The Relationship Between Wastewater and Chemical Contact Duration and Symptoms of Irritant Contact Dermatitis Among Workers at Sari Rejo Tofu Factory, Medan Polonia

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Direct contact with wastewater and chemicals during the tofu-making process can increase the risk of irritant contact dermatitis symptoms among workers. This study aimed to analyze the relationship between the duration of exposure to wastewater and chemicals and the symptoms of irritant contact dermatitis among tofu factory workers in Sari Rejo Village, Medan Polonia District. A cross-sectional study design was employed, with a sample of 50 workers selected using total sampling. Data were collected through interviews using a structured questionnaire and analyzed using Fisher's Exact Test. The results revealed a significant association between the duration of wastewater exposure and symptoms of irritant contact dermatitis (p = 0.022), as well as between the duration of chemical exposure and symptoms of irritant contact dermatitis (p = 0.040). Thus, the duration of exposure to wastewater and chemicals is associated with symptoms of irritant contact dermatitis among tofu factory workers in Sari Rejo Village, Medan Polonia District.

Keywords: irritant contact dermatitis, duration of contact, wastewater, chemicals, tofu factory workers.

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1. Introduction

Contact dermatitis is a skin disorder that can occur as a result of skin exposure to external substances that trigger either irritant or allergic reactions. Irritant contact dermatitis occurs when the skin is damaged by direct exposure to irritating substances. This condition may be characterized by symptoms such as redness, itching, stinging or burning sensations, dry skin, scaling, cracking, swelling, and changes in skin texture (Nabila et al., 2024).

Irritant contact dermatitis develops when the skin comes into contact with irritating substances. These substances can gradually damage the skin by eroding the stratum corneum and reducing the skin's ability to retain moisture, thereby resulting in cellular damage (Zuhrina, 2021).

Workers are among the groups at risk of developing contact dermatitis because occupational activities may involve repeated exposure to irritating substances. The duration of contact is one of the factors contributing to the occurrence of irritant contact dermatitis. Repeated and prolonged exposure can impair the skin barrier function, making the skin more susceptible to irritation. In the workplace, continuous exposure to water, also known as wet work, can weaken the skin barrier and increase skin permeability to irritants (Nani et al., 2022).

Tofu factory workers are potentially exposed to wastewater and chemicals during the production process. Wastewater is generated from various stages of production, including soybean soaking, grinding, boiling, and filtering. This wastewater contains organic substances such as proteins, fats, and carbohydrates and

generally has an acidic pH. Repeated direct contact with wastewater may potentially impair the skin's protective barrier function (Riyanto, 2023).

In addition to wastewater, workers may also come into contact with chemicals such as acetic acid or vinegar, which is used as a coagulant in tofu production. Direct and repeated exposure to these substances may cause skin irritation, particularly when exposure occurs over prolonged periods. During the production process, chemical contact may occur when workers mix the coagulant, stir the mixture, or transfer the coagulated product (Lawrencesou et al., 2022).

Acetic acid (CH3COOH) is one of the chemicals used as a coagulant in tofu production. Direct and repeated exposure to acetic acid may cause skin irritation. Initial symptoms commonly include pruritus (itching), redness, and stinging sensations, which may develop into irritant contact dermatitis if exposure continues over time (Bella et al., 2022).

Irritant contact dermatitis can occur in either an acute or chronic phase. In the acute phase, symptoms may include itching, stinging, burning sensations, redness, dry skin, swelling, and the appearance of small vesicles or blisters (Apriliani et al., 2022). The symptoms of acute contact dermatitis include dry skin, erythema, swelling, inflammation, and the formation of vesicles. Meanwhile, chronic symptoms are characterized by dry skin, redness, thickening, scaling, cracking, and fluid-filled blisters. In more advanced conditions, complications may include inflammation, reddish rashes, pain, and skin infections (Defani et al., 2025).

If exposure to irritants occurs repeatedly over a prolonged period, the condition may progress to the chronic phase. This phase is characterized by skin thickening (lichenification), scaling, cracking, hyperpigmentation, and changes in skin texture, which becomes rough. Workers who are frequently exposed to chemicals and wastewater are particularly susceptible to developing these conditions (Yudhi et al., 2022).

The term "length of employment" refers to the total period during which an individual has worked as an employee or worker in a company. Length of employment may reflect work skills, perseverance, determination, composure, and the ability to identify problems and respond to them promptly (Zikra et al., 2022). Based on a preliminary survey conducted at a tofu factory in Sari Rejo Subdistrict, the production process takes place daily, and workers perform various activities involving direct contact with wastewater and chemicals. The results of preliminary interviews and observations revealed that workers experienced skin complaints, including peeling skin, redness, itching, and stinging sensations on their hands.

Among tofu factory workers, the hands are the body parts most frequently exposed to wastewater because nearly all stages of the production process still involve direct manual contact. Repeated exposure over prolonged periods increases the likelihood of damage to the skin barrier, thereby increasing the risk of irritant contact dermatitis compared with short-term exposure (Gitte et al., 2022). Continuous exposure to acidic wastewater and wet working conditions can cause damage to the stratum corneum. Excessively moist skin may undergo maceration, making it more fragile and susceptible to irritation. These conditions increase the likelihood of tofu factory workers developing irritant contact dermatitis (Bambang et al., 2025). Based on these conditions, this study aims to analyze the relationship between the duration of contact with wastewater and the duration of contact with chemicals and the symptoms of irritant contact dermatitis among tofu factory workers in Sari Rejo Subdistrict, Medan Polonia District.

2. Literature Review and Problem Statement

Irritant Contact Dermatitis in Tofu Factory Workers

Irritant contact dermatitis is an inflammatory skin disorder caused by direct exposure to irritating substances that damage the skin barrier. This condition commonly occurs in individuals whose occupational activities

involve frequent contact with water, chemicals, and other irritating materials. Symptoms may include redness, itching, burning or stinging sensations, dry skin, scaling, cracking, and swelling (Nabila et al., 2024). In tofu factory workers, the risk of irritant contact dermatitis may increase because daily production activities involve direct contact with wastewater and chemical substances. Repeated exposure can weaken the skin's protective barrier, particularly on the hands, which are frequently involved in the production process.

Duration of Contact with Wastewater and Chemicals as Risk Factors for Irritant Contact Dermatitis

The duration of contact with irritating substances is an important factor that may influence the occurrence of irritant contact dermatitis. Prolonged and repeated exposure to water can weaken the skin barrier, increase skin permeability, and make the skin more susceptible to irritation. This condition is commonly associated with wet work, in which workers frequently perform activities involving water exposure (Nani et al., 2022). In tofu production, wastewater generated from soybean soaking, grinding, boiling, and filtering contains organic substances and may have acidic characteristics that can contribute to skin irritation. Furthermore, workers may be exposed to chemicals such as acetic acid (CH3COOH), which is used as a coagulant during tofu production. Direct and repeated exposure to these substances may trigger skin irritation, especially when contact occurs over prolonged periods (Lawrencesou et al., 2022; Bella et al., 2022). Therefore, the duration of contact with wastewater and chemicals needs to be considered as a potential occupational risk factor for irritant contact dermatitis.

Problem Statement: The Relationship Between Contact Duration and Symptoms of Irritant Contact Dermatitis among Tofu Factory Workers

Tofu factory workers in Sari Rejo, Medan Polonia, perform daily production activities that involve direct contact with wastewater and chemicals. Preliminary observations and interviews indicated that several workers experienced skin complaints, including peeling skin, redness, itching, and stinging sensations, particularly on their hands. These complaints suggest the possibility of skin irritation associated with occupational exposure. However, the relationship between the duration of contact with wastewater, the duration of contact with chemicals, and the symptoms of irritant contact dermatitis among these workers has not yet been clearly established. This condition highlights the need for further investigation to determine whether prolonged contact with wastewater and chemicals is associated with the occurrence of irritant contact dermatitis symptoms. Accordingly, this study focuses on analyzing the relationship between the duration of contact with wastewater and chemicals and the symptoms of irritant contact dermatitis among tofu factory workers in Sari Rejo, Medan Polonia.

3. Method

This study employed a quantitative research method with a *cross-sectional* design. The research was conducted at a tofu factory in Sari Rejo Subdistrict, Medan Polonia District, Medan City, from January to July 2026. The study population consisted of all tofu factory workers, totaling 50 individuals. The entire population was included as the research sample using the total sampling technique.

The independent variables in this study were the duration of contact with wastewater and the duration of contact with chemicals, while the dependent variable was the symptoms of irritant contact dermatitis among tofu factory workers. Contact duration was measured based on the average daily duration of direct skin contact with wastewater or chemicals during working hours. Contact duration was categorized into less than 3 hours/day, 3–5 hours/day, and more than 5 hours/day.

Symptoms of irritant contact dermatitis were measured using a structured questionnaire based on self-reported skin complaints affecting the respondents' hands. The symptoms assessed included redness, itching, dry skin, stinging or pain, cracked skin, swelling, vesicles, and skin thickening. The total number of

symptoms was subsequently classified into mild (1–3 symptoms), moderate (4–5 symptoms), and severe (≥6 symptoms). These categories represented the operational classification used in this study and did not constitute a clinical diagnosis of irritant contact dermatitis.

The research instrument underwent validity and reliability testing. The results indicated that all questionnaire items met the validity criteria, while the *Cronbach's Alpha* values for the contact duration variable and dermatitis symptoms variable were 0.928 and 0.723, respectively. Therefore, the research instrument was considered reliable. Data analysis was performed using univariate and bivariate analyses. Univariate analysis was conducted to describe respondents' characteristics and the distribution of contact duration and dermatitis symptoms. Bivariate analysis was used to determine the relationship between the duration of contact with wastewater and chemicals and the symptoms of irritant contact dermatitis. Since some cells had an *expected count* of less than 5, the association was analyzed using Fisher's Exact Test, with a significance level of $\alpha = 0.05$.

4. Results And Discussion

Results

Table 1. Frequency Distribution of Respondents by Age, Gender, Educational Attainment, and Length of Employment at the Tofu Factory in Sari Rejo Subdistrict

Age (Years)	n	%
<20	4	8.0
20-30	34	68.0
31-45	12	24.0
Total	50	100.0
Gender	**n**	**%**
Male	50	100.0
Total	50	100.0
Educational Attainment	**n**	**%**
Elementary School	9	18.0
Junior High School	11	22.0
Senior High School	30	60.0
Total	50	100.0
Length of Employment	**n**	**%**
<1 Years	13	26.0
1-5 Years	15	30.0
>5 Years	22	44.0
Total	50	100.0

Based on Table 1, the majority of respondents were aged 20–30 years, comprising 34 individuals (68%). All respondents were male, totaling 50 individuals (100%). Regarding educational attainment, most respondents had completed senior high school, accounting for 30 individuals (60%). In terms of length of employment, the largest group had worked for more than 5 years, comprising 22 individuals (44%).

Table 2. Frequency Distribution of Respondents Based on Duration of Contact with Wastewater

Duration of Contact with Wastewater	n	%
<3 hours/day	10	20.0
3–5 hours/day	15	30.0
>5 hours/day	25	50.0
Total	50	100.0

Table 2 shows that the largest proportion of workers had contact with wastewater for more than 5 hours per day, totaling 25 individuals (50%). This was followed by workers with a contact duration of 3–5 hours per day, comprising 15 individuals (30%), and those with a contact duration of less than 3 hours per day, comprising 10 individuals (20%).

Table 3. Frequency Distribution of Respondents Based on Duration of Contact with Chemicals

Duration of Contact with Chemicals	n	%
<3 hours/day	13	26.0
3–5 hours/day	18	36.0
>5 hours/day	19	38.0
Total	50	100.0

Table 3 indicates that the largest proportion of workers had contact with chemicals for more than 5 hours per day, totaling 19 individuals (38%). This was followed by workers with a contact duration of 3–5 hours per day, comprising 18 individuals (36%), and those with a contact duration of less than 3 hours per day, comprising 13 individuals (26%).

Table 4. Frequency Distribution of Respondents Based on Symptoms of Irritant Contact Dermatitis

Dermatitis Symptoms	n	%
Mild	7	14.0
Moderate	14	28.0
Severe	29	58.0
Total	50	100.0

Based on Table 4, the majority of respondents experienced symptoms of irritant contact dermatitis in the severe category, comprising 29 individuals (58%). Furthermore, 14 respondents (28%) experienced moderate symptoms, while 7 respondents (14%) experienced mild symptoms.

Table 5. Fisher's Exact Test Analysis of the Relationship Between Duration of Contact with Wastewater and Symptoms of Irritant Contact Dermatitis

Duration of Contact with Wastewater	Mild n (%)	Moderate n (%)	Severe n (%)	Total (n)	p-value
<3 hours/day	1 (14.3)	7 (50.0)	2 (6.9)	10	0.022
3–5 hours/day	3 (42.9)	3 (21.4)	9 (31.0)	15	
>5 hours/day	3 (42.9)	4 (28.6)	18 (62.1)	25	
Total	7 (100)	14 (100)	29 (100)	50	

Note: $\alpha = 0.05$.

Table 5 shows that among respondents with a wastewater contact duration of less than 3 hours per day, the majority experienced moderate dermatitis symptoms, accounting for 7 individuals (50%). Among respondents with a contact duration of 3–5 hours per day, the largest proportion experienced severe symptoms, comprising 9 individuals (31.0%). Meanwhile, among respondents with a contact duration of more than 5 hours per day, the majority experienced severe symptoms, totaling 18 individuals (62.1%).

The Fisher's Exact Test results yielded a p-value of 0.022, which was lower than the significance level of 0.05. Therefore, there was a statistically significant relationship between the duration of contact with wastewater and symptoms of irritant contact dermatitis among tofu factory workers.

Table 6. Fisher's Exact Test Analysis of the Relationship Between Duration of Contact with Chemicals and Symptoms of Irritant Contact Dermatitis

Duration of Contact with Chemicals	Mild n (%)	Moderate n (%)	Severe n (%)	Total (n)	p-value
<3 hours/day	4 (57.1)	2 (14.3)	7 (24.1)	13	0.040
3–5 hours/day	3 (42.9)	3 (21.4)	12 (42.4)	18	

>5 hours/day	0 (0.0)	9 (64.3)	10 (34.5)	19
Total	7 (100)	14 (100)	29 (100)	50

Note: α = 0.05.

Table 6 shows that among respondents with a chemical contact duration of less than 3 hours per day, the majority experienced mild dermatitis symptoms, accounting for 4 individuals (57.1%). Among respondents with a contact duration of 3–5 hours per day, the largest proportion experienced severe symptoms, comprising 12 individuals (42.4%). Meanwhile, among respondents with a contact duration of more than 5 hours per day, the majority experienced moderate symptoms, totaling 9 individuals (64.3%).

The Fisher's Exact Test results yielded a p-value of 0.040, which was lower than the significance level of 0.05. Therefore, there was a statistically significant relationship between the duration of contact with chemicals and symptoms of irritant contact dermatitis among tofu factory workers.

Discussion

Relationship Between Duration of Contact with Wastewater and Symptoms of Irritant Contact Dermatitis

The results showed that the majority of workers had contact with wastewater for more than 5 hours per day, accounting for 25 individuals (50%). The prolonged contact duration indicates that some workers experience considerable exposure to wastewater during the tofu production process.

Repeated and prolonged exposure to water can impair the skin barrier function. Wet work conditions may increase transepidermal water loss, making the skin more susceptible to the penetration of irritating substances (Jacob et al., 2022). The longer the duration of skin contact with irritants, the greater the possibility of epidermal damage and an increased inflammatory response (Nani et al., 2022).

These findings are consistent with a study by Diana et al. (2023) among tofu factory workers in Air Tiris Village, which reported a significant relationship between contact duration and dermatitis complaints (p-value = 0.000). Workers with longer exposure to coagulants and wet working environments tended to have a higher risk of experiencing dermatitis symptoms.

The statistical analysis revealed a significant relationship between the duration of contact with wastewater and symptoms of irritant contact dermatitis, with a p-value of 0.022. Respondents with a contact duration of more than 5 hours per day predominantly experienced severe dermatitis symptoms.

These findings are also consistent with the study conducted by Nani et al. (2022), which identified a significant relationship between contact duration and the occurrence of irritant contact dermatitis among laundry workers (p = 0.031). The longer an individual is exposed to irritating substances during work, the greater the risk of developing irritant contact dermatitis (Nani et al., 2022).

Similarly, Wijaya et al. (2022) reported that continuous exposure to irritating substances during occupational activities was one of the factors associated with the occurrence of irritant contact dermatitis among workers (Wijaya et al., 2022). However, a study by Amir and Muin (2022) among tofu factory workers in Soreang District found no statistically significant relationship between contact duration and dermatitis, with a p-value of 0.062 (Amir & Muin, 2022).

A study by Naomi et al. (2021) reported that tofu wastewater had a BOD_5 value of 2,843.5 mg/L and a COD value of 7,743.5 mg/L, while its pH and TSS parameters did not meet the wastewater quality standards for the industry. These findings indicate that tofu wastewater contains a high organic pollutant load and therefore requires treatment before being discharged into the environment.

The findings of this study can also be explained through John Gordon's epidemiological triangle theory, which states that disease occurrence results from the interaction between the host, agent, and environment.

In this study, tofu factory workers represent the *host*, wastewater generated from the tofu production process represents the *agent*, and the wet and humid working conditions represent the *environment*.

Relationship Between Duration of Contact with Chemicals and Symptoms of Irritant Contact Dermatitis

The results showed that the majority of respondents had contact with chemicals for more than 5 hours per day, accounting for 19 individuals (38%). Contact duration represents the length of time workers' skin is directly exposed to irritating substances. The longer the exposure, the greater the possibility of damage to the skin's protective barrier. Continuous exposure may cause the skin to become dry and more susceptible to the penetration of irritating substances (Lawrencesou et al., 2022).

During the tofu production process, workers frequently come into direct contact with coagulants, such as acetic acid or vinegar. Direct and repeated exposure to acetic acid may cause skin irritation. Symptoms that may occur include itching, redness, stinging sensations, dry skin, and cracking (Lawrencesou et al., 2022).

The statistical analysis demonstrated a significant relationship between the duration of contact with chemicals and symptoms of irritant contact dermatitis, with a p-value of 0.040. Among workers with a contact duration of 3–5 hours per day, 12 individuals experienced severe symptoms, while among those with a contact duration of more than 5 hours per day, 10 individuals experienced severe symptoms.

These findings are consistent with the study by Lawrencesou et al. (2022) among tofu factory workers, which indicated that the duration of exposure to substances used during the production process was associated with the occurrence of contact dermatitis among workers (Lawrencesou et al., 2022).

These findings are further supported by the study conducted by Tanesab et al. (2022), which stated that exposure to substances used throughout the tofu production process was one of the factors that could increase the risk of contact dermatitis among workers. Repeated and prolonged contact may impair skin barrier function, making the skin more susceptible to irritation (Tanesab et al., 2022).

Symptoms of Irritant Contact Dermatitis among Workers

The results showed that the majority of workers experienced severe symptoms of irritant contact dermatitis, accounting for 29 individuals (58%). Meanwhile, 14 individuals (28%) experienced moderate symptoms, and 7 individuals (14%) experienced mild symptoms.

Irritant contact dermatitis is an inflammatory skin condition caused by exposure to irritating substances that damage the skin's protective barrier. Common symptoms include itching, stinging, burning sensations, redness, dry skin, swelling, scaling, and cracking (Nabila et al., 2024).

In this study, dermatitis symptoms were assessed based on complaints self-reported by respondents through a questionnaire. Therefore, the findings represent symptoms of irritant contact dermatitis rather than a clinical diagnosis.

The hands were selected as the primary body area for assessment because almost every stage of tofu production involves manual activities, including washing, filtering, coagulation, and molding. Based on preliminary observations, the hands were the body parts most frequently exposed to wastewater and chemicals during the production process (Lawrencesou et al., 2022).

A study by Maulidya et al. (2025) demonstrated a significant relationship between workers' knowledge and attitudes and the use of personal protective equipment (PPE). Therefore, improving workers' knowledge and compliance with PPE use should be continuously encouraged as part of occupational safety and health practices.

5. Conclusion

Most tofu factory workers in Sari Rejo Subdistrict had contact with wastewater for more than 5 hours per day (50%), while 38% had contact with chemicals for more than 5 hours per day. The majority of workers experienced severe symptoms of irritant contact dermatitis (58%). There was a statistically significant relationship between the duration of contact with wastewater and symptoms of irritant contact dermatitis among tofu factory workers, with a p-value of 0.022. Furthermore, a significant relationship was also found between the duration of contact with chemicals and symptoms of irritant contact dermatitis, with a p-value of 0.040. Based on these findings, workers are advised to consistently use personal protective equipment (PPE) to reduce direct contact with wastewater and chemicals. Factory owners are also expected to provide adequate PPE, supervise its proper use, and provide production equipment that can minimize workers' direct exposure to irritating substances.

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