijn.13222	regression analysis.	family, coworkers, and health care providers, and the availability of personal protection.	cannot be generalized.		
3.	Joko, et al. (2020)	Pesticide Poisoning and the Use of Personal Protective Equipment (PPE) in Indonesian Farmers / Journal of Environmental and Public Health / Volume 2020 https://doi.org/10.1155/2020/5379619	100 red onion farmers in Wanasari Subdistrict, Brebes, Indonesia.	Observational research with a cross-sectional design. Data collected through questionnaires and focus group discussions (FGD). Statistical analysis using chi-square continuity correction and odds ratio (OR) calculation.	Significant correlation between the use of PPE and pesticide poisoning symptoms ($p < 0.005$). Symptoms included excessive fatigue, excessive saliva, difficulty breathing, frequent urination, blurred vision, dizziness, and finger pain. An OR of 1.137 indicated that PPE was a risk factor for health problems.	Limited to self-reported symptoms; no biochemical confirmation of pesticide exposure (e.g., blood or urine metabolites)	To investigate the relationship between PPE use and symptoms of pesticide poisoning among red onion farmers in Wanasari, Brebes.
4.	Lari, Vanka, et al. (2023)	Mitigation of pesticide residue levels in the exposed dermal regions of occupationally exposed farmworkers by use of personal protective equipment / Frontiers in Public Health / Volume 11 https://doi.org/10.3389/fpubh.2023.1232149	The study sample was 120 farmworkers from three crop groups (paddy, vegetable, cotton) and from four villages in Rangareddy district, Telangana, India.	Community-based follow-up study accompanied by a pre-test.	This study shows very low compliance with personal protective equipment (PPE) among farmers in Rangareddy District, Telangana, India. Of the 120 farmers studied, about 99% did not use PPE while spraying pesticides, and only one person used minimal protection, such as a handkerchief or towel. This low compliance was	A limitation of this study is that the results may not fully represent all field conditions, given the sample size of only 120 farmers from four villages in one district in India. In addition, although PPE use reduces exposure, the effectiveness of local PPE remains	This study aims to evaluate dermal pesticide exposure among farmworkers in Rangareddy district, Telangana, India, and to systematically assess how the use of PPE can mitigate pesticide exposure and associated health risks for agricultural workers.

due to a lack of awareness of the risks of pesticide exposure, the inconvenience of using PPE in hot, humid tropical climates, and limited access and cost. Although most farmers understand the importance of personal protection, they tend to follow the advice of pesticide sellers rather than safe farming practices. After the intervention of providing free PPE, both commercial and locally made, there was an increase in PPE use and a significant decrease in pesticide residues on the skin, proving the effectiveness of PPE in reducing dermal exposure to pesticides.

5.	Udoh & Gibbs (2022)	Commentary : Highlighting the need for pesticide safety training in Nigeria: A survey of households in River state / Frontiers in Public Health / Volume 10	Respondents were 152 cassava and vegetable farmers in Kom-kom, Obeama, and Mmiriwanyi Oyigbo districts of Rivers State, Nigeria.	This article uses interviews with 152 cassava and vegetable farmers in Pidgin English, with the criterion that farmers have a home within a 10km radius of Norina Farms' office in Mmiriwanyi.	After interviewing 152 farmers, it was found that only 2% used complete personal protective equipment (PPE), with the rest wearing only home clothes and rubber gloves or face masks. 66% of farmers use and	The authors conducted interviews only in the vicinity of Norina Farms, so their findings do not reflect farmers' compliance with PPE use across Nigeria.	This article discusses the use of PPE among farmers and the factors that lead to non-compliance.
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<https://doi.org/10.3389/fpubh.2022.988855>

consider home clothes PPE, and even reuse them at home, which could increase the risk of exposure to others. Several factors contributed to farmers' non-compliance with PPE use in Mmiriwanyi, Nigeria, including limited access, lack of education on proper PPE use, high PPE costs, inappropriate sizes, heat, and stuffiness during activities. The reuse of PPE and the lack of management of pesticide containers are also impacts of the lack of education on PPE and pesticide use among farmers.

6.	Abdolla hzadeh & Sharifz adeh (2021)	Predicting Farmers' Intention to Use PPE for Preventing Adverse Effects: An Examination of The Health Belief Model (HBM) / Journal of the Saudi Society of Agricultural Sciences /	387 rice farmers in Sari District, Mazandaran Province, Iran were randomly selected from five sub- districts and were all male, with an average age of 44.25 years.	Quantitative using the Health Belief Model (HBM).	The results showed that the majority of farmers (56.33%) agreed they would use the full range of PPE to prevent future infection risks associated with pesticide use. Factors that positively influence farmers' intention to use a range of PPE include the three components of	This study has several limitations, including the sample, which consisted of small-scale rice farmers with low levels of education and low income, limiting the generalizabili ty of the results to other groups	This study was conducted to identify factors influencing farmers' decisions to use PPE to mitigate the adverse effects of pesticide use, using the Health Belief Model (HBM).
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	<p>Volume 20, Issue 1 https://doi.org/10.1016/j.jssas.2020.11.001</p>		<p>HBM: a higher perceived severity of pesticide adverse effects, cues to action, and perceived PPE benefits. In addition, perceived PPE barriers negatively affected farmers' intentions. This study suggests that extension and training programs that focus on the severity of pesticide-related adverse effects, as well as perceived PPE benefits and barriers, are more effective at increasing farmers' preventive behavior.</p>	<p>of farmers. In addition, the regression analysis did not include farmers' personal demographic variables and farm production system characteristics, which are important factors in the willingness to use PPE in agricultural practices.</p>	
<p>7. Sapbar et al. (2024)</p>	<p>Socio-demographic, agricultural, and personal protective factors in relation to health literacy among farmers from all regions of Thailand / <i>Frontiers in Public Health</i> / Volume 12 https://doi.org/10.3389/fpubh.2024.1364296</p>	<p>A total of 4,035 farmers from all major regions of Thailand, with representation from four large regions, with data collected via a cross-sectional design during January to July 2023</p>	<p>This study used a cross-sectional survey design, employed the European Health Literacy Survey-47 (HLS-EU-Q47) questionnaire to measure health literacy, and analyzed the data using descriptive statistics and multiple linear regression to identify related factors.</p>	<p>The results showed that the average health literacy score was 34.7 with a standard deviation of 8.7. The Northern region had the highest prevalence of limited health literacy at 75.8%. Factors such as gender, region of residence, marital status, education level, presence of comorbidities, and household size significantly influenced</p>	<p>Significant limitations included potential recall bias from retrospective data collection, low baseline health literacy levels that affected questionnaire comprehension, and cultural and language diversity across regions that potentially influenced</p>

farmers' health data literacy. interpretation. Additionally, , and the farming , cross-sectional practices, such as the number of pesticides used, working hours, and protective gear like hats prevented establishing causal relationships. and goggles, also affected their health literacy.

<p>8. Ali, et al. (2020) Farmer's Behavior in Pesticide Use: Insights Study from Smallholder and Intensive Farms in Bangladesh / Science of the Total Environment / Volume 7 https://doi.org/10.1016/j.scitotenv.2020.141160</p>	<p>917 farming households across four different regions of Bangladesh, cultivating rice, vegetables, and mixed crops.</p>	<p>Quantitative survey using a structured questionnaire with 30 questions covering farmers' knowledge, perceptions, pesticide use behaviors, and trust towards retailers and government. Data analysis involved descriptive statistics and factor modeling using SPSS and the 'lavaan' package.</p>	<p>Protective behaviors (PB) varied significantly across crop types and regions. Higher knowledge and positive risk perceptions correlated with safer practices, but trust in government and retailers surprisingly decreased protective behaviors. A notable gap exists among farmers, authorities, and pesticide suppliers that requires targeted policy intervention.</p>	<p>The study is region-specific and cross-sectional, limiting insights into behavioral changes over time and the contextual factors influencing pesticide practices.</p>	<p>To identify the key factors influencing farmers' pesticide use behaviors and to propose policies that involve all stakeholders to improve pesticide safety and sustainability in Bangladesh.</p>
<p>9. Oshingbade, et al. (2024) Determinants of Safe Pesticide Handling and Application</p>	<p>The study involved 383 farmers in rural communities of Oyo State, Nigeria.</p>	<p>Cross-sectional, two-stage cluster sampling, structured questionnaire,</p>	<p>This study found that only about half of the farmers (50.2%) routinely use personal</p>	<p>Limitations of this study include its cross-sectional design, which</p>	<p>To determine factors influencing compliance and safe practices in pesticide handling</p>

Among Rural
Farmers /
Int. J.
Environ.
Res. Public
Health /
Volume 22,
Number 2
<https://doi.org/10.3390/ijerph22020211>

descriptive
statistical
analysis, and
logistic
regression.

protective
equipment (PPE)
such as
coveralls, gloves,
and masks when
applying
pesticides. The
majority of
farmers (73.5%)
had good
knowledge of
pesticide
hazards, and the
training and
knowledge
significantly
improved safe
pesticide
handling
practices. However,
risky
behaviors such
as using used
pesticide
containers and
blowing nozzles
with the mouth
were still found.
The most
commonly
reported health
symptoms due to
pesticide
exposure were
skin irritation,
itchy eyes, and
excessive
sweating.

describes the
situation at a
single point in
time and
cannot
assess
changes in
behavior over
time. In
addition, the
data
collected was
self-reported,
potentially
leading to
reporting bias
or social
desirability
bias. The
study was
conducted in
only two local
areas in Oyo
State, so the
results may
not be
generalizable
to the entire
population of
farmers in
Nigeria or
other
developing
countries.

and application,
particularly
regarding PPE
use, among rural
farmers in Oyo
State, Nigeria.

10	Mehmo od, et al. (2021)	Occupationa l hazards, health costs, and pesticide handling practices among vegetable growers in Pakistan / Environment al Research / Volume. 200 https://doi.org/10.1016/j.envres.2021.111340	307 vegetable farmers in Punjab, Pakistan	Cross- sectional survey using a structured questionnaire; logistic regression model to analyze determinants of protective equipment use and pesticide container disposal practices.	The average protection and health costs due to pesticide exposure were USD \$3.60 per farmer per vegetable season. Significant factors for safety equipment use included age, education, IPM training, health effects, and health costs. Most farmers used inadequate protective gear and disposed of pesticides unsafely.	Did not explore reasons for non-use of PPE; focused only on short- term health impacts; recall bias possible; lacked comparison with hospital data.	To analyze the health costs of pesticide exposure and identify the determinants of pesticide handling practices among vegetable growers in Pakistan
11	Galli, et al. (2022)	Assessment of pesticide safety knowledge and practices in Vietnam: A cross- sectional study of smallholder farmers in the Mekong Delta / Journal of Corporate and Environment al Hygiene / Volume 19, Issue 9. https://doi.org/10.1080/15459624.2022.2100403	The sample size was estimated to be approximately 400 farmers, randomly selected from three communities in Thoi Lai District, Can Tho, Vietnam. Inclusion criteria included farmers who were at least 18 years old, who had grown crops and used pesticides for at least the past 12 months.	Data were collected through a questionnaire survey comprising 24 questions on knowledge and practices related to pesticides, developed with the Open Data Kit (ODK). The survey was conducted in person with an interpreter to ensure understanding. Data were analyzed using regression model analysis to identify factors influencing knowledge and practices of safe pesticide use. To	The study showed that farmers' knowledge of safe pesticide use remains low despite the education program provided. Unsafe pesticide use practices are standard, such as failing to use appropriate personal protective equipment and improper storage methods. A significant positive correlation was found between knowledge and safe practices, indicating that farmers with greater knowledge tend to implement	This study has some limitations. The cross- sectional design does not allow for causal inference regarding the relationship between pesticide knowledge and practices. The data collected also did not directly measure pesticide exposure or environment al impacts. The lack of detailed information on types of personal	This study aims to describe the levels of knowledge and practice regarding pesticide use among smallholder farmers in the Mekong Delta, Vietnam. More specifically, the study focuses on identifying the determinants of pesticide safety knowledge and examining the relationship between knowledge level and safe and unsafe pesticide use practices. In other words, the main objective of the study is to understand how knowledge levels shape farmers' pesticide-related

			analyze the determinants and the relationship between knowledge and practice, statistical analyses such as regression and latent class analyses were used.	safer practices. Factors that influence pesticide use include education level, farming experience, and participation in official educational programs, such as IPM and GAP.	protective equipment, materials, and comfort limits the interpretation of protective practices. Other factors, such as attitudes, economic conditions, and crop types, were not analyzed, which can influence pesticide use practices.	practices, and the factors that can improve knowledge and practices to enhance farmers' safety and the sustainability of safe pesticide use in the area.	
12	Teyssere, et al. (2020)	Assessment of residential exposures to agricultural pesticides: A scoping review, published in <i>PLOS ONE</i> , Volume 15 https://doi.org/10.1371/journal.pone.0232258	The review analyzed 151 studies published between 1988 and 2019, including epidemiological studies (98), observational measurement studies (26), and risk assessment studies (8). Studies mainly originated in North America and Europe and involved residents living close to agricultural sites.	The review followed a scoping methodology based on Arksey and O'Malley's framework and PRISMA-ScR guidelines. Data were charted and summarized based on study type, measurement methods, and exposure pathways.	Most studies used Geographic Information Systems (GIS) and surveys to assess exposure. Biological measurements (urine, teeth) and environmental samples (dust, air) were standard methods for measuring direct exposure. Few studies have quantified health risks for management purposes, mainly through modeling. Exposure is mainly linked to the proximity of residences to farming activities, but the evidence for safe distances remains inconclusive.	The studies' heterogeneity and varying quality prevent definitive conclusions. The assessment tools and methods differ widely, and the complex nature of pesticide dispersion and exposure routes poses challenges. Also, temporal and geographical variability limit generalizability.	To provide an overview of scientific literature characterizing residential exposure to agricultural pesticides, review measurement methods, and identify gaps for future research.

3. DISCUSSION

Agronursing represents an innovative healthcare approach that bridges nursing science with agricultural contexts to address the unique health challenges faced by farming communities, particularly those related to pesticide exposure. Within this framework, agronurses serve as critical agents of change, providing targeted health education, conducting risk assessments, and promoting safety behaviors among farmers who routinely handle hazardous agrochemicals (Ramadhani et al., 2025; Asmaningrum et al., 2025). Despite widespread awareness of pesticide risks, research consistently reveals suboptimal compliance with personal protective equipment (PPE) use, with studies showing that many farmers neglect complete protective gear, such as chemical-resistant gloves, respirators, goggles, and coveralls, during mixing, application, or equipment cleaning. Barriers to PPE adherence include discomfort in hot climates, perceived inconvenience, inadequate training, and limited access to proper equipment, leaving agricultural workers vulnerable to acute poisoning and chronic health effects. Agronursing interventions thus play a vital role in closing this safety gap by delivering culturally appropriate education, demonstrating proper PPE use, and empowering farmers to adopt protective behaviors that align with regulatory standards, such as the Worker Protection Standard, ultimately reducing occupational health risks in agricultural settings (Kurniyawan et al., 2025).

Based on the results of the analysis from the 12 journals above, it can be stated that the level of farmers' compliance in the use of personal protective equipment (PPE) when spraying pesticides is still in the low category in various

regions, as evidenced by the results of research on farmers in River, Nigeria where only 2% of farmers use complete PPE (Udoh & Gibbs, 2022). In Telangana, India, a small proportion of farmers reported compliance with PPE during pesticide spraying (Lari et al., 2023). This is due to several factors that lead to farmers' non-compliance with PPE use, such as limited access to PPE, lack of education for farmers on its use, inappropriate PPE sizes, heat experienced when using PPE, and the high cost of PPE (Udoh & Gibbs, 2022). Some types of PPE are often used by farmers, such as boots and hats; some farmers also use gloves and face masks (Sookhtanlou & Allahyari, 2021).

Inadequate use of PPE can affect the health of farmers and families, for example, through pesticide poisoning. In fact, most farmers reuse PPE used for spraying pesticides at home, further increasing the risk of exposure to pesticides and poisoning others. Poor management of pesticide containers can also pose a risk of pesticide poisoning (Udoh & Gibbs, 2022). Symptoms of pesticide poisoning include excessive fatigue, excessive salivation, shortness of breath, blurred vision, dizziness, and finger pain (Joko et al., 2020). In addition, skin irritation, itchy eyes, and excessive sweating can occur with pesticide poisoning (Oshingbade et al., 2024). Several factors that can affect farmers' health, primarily when pesticide poisoning occurs, include attitudes towards poisoning, support from family, coworkers, and health workers, and the availability of PPE (Aye et al., 2023). Gender, area of residence, marital status, education level, presence of comorbidities, and number of family members also affect farmers' health (Sapbamrer et al., 2024).

Studies have also shown that farmers' risk perception and knowledge of pesticide hazards significantly affect their self-protection behavior. Sookhtanlou & Allahyari (2021) found that only 25.4% of farmers were aware

of the dangers of Paraquat, and 36.5% were aware of the dangers of Chlorpyrifos, highlighting a significant gap in pesticide risk awareness. This low perception of risk leads many farmers not to feel the need to consistently use PPE. Psychological and social factors also play an important role, as described in the Health Belief Model (HBM) by Abdollahzadeh & Sharifzadeh (2021), which shows that perceptions of risk severity and the benefits of PPE influence farmers' intentions to protect themselves. Support from family, colleagues, and health workers has also been shown to increase protective behaviors (Aye et al., 2023), while excessive trust in pesticide sellers or the government actually decreases farmers' awareness of the importance of PPE (Ali et al., 2020).

On the other hand, structural and economic factors are also significant obstacles. The availability and price of PPE are the main obstacles, especially for low-income farmers. Mehmood et al. (2021) noted that the average cost of treatment and protection due to pesticide exposure reaches USD \$3.60 per growing season per farmer, a considerable figure for farming families in developing countries. Free PPE-based interventions have been shown to improve compliance, as demonstrated by Lari et al. (2023) and Udoh & Gibbs (2022). In addition, the design of PPE that is not ergonomic and uncomfortable to wear in tropical climates is the main reason why farmers are reluctant to use it (Lari et al., 2023; Udoh & Gibbs, 2022). This shows the need for innovative PPE designs that are lighter, cooler, and sized to the farmer's body. Gender inequality must also be considered, as women farmers often face greater barriers to access to size-appropriate training, information, and PPE (Sapbamrer et al., 2024).

Low health literacy can also exacerbate the situation, especially in areas with low levels of education and limited access to information. Sapbamrer et al. (2024) reported that 75.8% of farmers in the northern region have limited health literacy, which is influenced by factors such as education level, marital status, and number of family members. This has a direct impact on decision-making in the use of PPE and safe spraying practices. Training in Integrated Pest Management (IPM) and Good Agricultural Practices (GAP) has been shown to increase farmers' awareness and skills in handling pesticides safely (Galli et al., 2022). Multidisciplinary approaches are also increasingly needed, such as the use of Geographic Information Systems (GIS) and biomonitoring to map high-risk areas and design data-driven interventions (Teyseire et al., 2020). Therefore, efforts to improve PPE compliance must be carried out through an integrated approach, including ongoing education, evidence-based interventions, adequate PPE provision, and policies that prioritize farmers' long-term health

CONCLUSION

Based on the literature review of 12 studies, it can be concluded that farmers' compliance with the use of personal protective equipment (PPE) during pesticide handling remains low, particularly in developing countries. Key contributing factors to this non-compliance include limited knowledge and low risk perception regarding pesticide hazards, inadequate access to proper PPE, high costs, discomfort during use, and a lack of formal education and training. Exposure to pesticides without adequate protection can lead to both acute and chronic health issues, including neurological disorders, skin and eye irritation, and decreased cholinesterase enzyme activity. Demographic factors

such as age, education level, gender, farming experience, and social support also influence compliance levels. Moreover, access to information through public agricultural extension services and community-based interventions has proven effective in improving farmers' safety behavior. Improving PPE compliance requires an integrated approach involving continuous education tailored to local characteristics, provision of ergonomically designed and affordable PPE, and strengthened policies to protect farmers' occupational health. Such efforts will not only enhance agricultural workplace safety but also contribute to the sustainability of food systems and rural community well-being.

4. ACKNOWLEDGEMENT

We would like to thank all the authors who contributed to the writing of this article. Solid collaboration and complementary teamwork are the main keys in completing this scientific work. Thanks to Sri Intan Nur'aini, Riky Styawan, Bunga Istiqomah Awalia Ramadhani, Marshanda Avy Sal Sabila, Rafelina Putri Aindani, Janica Ainun Balqies, Putri Dwi Ramadina, Salman Al Farisi, and Mila Hindrayani. Their discussions and support have helped strengthen the quality of this paper.

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