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Factors Affecting Irritant Contact Dermatitis Among Horticulture Farmers in Semarang District, Indonesia

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Abstract

Irritant contact dermatitis is a common condition among farmers, but its underlying causes remain poorly understood. This study aimed to identify factors associated with irritant contact dermatitis among horticulture farmers in Semarang District, Indonesia. A cross-sectional survey was conducted among 427 farmers using a validated, reliable structured questionnaire. The results indicated complaints of dermatitis related to contact with irritants. Data were analyzed using the Chi-square test and logistic regression. Analysis revealed that sex, personal hygiene habits, education level, and the number of pesticide types used were significantly associated with irritant contact dermatitis. Female farmers were less likely to develop irritant contact dermatitis. Conversely, farmers with poor personal hygiene habits or lower levels of education were more likely to develop the condition. Farmers who used fewer types of pesticides had a lower risk of irritant contact dermatitis than those who used a greater variety. In conclusion, irritant contact dermatitis among farmers is influenced by both work-related exposures and hygiene practices. Improving personal hygiene habits and limiting the use of multiple pesticide types may help prevent irritant contact dermatitis under typical farming conditions.

Keywords: farmers, irritant contact dermatitis, pesticides, pesticide exposure, risk factors

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Introduction

Irritant contact dermatitis (ICD) is a common disease among workers who handle chemical substances. Pathophysiologically, ICD is defined as direct harm to keratinocytes, which activates the innate immune system, stimulates the production of proinflammatory cytokines, and ultimately causes harm to dermal tissue.^{1,2} In the world, skin diseases account for approximately 30%–45% of occupational illnesses, and ICD represents approximately 95% of all occupational skin diseases (OSDs).³ This condition causes serious discomfort, decreases work performance, and lowers the quality of life among affected workers. This creates substantial economic and social burdens.^{4,5} Thus, ICD is a significant occupational health problem that requires continuous control and precaution efforts.^{6,7} Clinical symptoms of ICD can range from mild erythema to severe acute lesions, which may further reduce work performance and quality of life.^{8,9}

Farming is an occupation with a high risk of ICD because farmers often come into direct contact with pesticides, fertilizers, and other

chemical substances.^{10,11} Several studies have reported a strong correlation between skin diseases in farmers compared with other professions. For example, a survey in Thailand found that approximately 14.6% of agricultural workers experienced ICD.¹² A study in Ethiopia reported that approximately 48% of agricultural workers had dermatitis on the hands, with additional involvement of the face and arms, indicating frequent direct dermal exposure to pesticides during routine farming activities.¹³ Similarly, about 38.3% of rice mill workers in India suffered from skin lesions, such as dermatitis, pigmentation, and infections.¹⁴

The farming sector employs approximately 26% of the workforce and plays an important role in food production in Indonesia.¹⁵ Despite this, farmers receive limited health protection, as evidenced by a lack of awareness about the harmful effects of pesticides, neglect of personal protective equipment (PPE), and minimal access to healthcare facilities.^{16,17} These conditions place Indonesian farmers at a higher risk of ICD compared with farmers in industrialized

countries, where safety systems are more robust.^{18,19} Indonesian farmers are exposed to high occupational risks, highlighting the need to identify and provide evidence on the factors contributing to ICD. For decades, pesticides have been continuously used in Indonesia, with their usage increasing tremendously.²⁰ In 2020, the Indonesian Ministry of Agriculture recorded more than 5,000 pesticide brands.²¹ Central Java Province, the largest agricultural area, has nearly one million hectares of farmland.²² These data indicate a high level of chemical exposure among farmers in this region.

Many studies have identified individual and environmental factors that affect ICD among farmers. Those factors include sex, age, education level, working duration, use of PPE, and hygiene habits.^{23,24} A study of greenhouse workers in Cyprus found that the occurrence of skin disease symptoms was higher among workers who worked more than 8 hours a day and more than 25 days a month.²⁵ In addition, a population-based study in South Korea revealed a strong correlation between the length of working hours and OSDs, with the highest rates observed in the agriculture, forestry, and fishery sectors.²⁶ In Indonesia, 30% to 50% of horticultural farmers suffer from dermatitis because of unsafe pesticide handling and poor hygiene practices, as revealed in several local studies.^{24,20} However, many previous studies were descriptive in nature and did not examine the combined effects of behavioral and exposure-related factors using multivariate approaches. This gap has encouraged the authors to conduct analytical studies to identify independent predictors of ICD among farmers in Indonesia.

There is limited empirical evidence identifying the primary risk factors for ICD among Indonesian farmers, although pesticide-related dermatitis has been recognized as a serious occupational health problem. Previous studies have mainly focused on estimating prevalence or examining a single associated factor without considering other potential risk factors. Strengthening targeted preventive interventions and enhancing occupational health surveillance in the agricultural sector are essential to address this issue. Therefore, this study aims to address this gap by assessing the main factors associated with ICD among Indonesian farmers.

This study aimed to identify the causes of ICD among farmers in Semarang District, Indonesia. Three outcomes are expected from this research. First, it seeks to support the development of effective prevention strategies for ICD. Second, it aims to enhance farmers'

understanding of personal hygiene habits and the safe use of pesticides. Third, it intends to provide evidence to inform occupational health policymaking in the agricultural sector of developing countries.

Method

An observational, analytic, quantitative design with a cross-sectional approach was used in this study. A cross-sectional design was used to examine the relationships among individual, behavioral, and exposure-related factors and ICD. This method was appropriate for measuring the prevalence of ICD and identifying factors associated with its occurrence among agricultural workers. This study was conducted in three agricultural villages—Coblong, Talun, and Bumen—selected because they represent major vegetable and flower production centers that supply regional demand, where pesticide use among farmers is common. Coblong and Talun are located in Bandungan Subdistrict, known as one of the leading horticultural production areas in Semarang District, particularly for high-value vegetables and ornamental flowers that require intensive pesticide use. Bumen Village is located in Sumowono Subdistrict, which also has active agricultural production but with slightly different cropping patterns and somewhat lower pesticide use intensity. All three villages are situated in Semarang District, Indonesia. Data were collected from October to December 2024, during the main pesticide spraying season, ensuring representative exposure conditions among farmers.

The study population included all vegetable and flower farmers residing in the three study villages. According to village agricultural records, there were 80 farmers in Coblong Village, 246 in Bumen Village, and 114 in Talun Village, for a total of 440 farmers. A total sampling technique was applied, including all farmers who met the specified criteria. A separate sample size calculation was not required because the total population was manageable. Three inclusion criteria were established: farmers had to have lived in the study area for at least five years, had to have direct occupational contact with pesticides, defined as involvement in pesticide mixing, loading, or spraying during routine farming activities, and had to be willing to participate and provide accurate information. Based on field verification and eligibility screening, 427 farmers met the inclusion criteria and were included as study respondents. Local farmer group leaders supported the selection process to ensure complete population coverage.

The dependent variable was ICD complaints. The

independent variables included sociodemographic characteristics (age, sex, education level, and farming experience), behavioral factors (PPE use, personal hygiene habits, knowledge of pesticide risks, and smoking habits), and exposure-related factors (exposure duration, pesticide spraying frequency, pesticide spraying direction, pesticide dosage, and pesticide types). Data were collected using a structured, interviewer-administered questionnaire. The instrument consisted of closed-ended and Likert-type items. To ensure interviewers fully understood the detailed questions and to minimize bias, training was conducted before the interview process. A self-reported symptom checklist adapted from the validated Indonesian version of the Occupational Contact Dermatitis Screening Questionnaire was used to assess ICD complaints. Structured items derived from the World Health Organization's pesticide safety guidelines and the Indonesian Ministry of Agriculture's Good Agricultural Practices standards were used to assess behavioral and exposure-related variables, including PPE use, personal hygiene habits, pesticide handling, dosage, and application techniques.

Thirty farmers from Coblong Small Village and Pakopen Village in Semarang District participated in testing the questionnaire's content and construct validity. Items with a correlation coefficient (r) greater than 0.30 were considered valid. Reliability testing yielded a Cronbach's alpha coefficient of 0.833, indicating good internal consistency. Standard psychometric criteria ($\alpha \geq 0.70$ = acceptable reliability) were used to interpret the results. The data were checked for completeness and consistency, coded, and entered into a spreadsheet before analysis. Variables were categorized as follows: age (<60 years, ≥ 60 years); education level as low (no formal education, primary school, or junior high school) and medium-to-high (senior high school, vocational school, or higher education); farming experience (<10 years, ≥ 10 years); PPE use (poor, good); and personal hygiene habits (poor, good); knowledge of pesticide risks (poor, good); smoking habits (smoker, non-smoker); categorized using median cutoff values derived from PPE completeness scores and personal hygiene habits scores. Exposure duration was categorized as <3 hours/day ≥ 3 hours/day, pesticide spraying frequency was categorized as <2 times/week and ≥ 2 times/week, pesticide spraying direction was categorized as downwind and upwind, pesticide dosage was categorized into as recommended and not

recommended, and pesticide types were categorized by the number of distinct pesticide products used (<3 or ≥ 3). These categorizations were based on median values or standard references from previous studies.^{11,27,28}

Data analysis was conducted in three steps using JASP version 0.95.0.0 (open-source statistical software under the GNU General Public License). First, univariate analysis was performed to describe respondents' characteristics and summarize the frequency distribution of all study variables. Results were presented as means, standard deviations, and proportions in tables. Next, bivariate analysis using the Chi-square test was conducted to assess the association between each independent variable and the presence of ICD complaints. Variables with a p-value less than 0.25 were included in the subsequent multivariate analysis to control for potential confounding effects. To identify independent factors associated with ICD complaints, multivariate analysis was performed using binary logistic regression. The strength of associations was expressed as odds ratios (ORs) with corresponding 95% confidence intervals (CIs). The confidence level was set at 95%, and statistical significance was determined at $\alpha = 0.05$. Variables with p-values less than 0.05 were considered statistically significant. The interpretation of the results was based on statistical significance, effect size, and consistency with theoretical expectations. The direction and magnitude of the associations were discussed in relation to previous studies to provide context and highlight their public health relevance.

Results

The results are presented in accordance with the analysis framework. The presentation begins with descriptive statistics, followed by an assessment of associations using the Chi-square test. Finally, key factors are identified through multivariate logistic regression analysis.

The respondents' characteristics are presented in Table 1, which includes demographic attributes, work-related conditions, patterns of pesticide exposure, and the proportion of farmers reporting ICD. Table 1 shows that the farmers in this study ranged in age from 20 to 85 years, with a mean age of 50.21 years ($SD = 12.95$). More than half of the respondents had completed primary school, and only a small proportion had attained senior high school or higher education. The median duration of farming experience was 30 years, indicating long-term

Table 1. Farmers' Characteristics (n = 427)

Variable	n	%	Mean±SD*
Age (years)	427	100	50.210±12.95
Education Level			
Uneducated	28	6.3	-
Primary School	247	55.4	-
Junior High School	100	22.4	-
Senior High/Vocational School	48	10.8	-
Higher Education	4	0.9	-
Farming Experience	427	100	29.800±15.55
Daily Working Hours	427	100	7.629±2.42
Pesticide Type	427	100	2.890±1.26
Pesticide Spraying Frequency	427	100	1.778±0.71
ICD Complaints			
Present	179	41.9	-
Absent	248	58.1	-

Notes: Note: ICD = irritant contact dermatitis; *Education level and ICD complaints were analyzed as categorical variables. Therefore, descriptive statistics were presented as frequencies and percentages.

Table 2. Associations Between Independent Variables and ICD Complaints Among Farmers

Variable	ICD Complaints				Total	p-value	OR (95% CI)
	Present		Absent				
	n	%	n	%	n	%	
Age							
<60 years	124	40.5	182	59.5	306	100.0	0.352*
≥60 years	55	45.5	66	54.5	121	100.0	
Sex							
Female	34	28.6	85	71.4	119	100.0	<0.001*
Male	145	47.1	163	52.9	308	100.0	
Education Level							
Low	121	44.0	154	56.0	275	100.0	0.241*
Medium-to-high	58	38.2	94	61.8	152	100.0	
Farming Experience							
<10 years	23	39.0	36	61.0	59	100.0	0.622
≥10 years	156	42.4	212	57.6	368	100.0	
PPE Use							
Poor	73	40.1	109	59.9	182	100.0	0.513
Good	106	43.3	139	56.7	245	100.0	
Personal Hygiene Habits							
Poor	100	48.1	108	51.9	208	100.0	0.012*
Good	79	36.1	140	63.9	219	100.0	
Knowledge							
Poor	61	42.7	82	57.3	143	100.0	0.827
Good	118	41.5	166	58.4	284	100.0	
Smoking Habits							
Smoker	97	48.7	102	51.3	199	100.0	0.008*
Non-smoker	82	36.0	146	64.0	228	100.0	
Exposure Duration							
<3 hours/day	81	38.4	130	61.6	211	100.0	0.144*
≥3 hours/day	98	45.4	118	54.6	216	100.0	
Pesticide Spraying Frequency							
<2 times/week	62	40.0	93	60.0	155	100.0	0.544
≥2 times/week	117	43.0	155	57.0	272	100.0	
Pesticide Spraying Direction							
Downwind	132	44.3	166	55.7	298	100.0	0.131*
Upwind	47	36.4	82	63.6	129	100.0	
Pesticide Dosage							
As recommended	154	44.5	192	55.5	346	100.0	0.025*
Not as recommended	25	30.9	56	69.1	81	100.0	
Pesticide Type							
<3 types	56	34.1	108	65.8	164	100.0	0.010*
≥3 types	123	46.8	140	53.2	263	100.0	

Notes: PPE = personal protective equipment; OR = odds ratio; CI = confidence interval. Statistical significance was set at p-value <0.05

involvement in agricultural work. The median daily working time was 8 hours. The median number of pesticide types used was three, and most respondents reported spraying approximately twice per month. Overall, 41.9% of respondents reported ICD complaints.

The associations between the independent variables and ICD complaints were examined using the Chi-square test, and ORs with 95% CIs are presented in Table 2. Variables with p-values less than 0.25 were retained for subsequent multivariate analysis, regardless of statistical significance. Sex showed a statistically significant association with ICD complaints, with female respondents having lower odds of reporting ICD compared with male respondents (OR <1). Personal hygiene habits was also significantly associated with ICD

complaints, as respondents with poor hygiene had higher odds of reporting ICD. Smoking habits and pesticide dosage were significantly associated with ICD complaints, with smokers and those using pesticide dosages not in accordance with recommendations having higher odds of reporting ICD. The pesticide types showed a protective association: respondents who used fewer than 3 types had lower odds of ICD (OR <1). Other variables did not demonstrate statistically significant associations in the bivariate analysis. Variables with p-values less than 0.25 in the bivariate analysis were included in the multivariate logistic regression model to identify independent determinants of ICD complaints. The adjusted odds ratios (AORs) and 95% CIs are presented in Table 3.

Table 3. Multivariate Logistic Regression Model for Determinants of Irritant Contact Dermatitis Complaints

Variable	B (Estimate)	SE	AOR	95% CI (Lower-Upper)	p-value
Sex	-0.711	0.283	0.491	0.282-0.854	0.012
Education Level	0.448	0.221	1.566	1.016-2.413	0.042
Personal Hygiene Habits	0.515	0.208	1.674	1.114-2.516	0.013
Smoking Habits	0.279	0.244	1.322	0.821-2.131	0.251
Exposure Duration	-0.020	0.212	0.980	0.646-1.486	0.924
Pesticide Spraying Direction	0.277	0.235	1.319	0.831-2.093	0.240
Pesticide Dosage	0.522	0.282	1.686	0.970-2.928	0.064
Pesticide types	-0.437	0.223	0.646	0.417-1.001	0.050

Notes: SE = standard error, AOR = adjusted odds ratio, CI = confidence interval, B (Estimate) represents the regression coefficient on the log-odds scale

Table 4. Model Fit and Classification Performance of the Logistic Regression Model

Indicator	Value	Interpretation
Model Chi-Square ($\Delta\chi^2$)	35.110 (p-value <0.001)	Improvement in model fit compared with the null model
Nagelkerke R ²	0.106	The model explains a modest proportion of variance
Overall Accuracy	64.87%	Proportion of correctly classified cases
AUC	0.669	Indicates acceptable discrimination ability
Sensitivity	0.802	Proportion correctly classified as ICD present
Specificity	0.436	Proportion correctly classified as ICD absent

Notes: AUC = area under curve, ICD = irritant contact dermatitis

Sex remained significantly associated with ICD complaints, with female respondents having lower odds of reporting ICD compared to male respondents (AOR <1). Personal hygiene habits were positively associated with ICD complaints, as respondents with poor hygiene had higher odds of reporting ICD. Education level was also significantly associated with ICD complaints, with respondents in the medium-to-high education category having higher odds of reporting ICD than those with lower education levels. The number of pesticide types used showed a protective association: respondents who used fewer than 3 types had lower odds of ICD complaints (AOR <1).

The model fit and classification performance of the final multivariate logistic regression model are summarized in Table 4. The multivariate logistic regression model provided a better fit than the null model. This was evidenced by a reduction in deviance and a statistically significant chi-square value ($\Delta\chi^2$, p-

value <0.001). The model explained a modest proportion of the variation in ICD complaints, as indicated by the Nagelkerke R² value. The classification results showed that the model correctly identified a higher proportion of participants without ICD complaints than those with ICD complaints, with an overall accuracy of 64.87%.

The area under the curve (AUC) indicated acceptable discrimination, and sensitivity was higher than specificity at the selected cutoff of 0.5. Overall, the model demonstrated a moderate ability to distinguish between participants with and without ICD complaints. The independent factors included in the final model were gender, personal hygiene habits, educational level, and the number of pesticide types used.

Discussion

This study showed that ICD complaints among farmers were influenced by individual characteristics and work behaviors, particularly sex, personal hygiene

habits, education level, and pesticide types. These findings confirmed that the risk of dermatitis was related not only to the chemical properties of pesticides but also to how exposure occurs and is managed in daily farming activities. Female farmers in this study were less likely to report ICD complaints than males. This difference appears to be related to the division of labor in agricultural activities, with males more frequently involved in mixing and spraying pesticides, tasks associated with the highest levels of skin exposure. Studies have shown that male workers experience more intensive direct dermal exposure and demonstrate lower levels of PPE compliance than females.^{27,28} Previous studies further emphasized that task-based differences significantly influence variations in dermatitis risk among agricultural workers.^{29,30} Therefore, the association between sex and ICD risk observed in this study likely reflected differences in exposure levels rather than differences in biological susceptibility.

Personal hygiene habits significantly influenced ICD. Farmers who did not wash their hands or bathe after spraying retained pesticide residues on their skin for longer periods. This condition increased the risk of irritation and damage to the skin barrier. Previous studies also reported similar findings, highlighting the importance of immediately cleaning or washing the skin after pesticide exposure to prevent the accumulation of irritants.^{31,32} These results showed that understanding and practicing simple, realistic, and applicable hygiene measures in agricultural work have an important preventive impact.

The findings regarding education level showed that farmers with secondary education or higher were more likely to report ICD than those with lower levels of education. Theoretically, a higher level of education is associated with greater knowledge and a better understanding of preventive practices.^{33,34} However, this study's findings appeared to differ from this expectation. This difference may be because farmers with lower levels of education were less likely to recognize or report ICD symptoms than those with higher levels. The findings did not necessarily indicate a lower occurrence of ICD among farmers with lower education. Previous studies have also noted that perception and awareness of symptoms play an important role in dermatitis reporting.^{35,36} Thus, these findings should be interpreted carefully.

The risk of ICD increased with the use of three or more types of pesticides. This finding supported the concept that cumulative irritant effects may be stronger when the exposure involves chemical mixtures. Previous studies have shown that additive interactions between

pesticide active ingredients can worsen skin barrier damage.^{37,38} Hence, restricting the number of pesticide mixtures and regulating chemical rotation should be considered in occupational health strategies.

In general, this study's findings aligned with the recent literature, indicating that ICD is affected by multiple factors. These factors involve interactions of personal characteristics, working behaviors, and chemical exposure patterns.^{39,40} Therefore, preventive approaches are not limited to preparing PPE or decreasing pesticide dosage. However, it requires several aspects, such as providing hygiene education, implementing role-based workload management, and controlling the use of pesticide combinations.

The strength of this study lies in its use of multivariate analysis, which clearly identifies independent factors. However, the cross-sectional design limits the ability to draw causal conclusions. Therefore, further studies using cohort designs and qualitative methods to better understand risk perceptions and symptom-reporting practices are needed.

Conclusion

Differences in work roles, hygiene habits, and pesticide use patterns influence ICD complaints among farmers. Good personal hygiene habits and limiting the number of pesticide types used play important roles in reducing risk. Additionally, differences in sex and education level suggest that perceptions and preventive practices vary among farmers. Effective prevention should prioritize practical hygiene behaviors, safer pesticide-handling practices, and control of pesticide mixtures. Risk communication and preventive strategies should also account for differences in work roles and educational backgrounds to enhance the adoption of safe agricultural practices among farmers.

Abbreviations

ICD: irritant contact dermatitis; OSD: occupational skin disease; PPE: Personal Protective Equipment; OR: Odds Ratio; CI: Confidence Interval; AUC: Area Under the Curve.

Ethics Approval and Consent to Participate

This study obtained ethical approval from the Health Research Ethics Committee of Universitas Dian Nuswantoro, with approval number 002803/UNIVERSITAS DIAN NUSWANTORO/2024. All participants received explanations regarding the study procedures, and written informed consent was obtained prior to data collection.

Competing Interest

The authors declare that they have no competing interests related to this research.

Availability of Data and Materials

The dataset generated and analyzed during this study is available from the corresponding author upon reasonable request.

Authors' Contribution

MGCY designed and conducted the research and contributed to manuscript drafting. H performed data processing and statistical analysis and assisted in the preparation and revision of the manuscript. DS provided guidance on structuring the manuscript and contributed to refining the final article. All authors read and approved the final manuscript.

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Declaration on the Use of Artificial Intelligence

The authors declare that artificial intelligence (AI) tools were utilized solely for language editing and grammatical refinement to improve the clarity and readability of the manuscript. The specific AI tool used is ChatGPT4. AI was not involved in content generation, data analysis, interpretation, or any decision-making processes. All scientific content, interpretations, conclusions, and responsibilities related to the manuscript rest solely with the authors.

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