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Review

Exposure to Pesticides and Mucocutaneous Adverse Effects Among Asian Agricultural Workers: A Scoping Review

Warin Intana [1], Chime Eden [2] and Weeratian Tawanwongsri [3,*]

[1] School of Agricultural Technology and Food Industry, Walailak University, Nakhon Si Thammarat 80160, Thailand
[2] Department of Dermatology, Jigme Dorji Wangchuck National Referral Hospital (JDWNRH), Thimphu 11001, Bhutan
[3] Division of Dermatology, Department of Internal Medicine, School of Medicine, Walailak University, Nakhon Si Thammarat 80160, Thailand
* Correspondence: weeratian.ta@wu.ac.th

Abstract

Pesticides are commonly used in agriculture to ensure disease-free products; however, comprehensive evidence of their mucocutaneous effects among Asian agricultural workers is limited. This scoping review aimed to map the prevalence, clinical characteristics, and contributing factors of pesticide-related mucocutaneous conditions among agricultural workers in Asia. The study was conducted in PubMed, Scopus, and the Directory of Open Access Journals to identify studies published between 2005 and January 2025. Observational and cross-sectional studies involving agricultural workers in Asia and examining pesticide exposure with associated mucocutaneous effects were included. Data were charted using a standardized form, including study details, participant demographics, prevalence of mucocutaneous symptoms, types of pesticides used, and exposure-related outcomes. A total of ten studies were included in the study. Skin-related symptoms ranged from 4.8% to 37.5%, while ocular symptoms ranged from 6.0% to 41.2%. Allergic contact dermatitis was reported in 26.1% of workers, and acute dermatitis accounted for 24.0% to 54.0% of pesticide-related dermatitis cases. Organophosphate insecticides, bipyridylium herbicides, and fungicides were commonly reported in relation to these effects. Limited personal protective equipment use and unsafe practices may have increased exposure risk. This review highlights the need for standardized exposure assessment, improved protective measures, and stronger occupational safety interventions.

Keywords: pesticides; occupational exposure; agricultural workers' diseases; dermatitis; occupational; mucocutaneous manifestations

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1. Introduction

Pesticides are chemical compounds or biological agents formulated to eliminate, inhibit growth, or repel specific organisms [1]. While "biocide" can broadly refer to chemical agents used in both agricultural and non-agricultural settings, this review uses "pesticide" to refer specifically to agricultural chemicals associated with occupational exposure affecting farmworkers' skin, eyes, and mucosa [2]. Although these are designed to be toxic to target species such as insects, fungi, nematodes, and weeds, they should ideally pose minimal risk to humans and non-target organisms [2]. In modern agriculture, pesticides play a vital role in protecting crops from pests, diseases, and weeds, enhancing yield, and improving the quality of food and fiber products [3]. Their use enhances the economic viability and sustainability of agricultural production by minimizing crop losses and maintaining high productivity [4]. However, pesticide residues can persist in soil and water, potentially compromising environmental quality and posing risks to human health [1,5].

Certain pesticides are known to cause dermatoses [6]. Among fungicides, captan, chlorothalonil, and sulfur are common culprits, while herbicides such as glyphosate and paraquat are also linked to skin reactions. Insecticides like pyrethroids and chlorpyrifos, as well as nematicides such as methyl parathion, have been associated with dermatological effects. Contact dermatitis is commonly linked to captan, chlorothalonil, sulfur, and pyrethroids. Urticaria has been reported with exposure to chlorothalonil and captan, while erythema multiforme is associated with parathion and glyphosate. Chlorothalonil has been implicated in ashy dermatoses, and chloracne has been linked to pentachlorophenol. Additionally, paraquat exposure has been associated with nail dystrophy. Agricultural workers frequently come into direct contact with pesticides during mixing, loading, and spraying, resulting in significant dermal exposure. Skin contact is one of the primary pathways for pesticide absorption, mainly when inadequate protective measures leave exposed body areas vulnerable to various dermatologic conditions [7]. Using personal protective equipment (PPE), including gloves, masks, and protective clothing, effectively reduces mucocutaneous risks associated with pesticide exposure [8]. However, PPE adoption remains low, primarily due to limited awareness and resource constraints. A previous study reported that over 95% of agricultural workers did not adhere to minimum safety protocols, and 90% experienced adverse health effects, such as skin pain and pruritus, following pesticide use [9].

Asia represents a particularly relevant regional context for examining mucocutaneous effects related to agricultural pesticide exposure. The region includes a large agricultural workforce and several countries with intensive pesticide production, consumption, and application in small-scale farming systems. For example, India has been described as one of the major pesticide producers in Asia, while China has been reported as one of the world's largest pesticide producers and consumers, reflecting the scale of agricultural chemical use in the region [10,11]. In many Asian agricultural settings, workers may be exposed through mixing, loading, spraying, cleaning equipment, handling spills, and post-spraying fieldwork, with dermal and ocular contact representing important exposure pathways [12,13].

Several regional factors may further increase mucocutaneous exposure risk. These include the continued use of moderately to highly hazardous pesticides, reliance on low-technology or faulty spraying equipment, limited occupational hygiene regulation, low literacy or limited pesticide-label comprehension, and socioeconomic barriers to purchasing or consistently using personal protective equipment [10–12]. In addition, hot and humid climates may discourage the use of gloves, masks, coveralls, and other protective measures because of thermal discomfort, particularly among smallholder or migrant agricultural workers [10,13]. These conditions may contribute to direct skin, eye, and mucosal exposure and help explain the frequent reporting of dermatitis, skin irritation, eye irritation, scaling, pruritus, and other mucocutaneous symptoms among agricultural workers in Asian settings [10–12].

Despite these concerns, the evidence on pesticide-related mucocutaneous outcomes among Asian agricultural workers remains dispersed across countries, study designs, pesticide classes, exposure definitions, and outcome measures. A region-specific scoping review is therefore appropriate to map the available evidence, summarize reported patterns of mucocutaneous effects, identify exposure-related and preventive factors, and clarify research gaps relevant to occupational health policy and future epidemiological surveillance in Asian agricultural settings.

Previous reviews have addressed pesticide exposure and health risks among agricultural workers, but their focus has generally differed from the objective of the present review. Some reviews have summarized broad pesticide-related health outcomes, including neurological, respiratory, reproductive, renal, gastrointestinal, dermatological, and carcinogenic effects, without specifically analyzing mucocutaneous outcomes as the central focus [14]. Other reviews have focused primarily on dermal exposure assessment methods, pesticide absorption pathways, or the role of personal protective equipment rather than clinical skin, ocular, or mucosal outcomes [13,15,16]. Although occupational contact dermatitis among farmworkers has been reviewed, this evidence has largely been global or focused on migrant and seasonal farmworkers and has included multiple occupational allergens beyond agricultural pesticides [17]. Therefore, evidence specifically mapping pesticide-related mucocutaneous adverse effects among agricultural workers in Asia remains limited and dispersed. To our knowledge, this is the first scoping review to systematically map the extent, characteristics, and gaps in evidence regarding pesticide-related mucocutaneous adverse effects among agricultural workers in Asia. This review aimed to identify patterns of agricultural pesticide exposure, summarize the reported prevalence and clinical characteristics of mucocutaneous outcomes, describe contributing occupational and preventive factors, and highlight evidence gaps relevant to future epidemiological research, occupational health surveillance, and policy development in Asian agricultural settings.

2. Materials and Methods

2.1. Study Design

This scoping review employs the Joanna Briggs Institute (JBI) methodology, ensuring a structured and comprehensive approach to identifying, selecting, and synthesizing relevant literature [18]. It follows the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) [19]. Preliminary searches were conducted in March 2026 to assess the feasibility of the review and refine the search strategy. The protocol was prospectively registered with INPLASY on 8 May 2026 (INPLASY202650042; DOI: 10.37766/inplasy2026.5.0042). The formal database searches, study selection, and data charting commenced after protocol registration. The review question addressed the current knowledge regarding mucocutaneous adverse effects associated with pesticide exposure among adult agricultural workers in Asia. The population was adult agricultural workers, the concept was pesticide exposure and mucocutaneous outcomes, and the context was agricultural settings in Asia. A comprehensive literature search was conducted using three major electronic databases: PubMed, Scopus, and the Directory of Open Access Journals (DOAJ). The search strategy was designed to identify relevant studies on pesticide exposure in agricultural settings and its associated mucocutaneous effects among Asian agricultural workers. Keywords and Medical Subject Headings (MeSH) terms related to pesticide, agriculture, occupational exposure, and mucocutaneous health outcomes were employed to retrieve relevant studies. Two authors independently evaluated the articles for inclusion. In cases of discrepancies, discussions were held to resolve disagreements, with a final decision reached through consensus.

2.2. Search Strategy

The researchers developed a comprehensive search strategy to identify relevant literature. Three electronic databases were searched: Scopus, PubMed, and DOAJ. The formal database searches were conducted on 8 May 2026, after protocol registration. The searches were restricted to English-language studies published between 2005 and 31 January 2025.

The search strategy combined terms related to pesticides, agricultural workers, mucocutaneous outcomes, and pesticide-related health effects. The full search strategy was developed for Scopus and adapted as appropriate for the other databases.

The Scopus search strategy was as follows:

(TITLE-ABS-KEY ((pesticide* OR biocide* OR fungicide* OR herbicide* OR insecticide* OR agrochemical* OR "agricultural chemical*") AND (farmer* OR "farm worker*" OR "agricultural worker*" OR "greenhouse worker*" OR "pesticide applicator*" OR "pesticide sprayer*" OR "drone operator*" OR agriculture OR agricultural) AND (dermatitis OR "contact dermatitis" OR "occupational dermatitis" OR "skin disease*" OR "skin symptom*" OR "skin irritation" OR rash OR pruritus OR itch* OR erythema OR "eye irritation" OR "ocular irritation" OR conjunctivitis OR "mucosal irritation" OR mucocutaneous OR "health symptom*")) OR TITLE-ABS-KEY ("pesticide-related dermatitis" OR "hospital-based survey of pesticide poisoning" OR "pesticide poisoning in Japan" OR "effects of pesticides on farmers' health" OR "knowledge and practices of pesticide use" OR "pesticide-related disease risk")) AND PUBYEAR > 2004 AND PUBYEAR < 2026 AND (LIMIT-TO (LANGUAGE, "English")).

Similar search concepts and keywords were adapted for PubMed and DOAJ according to the search functions of each database. Filters were applied to include English-language articles published from 2005 onward. Eligibility criteria related to adult participants, observational or cross-sectional study design, Asian agricultural settings, mucocutaneous outcomes, and a sample size of at least 300 participants were applied during title, abstract, and full-text screening. Reference lists of included articles were manually screened to identify additional relevant studies.

2.3. Eligibility Criteria

Studies were selected based on predefined inclusion and exclusion criteria. Studies were eligible for inclusion if they involved human participants aged over 18 years, were conducted among agricultural workers or farmers in Asia, and followed an observational, cross-sectional, or retrospective study design. Eligible studies had to explicitly examine biocide or pesticide exposure in agricultural settings and report mucocutaneous outcomes, such as dermatitis, skin irritation, rash, pruritus, ocular irritation, mucosal irritation, allergic reactions, chronic skin conditions, or chemical burns. For the purposes of this review, "biocide" is used broadly to encompass all chemical agents applied to control harmful organisms, whereas "pesticide" specifically refers to chemical agents applied to crops. Only English-language studies published from 2005 onward were considered. Studies were excluded if they focused only on systemic or non-mucocutaneous health effects, lacked sufficient methodological detail, involved non-human subjects or in vitro models, or if the full text was unavailable for review.

Only studies with a sample size of at least 300 participants were included. This threshold was prespecified as a pragmatic criterion to prioritize larger epidemiological studies with more stable prevalence estimates and to reduce the influence of small-sample variability, outliers, and imprecision [20–22]. However, we recognize that this threshold may have excluded smaller but clinically informative studies, particularly from countries or settings with less research infrastructure. Therefore, potentially relevant smaller studies identified during screening were documented as excluded studies and considered when interpreting the scope of the evidence gap, but they were not included in the main synthesis. Accordingly, the final number of included studies reflects both the limited availability of directly relevant literature and the strict application of the prespecified eligibility criteria.

2.4. Screening and Selection

The screening process followed a three-stage approach: title screening, abstract screening, and full-text review. Two independent reviewers screened the titles and abstracts for relevance. Full-text articles were then assessed for eligibility based on the inclusion and exclusion criteria. Discrepancies were resolved through discussion or consultation with a third reviewer.

2.5. Data Extraction and Data Synthesis

Data from the included studies were systematically extracted using a standardized data collection form. Key variables recorded included the geographical region where the study was conducted, the number of participants, and the study design (observational or cross-sectional). Information on mucocutaneous health outcomes, such as dermatitis, mucosal irritation, allergic reactions, and chronic skin conditions, was also documented. Additionally, the type of pesticide exposure, including herbicides, insecticides, fungicides, and other relevant categories, was identified. The extracted data were synthesized to identify patterns of pesticide exposure and its association with mucocutaneous health effects among Asian agricultural workers. Data from the included studies were charted using a standardized data-charting form, which was pilot-tested on a sample of included studies before full extraction. Data charting was performed independently by two reviewers, and discrepancies were resolved through discussion or consultation with a third reviewer. Study authors were not contacted for additional information. The charted variables included author, publication year, country, study design, sample size, participant characteristics, type of agricultural pesticide exposure, exposure context, mucocutaneous outcomes, prevalence estimates, effect estimates when available, PPE use, and other exposure-related risk factors.

To improve consistency in the narrative synthesis, reported mucocutaneous outcomes were organized using an operational taxonomy developed for this review. Original outcome terms were preserved during data extraction and then grouped into clinically meaningful categories, including skin symptoms, clinically diagnosed dermatitis, ocular outcomes, mucosal symptoms, chemical injuries or burns, and allergic reactions. The taxonomy was used only to structure the narrative synthesis and did not replace the original outcome definitions reported in the included studies. The full taxonomy is provided in Supplementary Table S2.

For each study, active pesticide ingredients were also classified according to the World Health Organization (WHO) toxicity classification (Ia: extremely hazardous; Ib: highly hazardous; II: moderately hazardous; III: slightly hazardous; U: unlikely to present acute hazard) [23]. This classification was used to contextualize reported mucocutaneous outcomes and to explore descriptive patterns in relation to hazard category, such as whether higher toxicity classes were associated with increased prevalence or severity of skin, ocular, or mucosal symptoms.

2.6. Approach to Descriptive Methodological Assessment

Although formal critical appraisal is not mandatory for scoping reviews, a descriptive methodological assessment was conducted to improve interpretation of the included evidence. The revised Joanna Briggs Institute Critical Appraisal Checklist for Analytical Cross-Sectional Studies was used as a guiding framework because most included studies were cross-sectional and its domains were relevant to the review question [24]. For retrospective descriptive studies, only applicable domains were assessed, and domains that could not reasonably be applied were recorded as not applicable. The assessment was not used to calculate summary scores, categorize overall study quality, exclude studies, generate pooled estimates, or make formal certainty-of-evidence judgments.

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2.7. Ethical Considerations

The researchers adhered to ethical principles outlined in the Declaration of Helsinki to ensure integrity, accuracy, and transparency in the reporting of findings [25]. This scoping review was based exclusively on previously published literature and did not involve direct recruitment of human participants, collection of new human data, or access to identifiable personal information. According to institutional requirements, the study protocol was submitted to the Ethics Committee in Human Research, Walailak University, and was classified as exempt from full ethics review. The exemption approval was granted under protocol number WUEC-25-120-01 on 11 April 2025.

3. Results

A total of ten studies were included in this review, encompassing diverse study designs, sample sizes, and geographic regions. The study selection process is presented in Figure 1.

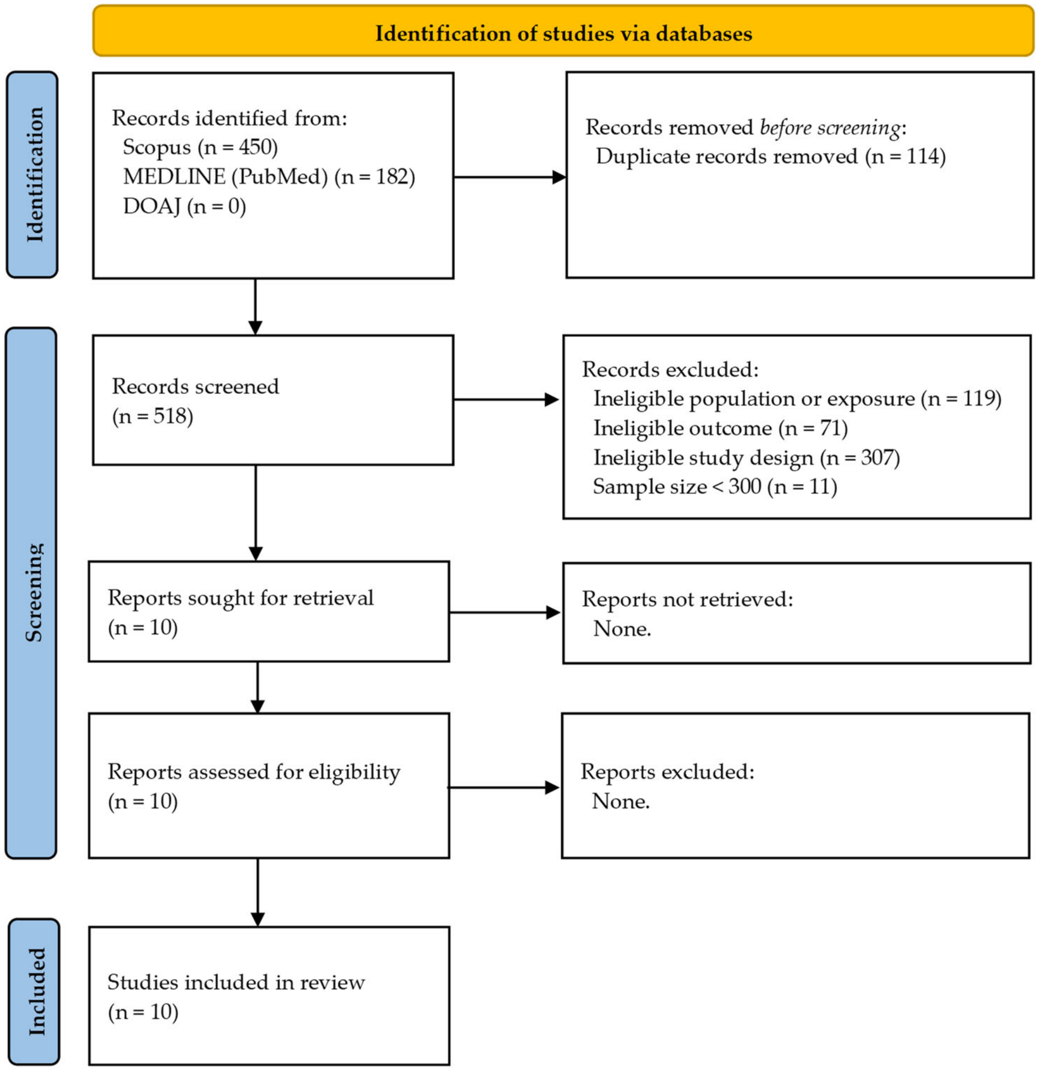

Figure 1. Flow diagram of the study selection process according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR).

The prevalence of mucocutaneous symptoms among agricultural workers exposed to pesticides varied across Asian regions, with differences in symptom severity and associated risk factors, as shown in Table 1. Reported mucocutaneous outcomes were synthesized according to the operational taxonomy described in the Methods and detailed in Supplementary Table S2. The majority of studies (seven) were cross-sectional, while three were retrospective studies on pesticide-related dermatitis cases. Sample sizes ranged from 300 to 6118 participants, covering a broad population of agricultural workers exposed to pesticides. The studies were conducted in Thailand, Taiwan, Vietnam, Pakistan, Turkey, Palestine, Japan, and India, with Thailand being the most represented. The findings provide key insights into the prevalence of mucocutaneous conditions associated with pesticide exposure in agricultural settings across Asia.

The wide range of mucocutaneous prevalence estimates should be interpreted in light of heterogeneity across the included studies. Differences in study design, population characteristics, agricultural setting, crop type, pesticide class, exposure assessment, PPE use, safety practices, and outcome definitions likely contributed to the observed variation. In particular, some studies reported broad self-reported symptoms, such as dry skin, itching, rash, or eye irritation, whereas others reported clinically diagnosed conditions, such as allergic contact dermatitis, irritant contact dermatitis, keratitis, acute dermatitis, or chemical burns. Therefore, these ranges should be viewed as descriptive indicators of the available evidence rather than directly comparable pooled prevalence estimates.

3.1. Types of Pesticides and Health Impacts

Agricultural pesticides include insecticides, herbicides, fungicides, rodenticides, and molluscicides, each serving distinct functions but often posing significant health risks to agricultural workers. The primary pesticide categories commonly used in Asian agricultural settings include herbicides (77.3%), insecticides (68.8%), fungicides (54.5%), nematocides (49.2%), molluscicides (39.2%), and rodenticides (36.5%) [26]. Among these, the most frequently used pesticide classes are organophosphate insecticides (36%), bipyridylium herbicides (20%), and carbamate insecticides (6%), which are widely applied in pest and weed control [27]. Several specific pesticides have been identified in studies, including dimethoate (55.0%), quinalphos (49.4%), endosulfan (48.5%), monocrotophos (45.9%), abamectin (36.7%), carbaryl (24.1%), difenoconazole (22.0%), and propargite (19.2%), all of which have been associated with occupational health risks among agricultural workers [10,27,28]. In terms of pesticide origins, chemical pesticides (79.4%) are more prevalent than biological pesticides (20.6%), reflecting the continued reliance on synthetic chemicals for pest management [29].

Based on reported WHO toxicity categories, Group Ia pesticides were not reported, whereas Group Ib pesticides accounted for 23.3% in one study, Group II pesticides ranged from 12.5% to 54.7%, Group III pesticides ranged from 18.0% to 68.8%, and Group U or equivalent lower-hazard categories accounted for 4.0% to 18.8% of reported pesticides [12,29]. These toxicity categories were used to support descriptive interpretation of mucocutaneous findings rather than to generate pooled estimates. Studies reporting higher-hazard pesticides, particularly Group Ib and Group II compounds, also reported skin irritation, eye irritation, burning or itching eyes, dry or sore throat, and skin redness or scaling [10,12,29]. However, direct comparison across WHO toxicity groups was limited because several studies did not report complete active ingredients, exposure intensity, duration of exposure, PPE use, or outcome severity according to toxicity category.

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Table 1. Mucocutaneous effects associated with pesticide exposure among Asian agricultural workers.

Authors, Year	Country	Sample Size	Study Design	Prevalence of Mucocutaneous Symptoms	Pesticide Use	Other Relevant Potential Findings
Sapbamrer et al., 2024 [26]	Thailand	4035	A cross-sectional study	• Eye symptoms: 41.2% (Itching eyes 26.3%, burning eye 26.3%, conjunctivitis 24.6%) • Skin symptoms: 14.8% (Red/white rashes 14.4%, red/white pimples 1.4%, wound 0.9%)	• Herbicides: 77.3% • Insecticides: 68.8% • Fungicides: 54.5% • Nematocides: 49.2% • Molluscicides: 39.2% • Rodenticides: 36.5%	Pesticide Use and Symptom Associations • Eye symptoms: ○ Insecticide use: adjusted OR 1.89 (95% CI: 1.52–2.35) ○ Fungicide use: adjusted OR 1.35 (95% CI: 1.11–1.64) ○ Rodenticide use: adjusted OR 1.53 (95% CI: 1.26–1.87) • Skin symptoms: ○ Fungicide use: adjusted OR 2.03 (95% CI: 1.51–2.73) ○ Rodenticide use: adjusted OR 1.47 (95% CI: 1.11–1.94) ○ Molluscicide use: adjusted OR 1.73 (95% CI: 1.33–2.26) Perception and Practice Scores • Higher perception scores were associated with a lower prevalence of all symptoms (adjusted OR: 0.90–0.97). • Higher practice scores were associated with a lower prevalence of skin symptoms (adjusted OR 0.98, 95% CI: 0.98–0.99).
Wu et al., 2024 [30]	Taiwan	2268	A retrospective study	• Allergic contact dermatitis: 26.1% • Irritant contact dermatitis: 5.8% • Unspecified contact dermatitis: 12.4% • Keratitis: 7.4%	The most commonly used pesticides are organophosphates (no percentage provided).	Drone operators had significantly reduced risks of dermatitis compared with pesticide-spraying ground-based field crop operators. • Allergic contact dermatitis: OR = 0.40 (95% CI: 0.24–0.68) • Unspecified contact dermatitis: OR = 0.58 (95% CI: 0.35–0.97) • 3. Keratitis: OR = 0.51 (95% CI: 0.31–0.82)
Huyen et al., 2020 [29]	Vietnam	300	A cross-sectional study	• Eye symptoms: 21.3–26.8% • Skin symptoms: 22.5–29.6%	Types of pesticides: • Insecticides: 63.6% • Fungicides: 36.4% Origin of pesticides: • Chemical pesticides: 79.4% • Biological pesticides: 20.6% Toxicity groups (based on WHO classification): • Group I: 0.0% • Group II: 12.5% • Group III: 68.8% • Group IV: 18.8%	Contributing factors: • The high prevalence of eye and skin diseases is likely attributed to direct exposure to plant protection products and insufficient protective measures. Protective practices: • Only a small proportion of farmers used eye drops after pesticide application (13.5% in vegetable-producing communes), suggesting inadequate eye care practices.

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Table 1. *Cont.*

Authors, Year	Country	Sample Size	Study Design	Prevalence of Mucocutaneous Symptoms	Pesticide Use	Other Relevant Potential Findings
Guytingco et al., 2018 [31]	Thailand	6118	A cross-sectional study	• Dry skin/irritation: 4.8%	NR	Prevalence of Abnormal AChE Levels • 12.5% of participants had abnormal AChE levels. • Females: 15.2% prevalence. • Males: 10.2% prevalence. Risk Factors • Male agricultural workers had a significantly higher risk than female farmers (OR = 1.56, $p < 0.05$). • Sprayers were at 2.35 times the odds of abnormal AChE levels compared to self-employed workers.
Nuraydın et al., 2018 [32]	Turkey	423	A cross-sectional study	• Skin diseases: 30.1%	NR	61.1% of patients with skin diseases believed pesticide exposure was a potential occupational factor.
Khan et al., 2015 [12]	Pakistan	318	A cross-sectional study	• Eye irritation: 33.3% • Skin irritation: 33.6%	Toxicity groups (based on WHO classification): • Group Ib: 23.3% • Group II: 54.7% • Group III: 18.0% • Group U: 4.0%	• 82.0% of farmers reported health impairments from pesticide exposure. • 34.6% of farmers experienced multiple health effects, with an average of 2.6 symptoms per affected farmer. • High-Risk Practices ○ Dealing with pesticide spills: 76.4% ○ Using faulty sprayers: 67.9% ○ Spraying in windy conditions: 46.5%
Zyoud et al., 2010 [28]	Palestine	381	A cross-sectional study	• Skin rash: 37.5% • Excessive sweating: 24.9% • Redness of skin: 18.9% • Eyes itching: 15.2%	Commonly used pesticides: • Abamectin: 36.7% • Difeconazole: 22.0% • Penconazole: 19.9% • Propargite: 19.2% • Imidacloprid: 11.8%	Correlation Between Knowledge and Safety • Significant positive correlation between knowledge and safety procedure scores (r = 0.323, $p < 0.001$). Correlation Between Toxicity Symptoms and Protective Measures • Strong negative correlation between self-reported toxicity symptoms and protective measure scores (r = −0.83, $p < 0.001$).
Horiuchi et al., 2008 [27]	Japan	394	A retrospective study	• Acute dermatitis: 54% • Chronic dermatitis: 21% • Chemical burns: 17% • Solar dermatitis: 7% • Other dermatitis: 0.8%	Commonly used pesticides: • Organophosphorous pesticides: 20.1% • Sulfur products: 18.0% • Fungicides: 9.1% • Organochlorines: 8.1% • Soil fumigants: 7.4%	Exposure Context • 63% occurred during spraying, preparation, or post-spraying work. • 35% occurred during farm work unrelated to spraying. • 2% resulted from accidental exposure. Most affected body parts • Hand: 27% • Forearm: 18% • Face: 12% • Neck: 11% History of Skin Conditions • 40% had a history of pesticide-induced dermatitis. • 30% had a history of contact dermatitis from non-pesticide chemicals.

Table 1. *Cont.*

Authors, Year	Country	Sample Size	Study Design	Prevalence of Mucocutaneous Symptoms	Pesticide Use	Other Relevant Potential Findings
Chitra et al., 2006 [10]	India	631	A cross-sectional study	• Excessive sweating: 36.5% • Burning/stinging/itching of eye: 35.7% • Dry/sore throat: 25.5% • Skin redness/white patches/scaling: 20.6%	Commonly used pesticides: • Dimethoate: 55.0% • Qunalphos: 49.4% • Endosulfan: 48.5% • Monocrotophos: 45.9% • Carbaryl: 24.1%	• Burning, stinging, or itching eyes were significantly associated with pesticide exposure (RR: 1.5, 95% CI: 1.06–2.13). • 68.6% of farmers sprayed pesticides themselves, leading to direct exposure. • Over 75% used moderately or highly hazardous pesticides. • 88% handled pesticides without protection. • About 50% mixed different pesticide brands. • 37.2% had been spraying pesticides for over a decade.
Nagami et al., 2005 [33]	Japan	346	A retrospective study	• Acute dermatitis: 24% • Chemical burns: 15% • Eye disorders: 6%	• Organophosphate insecticides: 36% • Bipyridylium herbicides: 20% • Carbamate insecticides: 6%	Exposure Context • 16% of cases resulted from accidental exposure during spraying. Outcomes • 69% of cases recovered.

Note. AChE, acetylcholinesterase; adjusted OR, adjusted odds ratio; CI, confidence interval; NR, not reported; OR, odds ratio; WHO, World Health Organization. "NR" indicates that the information was not reported in the original article.

3.2. Exposure Pathways

Occupational pesticide exposure is a significant concern for farmers, agricultural workers, and pesticide applicators, occurring through multiple pathways. Dermal exposure is considered the primary route of pesticide absorption, particularly for applicators [12]. Pesticide accumulation on clothing, skin, and boots is typical after field spraying, increasing direct contact risks. Inhalation of spray residue or spray drift further contributes to exposure, particularly in poorly ventilated areas or under windy conditions [31]. Mixing tasks pose the highest risk for dermal exposure, often involving a single high-dose exposure through spills, splashes, and inhalation [26]. Additionally, using low-technology or faulty sprayers during application exacerbates exposure risks [12]. Beyond occupational settings, environmental exposure is another critical concern. Pesticide ingestion can occur if food is not washed correctly, while pesticide residues in water, soil, and food contribute to chronic exposure [26,31]. Unsafe disposal practices, such as dumping leftover pesticides at the field's edge, create hazards for farmers, caregivers, and harvesters. Similarly, washing pesticide containers and spraying tools in nearby canals after application further contaminates water sources, posing risks to both human and environmental health [29].

3.3. Mucocutaneous Effects

The prevalence of mucocutaneous symptoms among agricultural workers exposed to pesticides varies across studies and regions. In Thailand, eye symptoms (41.2%) and skin symptoms (14.8%) were reported among workers handling herbicides, insecticides, fungicides, nematocides, molluscicides, and rodenticides [26]. Notably, exposure to specific pesticides increased symptom risk, with insecticide use associated with a higher prevalence of eye symptoms (adjusted OR: 1.89, 95% CI: 1.52–2.35), and fungicide exposure increasing the likelihood of skin symptoms by 2.03 times (95% CI: 1.51–2.73). In Taiwan, a retrospective cohort study found that allergic contact dermatitis affected 26.1% of workers, while irritant contact dermatitis (5.8%) and unspecified contact dermatitis (12.4%) were also documented [30]. Compared with ground-based field-crop operators, drone operators had significantly lower odds of allergic contact dermatitis (OR 0.40, 95% CI 0.24–0.68) and unspecified contact dermatitis (OR 0.58, 95% CI 0.35–0.97). This suggests that advanced pesticide application methods may lower direct skin exposure risks. In Vietnam, skin symptoms ranged from 22.5% to 29.6%, with eye symptoms affecting 21.3% to 26.8% of agricultural workers exposed to chemical and biological pesticides [29]. A contributing factor was direct exposure to plant protection products combined with insufficient protective measures, as only 13.5% of farmers used eye drops after pesticide application, indicating a lack of proper post-exposure care. In Pakistan, 33.6% of workers experienced skin irritation, and 33.3% reported eye irritation, with highly hazardous pesticides (Group Ib) contributing to a significant proportion of cases [12]. The study also identified multiple high-risk practices, including handling pesticide spills (76.4%), using faulty sprayers (67.9%), and spraying in windy conditions (46.5%), all of which contributed to increased pesticide exposure. Similarly, in Palestine, 37.5% of agricultural workers reported skin rashes, and 24.9% experienced excessive sweating, often linked to exposure to abamectin, difeconazole, and propargite [28]. A significant negative correlation was observed between self-reported toxicity symptoms and protective measure scores ($r = -0.83$, $p < 0.001$), indicating that better adherence to safety protocols was associated with fewer health issues. In Japan, cases of acute dermatitis (54%), chronic dermatitis (21%), chemical burns (17%), and solar dermatitis (7%) were observed among farmers handling organophosphorous pesticides, sulfur-based products, and fungicides [27]. The most affected body parts were the hands (27%), forearms (18%), face (12%), and neck (11%), emphasizing the importance of adequate protective equipment. In India, 36.5% of workers were reported to have experienced excessive sweating, 35.7% reported burning, stinging, or itching eyes, 25.5% had dry or sore throats, and 20.6% experienced skin redness, white patches, or scaling. Notably, 88% of agricultural workers handled pesticides without protective measures, and over 75% used moderately or highly hazardous pesticides, further increasing their risk of adverse health effects [10].

3.4. Descriptive Methodological Assessment

Overall, methodological characteristics varied across the ten included studies (Table 2). Several studies clearly defined their study populations, used appropriate statistical analyses, and provided adequate descriptions of the study subjects and settings. Common limitations included reliance on self-reported symptoms, variable exposure assessment, limited clinical verification of outcomes, and incomplete adjustment for potential confounding. For retrospective descriptive studies, confounding and analytical domains that were not relevant to the study objectives were recorded as not applicable. The assessment was interpreted descriptively and was not used to assign overall quality categories.

Table 2. Descriptive methodological assessment of included studies using the revised JBI Critical Appraisal Checklist for Cross-Sectional Studies.

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Overall
Sapbamrer et al., 2024 [26]	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Higher
Wu et al., 2024 [30]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Higher
Huyen et al., 2020 [29]	Yes	No	Unclear	No	No	No	No	Yes	Limited
Guytingco et al., 2018 [31]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Higher
Nuraydın et al., 2018 [32]	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Higher
Khan and Damalas, 2015 [12]	Yes	No	Unclear	No	Yes	Yes	Yes	Yes	Moderate
Zyoud et al., 2010 [28]	Yes	No	Unclear	No	Yes	Yes	Yes	Yes	Moderate
Horiuchi et al., 2008 [27]	Yes	Yes	Yes	Yes	N/A	N/A	N/A	Yes	Limited
Chitra et al., 2006 [10]	Yes	No	Unclear	No	Yes	Yes	Yes	Yes	Moderate
Nagami et al., 2005 [33]	Yes	Yes	Yes	Yes	N/A	N/A	N/A	Yes	Limited

Note. JBI, Joanna Briggs Institute; N/A, not applicable. The methodological assessment was conducted using the revised JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies. Q1 indicates whether the criteria for inclusion in the sample were clearly defined; Q2, whether objective or standard criteria were used for measurement of the condition; Q3, whether the exposure was measured in a valid and reliable way; Q4, whether the outcomes were measured in a valid and reliable way; Q5, whether confounding factors were identified; Q6, whether strategies to deal with confounding factors were stated; Q7, whether appropriate statistical analysis was used; and Q8, whether the study subjects and setting were described in detail. For retrospective or descriptive studies, items that could not reasonably be applied were recorded as not applicable. Overall descriptive support was categorized as higher when most domains were satisfied, moderate when some domains were satisfied, and limited when few domains were satisfied or when the study design was descriptive and did not permit assessment of confounding or analytical associations. This assessment was used to contextualize methodological strengths and limitations and was not used to exclude studies, generate pooled estimates, or make formal certainty-of-evidence judgments.

4. Discussion

The findings of this review highlight a significant burden of mucocutaneous conditions among agricultural workers in Asia, primarily linked to pesticide exposure. Across the included studies, dermatitis, mucosal irritation, and allergic reactions were the most commonly reported health effects, with exposure occurring through dermal contact, inhalation, and ingestion. Notably, organophosphate insecticides, bipyridylium herbicides, and fungicides were frequently associated with these adverse outcomes. The prevalence of pesticide-induced dermatitis varied across regions, with studies from Thailand, Pakistan, and Vietnam consistently reporting high rates of skin irritation and allergic reactions [12,26,29,31]. Additionally, chronic dermatologic conditions such as eczema, hyperpigmentation, and chloracne were observed among individuals with prolonged exposure. Despite increasing evidence of these health risks, comprehensive epidemiological studies on the long-term dermatologic effects of pesticide exposure remain limited.

Comparison with evidence from other continents suggests that the mucocutaneous risks identified in Asian agricultural workers are consistent with broader global patterns of occupational pesticide exposure, although the underlying exposure context may differ by region. In Africa, dermal exposure has been identified as a major route of pesticide uptake among agricultural applicators. For example, among rice farm applicators in Ghana, dermal exposure accounted for most total chlorpyrifos exposure during pesticide application, and hot and humid working conditions were reported to discourage adequate PPE use [34]. Similarly, a Tanzanian biomonitoring study among smallholder horticultural farmers occupationally exposed to pesticide mixtures emphasized the relevance of inadequate protection and mixed pesticide exposure in low-resource agricultural settings [35]. These findings are comparable to the Asian studies included in this review, in which unsafe spraying practices, limited PPE use, and direct dermal or ocular contact were repeatedly associated with skin and eye symptoms. Evidence from Latin America also shows similarities with the Asian context, particularly regarding PPE barriers and high-risk application practices. In Brazil, only a small proportion of farmers used complete PPE, with discomfort, heat, cost, and shoulder-held sprayers contributing to direct pesticide contact [36]. Reviews and field studies from Latin American agricultural settings have also highlighted dermal exposure, inadequate protective clothing, and contact with pesticide-treated crops as important contributors to occupational skin disease [13,15]. In Europe, North America, and Oceania, occupational pesticide exposure also occurs through mixing, loading, application, equipment cleaning, and contact with contaminated clothing or crops, but the exposure context often differs because of stronger regulatory systems, greater availability of mechanized equipment, and more established occupational health surveillance [13,15,37]. Nevertheless, occupational contact dermatitis remains relevant in these regions, particularly among farmworkers exposed to sensitizing pesticides, rubber additives in protective equipment, wet work, and repeated skin contamination [17,38].

The use of pesticides has significantly increased globally over the past decades, driven by the need to enhance agricultural productivity to meet the demands of a growing population [39,40]. However, the risks associated with pesticide exposure, including mucocutaneous effects, are not limited to Asia, as similar health and environmental concerns have been reported in various regions, including Europe, Australia, Africa, and Latin America [35,37,41,42]. Studies have also highlighted chronic health effects of pesticide exposure, including dermatologic conditions such as contact dermatitis and systemic complications from prolonged exposure. Patch testing identified several common substances responsible for irritant contact dermatitis and allergic contact dermatitis. Frequently implicated irritants included carbaryl, benomyl, ethoprophos, chlorothalonil, imazalil, and glyphosate [43]. Common sensitizers included thiuram, propiconazole, metaldehyde, formaldehyde, mercaptobenzothiazole, cypermethrin and isoproturon [44]. Additionally, preservatives in pesticides were associated with mucocutaneous reactions, with methylisothiazolinone, followed by methylchloroisothiazolinone/methylisothiazolinone and methyldibromo glutaronitrile [45].

Mechanistic and occupational dermatology evidence suggests that mucocutaneous outcomes related to agricultural pesticides may arise through both irritant and allergic pathways. Irritant contact dermatitis may occur through direct chemical injury, solvent or surfactant effects, repeated wet work, sweating, friction from contaminated clothing or spraying equipment, and disruption of the epidermal barrier, which can promote penetration of agricultural chemicals [13,46,47]. In contrast, allergic contact dermatitis represents a delayed-type hypersensitivity reaction after sensitization to specific pesticide ingredients, preservatives, formulation additives, or occupational co-exposures such as rubber accelerators in gloves and boots [17,44,48,49]. This distinction is important because broad self-reported symptoms such as itching, burning, dryness, redness, and rash may reflect nonspecific irritation, whereas clinically diagnosed allergic contact dermatitis or patch-test-confirmed reactions indicate a more specific immune-mediated process [17,38,44]. The main pesticide classes identified in this review may contribute to mucocutaneous effects through different toxicological pathways. Organophosphate and carbamate insecticides primarily act through acetylcholinesterase inhibition, resulting in acetylcholine accumulation and overstimulation of muscarinic receptors, which may explain symptoms such as excessive sweating, lacrimation, salivation, blurred vision, and ocular discomfort [50–52]. Pyrethroids act mainly by prolonging the opening of voltage-gated sodium channels, producing repetitive neuronal discharges in sensory nerve terminals; this mechanism is consistent with dermal paresthesia, burning, pruritus, rash, and ocular irritation after direct contact [53,54]. Bipyridylium herbicides such as paraquat can generate reactive oxygen species through redox cycling, leading to oxidative stress, lipid peroxidation, and tissue injury, while glyphosate-surfactant formulations may cause direct caustic injury and deeper tissue penetration, resulting in chemical burns or ocular epithelial injury after high-level contact [52,55,56]. Fungicides, including phthalimides and thiocarbamates, may act as irritants or sensitizers; protein binding and delayed-type hypersensitivity mechanisms can contribute to allergic contact dermatitis, whereas direct barrier disruption may contribute to irritant dermatitis [38,44]. These class-specific mechanisms support the biological plausibility of the skin, ocular, and mucosal outcomes observed in this review, although the included epidemiological studies were not designed to confirm mechanisms directly.

Contextual confounders further complicate the interpretation of these outcomes. Tropical heat and humidity may increase sweating, reduce tolerance of gloves, masks, and protective clothing, and increase skin contact with contaminated clothing [13,57]. Crop type, spraying method, mixing and loading tasks, equipment quality, and the use of backpack or ground-based spraying may also influence exposure intensity [13,15]. Socioeconomic factors, education, pesticide safety knowledge, access to appropriate PPE, and access to occupational health services may affect both exposure risk and outcome detection [13,38,58]. Workers with limited healthcare access may underreport symptoms or lack clinical confirmation of dermatitis, ocular injury, or chemical burns [38,58]. Although formal dose–response synthesis was not possible because of heterogeneity in exposure assessment and outcome definitions, the available evidence suggests descriptive exposure-response patterns. Several included studies reported higher mucocutaneous symptom frequency or disease risk among workers with specific pesticide use, unsafe work practices, inadequate PPE use, spraying or mixing tasks, abnormal cholinesterase levels, or ground-based pesticide application [10,26,27,30,31,57]. Conversely, better safety practices, protective measures, and reduced direct contact, such as drone-based application, appeared to be associated with lower risk in some studies [26,28,30]. Future studies should use standardized exposure metrics, pesticide class-specific assessment, task-based exposure evaluation, PPE-use measurement, and clinically verified mucocutaneous outcomes to better characterize dose–response relationships. The WHO toxicity classification provided a practical framework for interpreting pesticide hazard levels across studies. However, because the classification is based primarily on acute toxicity rather than mucocutaneous-specific toxicity, it should be interpreted as a contextual hazard indicator rather than direct evidence of dermatologic risk. The co-occurrence of higher-hazard pesticides with reported skin and ocular symptoms supports the need for improved exposure control, but causal or dose–response interpretation remains limited by incomplete reporting of active ingredients, exposure frequency, PPE use, and clinically verified outcomes.

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To effectively reduce mucocutaneous risks among agricultural workers, the proper use of PPE is essential [8]. The choice of PPE is influenced by the toxicity of the pesticide, the conditions of exposure, and the preferences of the farmer. At a minimum, gloves and boots are required, but more hazardous pesticides typically necessitate the use of additional protective gear. Gloves are especially effective, cutting exposure by 27% for farmers and by 65% when used alongside coveralls [59]. Several factors influence the effectiveness of PPE. Proper fit and comfort are crucial, as ill-fitting or uncomfortable equipment discourages consistent use. Workers must also receive adequate training on pesticide-related risks and the correct use of protective gear to ensure the compliance [8,13]. Furthermore, regular monitoring and enforcement of PPE use are necessary to maintain high compliance rates among workers [60,61]. However, the biggest challenge remains low compliance, which is a significant concern among agricultural workers, increasing their risk of exposure to hazardous substances such as pesticides [62–64]. Multiple factors contribute to this issue, further elevating the likelihood of adverse health effects. Cultural and social dynamics, including gender roles and social hierarchies, play a key role in adherence, and some work settings have shown that teams with a higher proportion of female workers demonstrate better compliance with protective measures [61]. While many agricultural workers are aware of the dangers associated with pesticide exposure, their use of protective equipment remains inconsistent, often due to a lack of perceived immediate threat or an underestimation of long-term health risks [65]. Harsh environmental conditions, such as high temperatures and humidity, make wearing protective gear uncomfortable, discouraging workers from consistent use, while poorly fitting or low-quality equipment further reduces compliance [66]. Certain behavioral and workplace-related factors also contribute to this issue, as substance use, inadequate supervision, and limited access to occupational safety training have been linked to lower adherence rates, whereas regular training and workplace monitoring have been shown to improve compliance significantly [67]. Additionally, workplace policies and enforcement strategies play a crucial role, as strict regulations and penalties, such as those implemented in some industries like cement manufacturing in Indonesia, have proven effective in improving adherence, suggesting that similar approaches in agricultural settings could help mitigate pesticide exposure risks [67]. Figure 2 demonstrates linking agricultural pesticide exposure, exposure pathways, risk-enhancing factors, mucocutaneous outcomes, and prevention priorities among Asian agricultural workers. The framework highlights key pesticide categories and summarizes major exposure routes such as dermal, ocular, mucosal, inhalational, and indirect contact. It also emphasizes modifiable factors, including PPE use, safety training, spraying practices, equipment quality, and occupational safety enforcement.

We acknowledge several limitations that may affect the interpretation and generalizability of the findings. First, the relatively small number of included studies limits the robustness of the evidence. This small yield likely reflects both the limited availability of directly relevant literature and the strict application of eligibility criteria, including restriction to Asian agricultural workers, a sample size of at least 300 participants, English-language publication, and explicit reporting of mucocutaneous outcomes. The sample-size criterion may also have introduced selection bias by excluding smaller studies from countries or settings with limited research infrastructure. Some excluded studies may have provided clinically detailed information on occupational dermatitis, skin irritation, ocular symptoms, or patch-test findings, even though they lacked large epidemiological samples. Therefore, the findings should be interpreted as a descriptive map of available larger-scale evidence rather than as definitive regional prevalence estimates. Second, the methodological characteristics of the included studies limit causal interpretation. Most studies used cross-sectional or retrospective designs, which restrict assessment of temporality between pesticide exposure and mucocutaneous outcomes. The descriptive methodological assessment also showed variability in exposure assessment, outcome definitions, and confounder adjustment. Several studies relied on self-reported skin, ocular, or mucosal symptoms without clinical confirmation, increasing the possibility of recall bias and outcome misclassification. Differences in pesticide classification, exposure measurement, and reporting of clinically diagnosed versus self-reported conditions further limited direct comparison across studies and prevented firm conclusions regarding exposure-response relationships. Biomonitoring evidence was also limited, with only a small number of included studies incorporating objective biological indicators, such as acetylcholinesterase activity, rather than relying solely on self-reported pesticide exposure or symptoms [31]. Future studies should incorporate biomonitoring approaches, such as cholinesterase activity or pesticide metabolite measurement, together with prospective follow-up and clinically verified mucocutaneous outcomes to strengthen evidence on occupational exposure and toxic effects. Third, excluding non-English studies may have led to the omission of relevant research, particularly studies conducted in local Asian contexts where agricultural practices, pesticide use, and occupational health systems may differ from those reported in English-language publications. This language restriction may have reduced the comprehensiveness of the review. In addition, the search strategy was limited to the databases specified in the prospectively registered protocol. Although PubMed and Scopus provide broad biomedical and multidisciplinary coverage, and DOAJ was included as an open-access supplementary source, specialized occupational-health databases such as National Institute for Occupational Safety and Health Technical Information Center-2 (NIOSHTIC-2) and Occupational Safety and Health on CD-ROM (OSH-ROM) were not included. Therefore, some relevant occupational health records indexed only in specialized databases may have been missed. Future updates should consider including these sources to improve comprehensiveness. Fourth, there was a lack of long-term and prospective evidence on chronic mucocutaneous conditions. Most included studies focused on acute or recent symptoms, and the cumulative effects of repeated or prolonged exposure remain unclear. Future studies should use longitudinal designs, standardized exposure assessment, objective clinical outcome measures where feasible, and appropriate adjustment for confounding factors. Despite these limitations, this review provides a useful map of the available evidence and highlights important gaps for future epidemiological research, occupational health surveillance, and preventive interventions.

Despite the growing body of research on pesticide exposure and its health effects in agricultural settings, several critical knowledge gaps remain. First, long-term studies are lacking in assessing the chronic skin effects of pesticide exposure in agricultural settings. Without longitudinal data, it is challenging to determine the cumulative impact of prolonged exposure on dermatological health. Second, country-specific data on pesticide-related health effects remain scarce. Comparative studies between Southeast Asia and South Asia are particularly limited, making it difficult to identify regional variations in exposure patterns, risk factors, and health outcomes. Third, inconsistencies in reporting pesticide exposure levels and health effects hinder the establishment of clear dose–response relationships. Variability in study methodologies, exposure assessment techniques, and reporting standards further complicate efforts to synthesize findings across different populations. Fourth, there is a significant gap in the evaluation of regulatory and preventive strategies. Limited research has assessed the effectiveness of existing policies and safety measures in reducing pesticide-related health risks among agricultural workers. Understanding the impact of current interventions is crucial for developing more effective prevention and mitigation strategies. Addressing these knowledge gaps through well-designed research initiatives is essential for improving occupational health outcomes and informing policy decisions in agricultural settings.

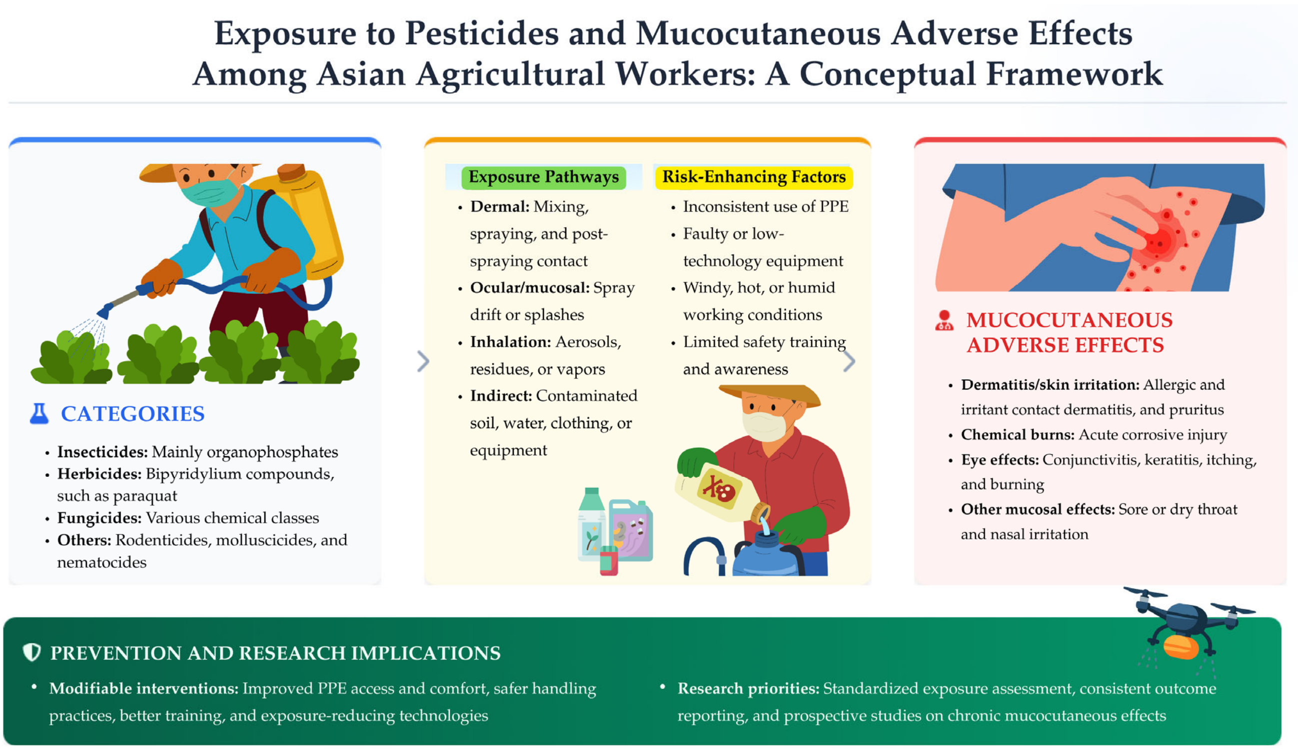

Figure 2. Conceptual framework linking agricultural pesticide exposure, exposure pathways, risk-enhancing factors, mucocutaneous outcomes, and prevention priorities among Asian agricultural workers. The model illustrates key exposure routes, including dermal, ocular, mucosal, inhalational, and indirect contact, and links them to risk-enhancing factors such as tropical climate, crop type, spraying and mixing practices, equipment quality, personal protective equipment (PPE) use, safety training, and occupational health enforcement. It also identifies practical intervention points, including provision and proper use of PPE, training on safe pesticide handling, safer spraying practices, equipment improvement, regulatory enforcement, and occupational health surveillance. This framework may guide workplace interventions, policy development, and future research aimed at reducing pesticide-related skin, ocular, and mucosal adverse effects in Asian agricultural settings.

5. Conclusions

This scoping review highlights important mucocutaneous risks associated with agricultural pesticide exposure among Asian agricultural workers, including skin irritation, dermatitis, ocular symptoms, mucosal irritation, and chemical burns. These outcomes were commonly linked to dermal and ocular exposure during pesticide mixing, loading, spraying, equipment cleaning, and post-spraying fieldwork. However, the small number of included studies, heterogeneity in exposure and outcome assessment, and predominance of cross-sectional or retrospective designs limit causal interpretation and generalizability.

The findings support the need for standardized exposure assessment, consistent reporting of mucocutaneous outcomes, and stronger occupational health surveillance in Asian agricultural settings. Where feasible, future studies should report pesticide hazard categories, such as WHO toxicity groups, task-based exposure, PPE use, and clinically verified mucocutaneous outcomes. Practical prevention priorities include improving access to affordable and climate-appropriate PPE, strengthening pesticide safety training, promoting safer application practices, and reinforcing occupational safety regulations. Future biomonitoring studies, prospective follow-up studies, and intervention evaluations are

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needed to better characterize chronic mucocutaneous effects and identify effective strategies to reduce dermal, ocular, and mucosal exposure.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/environments13060349/s1, Table S1: PRISMA Extension for Scoping Reviews (PRISMA-ScR) Checklist [68]; Table S2: Operational taxonomy of mucocutaneous outcomes used for narrative synthesis.

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Abbreviations

The following abbreviations are used in this manuscript:

AChE	Acetylcholinesterase
CI	Confidence interval
DOAJ	Directory of Open Access Journals
JBI	Joanna Briggs Institute
MeSH	Medical Subject Headings
N/A	Not applicable
NR	Not reported
OR	Odds ratio
PPE	Personal protective equipment
PRISMA-ScR	Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews
WHO	World Health Organization

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