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ORIGINAL ARTICLE

Personal Protective Footwear and The Risk of Tinea Unguium among Lojejer Villager Farmers

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ABSTRACT

Introduction: Tinea unguium is a nail infection caused by dermatophytes, characterized by nail discoloration, thickening, and brittleness. Farmers, often exposed to prolonged wet conditions, are at higher risk of this infection. The use of appropriate footwear is recommended to mitigate this risk. However, inadequate personal protective equipment (PPE) usage makes farmers more susceptible to Tinea unguium. Research on Tinea unguium among farmers in Lojejer Village is limited, with differing result on the link between wearing footwear as PPE and the occurance of Tinea unguium. This study aimed to investigate the relationship between the use of footwear as PPE and the incidence of Tinea unguium among farmers in Lojejer Village. **Methods:** This study uses a cross-sectional observational design. It involved 98 respondents determined using Slovin's formula. Data were collected through interviews and nail samples, which were subjected to fungal culture on sabouraud dextrose agar (SDA) medium and microscopic examination with lactophenol cotton blue staining. Fisher's Exact tests were used for analysis. **Results:** Results revealed that seven farmers (7.14%) were affected by Tinea unguium, predominantly males (85.8%) aged 45–64 years (57.1%). Trichophyton rubrum was identified as the primary dermatophyte, with Aspergillus sp. as a contaminant. Statistical analysis showed no significant relationship between footwear usage, personal hygiene, or footwear hygiene and Tinea unguium (p-values > 0.05). **Conclusion:** The study found no significant association between footwear use, hpersonal hygiene, and footwear hygiene with Tinea unguium incidence among farmers in Lojejer Village.

Keywords: dermatophyte, farmer, footwear as personal protective equipment, personal hygiene, tinea unguium

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INTRODUCTION

Tinea unguium is a nail infection classified as dermatophytosis, commonly caused by Trichophyton rubrum, Trichophyton mentagrophytes, and Epidermophyton floccosum. The infection leads to changes in nail color, thickening, and increased brittleness (Sariyanti *et al.*, 2021; Falotico and Lipner, 2022; Fonna *et al.*, 2023). Occupational exposure plays a significant role in occurrence of Tinea unguium. The work environment can significantly impact workers' health. One of the health issues that may arise from the workplace is a fungal infection, also known as superficial mycosis. When related to types of occupations, superficial mycosis can occur in various jobs, especially among workers who wear airtight personal protective equipment for extended periods, such as closed shoes. Wearing enclosed, non-breathable footwear during work can lead to moisture buildup on the feet, creating a favorable environment for fungal growth, particularly on the toenails (Sariyanti *et al.*, 2021; Suhartini, Aina and Rahayu, 2022). Direct soil contact and neglect in using footwear make them more susceptible to fungal infection (Sariyanti *et al.*, 2021; Suhartini, Aina and Rahayu, 2022).

Occupations associated with this condition include farmers, coal workers, and fishermen. Individuals engaged in these types of work are advised to use personal protective equipment, such as appropriate footwear, to reduce the risk of infection (Triana, Nawaliya and Sinuhaji, 2020; Nurfadilah *et al.*, 2021; Suhartini, Aina and Rahayu, 2022). A study on farmers in Kedokangabus Village, Indramayu Regency, showed that farmers who did not wear personal protective equipment (PPE) were

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more likely to contract Tinea unguium (Umar *et al.*, 2023). Meanwhile, another study on tofu factory workers in Kalideres, West Jakarta, found that prolonged use of rubber boots was associated with the occurrence of Tinea unguium. This condition was caused by foot moisture resulting from the extended wearing of boots (Rachmad, Apriani and Anggiani, 2021).

Farmers are advised Personal Protective Equipment (PPE), such as footwear, to minimize the risk of infection. Proper foot protection must be worn in work environments where there is a risk of injury such as slipping, being struck or crushed by falling objects, contact with hot or hazardous substances, or exposure to sharp tools, slippery, or wet surfaces. Safety shoes or boots are a type of personal protective equipment (PPE) specifically designed to protect farmers while working in agricultural settings. Footwear used by farmers should meet occupational safety standards. These shoes must have sturdy, non-slip soles, reinforced toe caps, and must be worn properly at all times. The height of the shoes should be sufficient to protect the ankles. Additionally, the design should be made of durable materials suitable for the working environment. Materials such as leather or synthetic rubber that are waterproof and easy to clean are commonly used. Proper ventilation is also important to prevent moisture and excessive heat from accumulating inside the shoes, which could lead to fungal infections. The use of sandals or footwear that does not meet safety standards is not recommended during work (Orr *et al.*, 2022; International Labour Organization, 2023).

A study in Kedokangabus Village, Indramayu Regency, showed that farmers who do not use footwear are more susceptible to Tinea unguium infections. Additionally, farmers who do not maintain personal hygiene have a higher risk of contracting Tinea unguium (Umar *et al.*, 2023). In contrast, another study found a strong association between prolonged footwear use and Trichophyton sp. infections in coal miners in East Kalimantan (Suhartini, Aina and Rahayu, 2022).

Lojejer Village is an agrarian area located in Wuluhan Subdistrict, Jember Regency, East Java Province, Indonesia. With a population of approximately 22,000 people, the majority of its residents are engaged in agriculture, either as individual farmers or as members of organized farmer groups. Administratively, Lojejer Village is divided into 5 hamlets: Krajan, Sulakdoro, Kepel, Sebanen, and Grintingan. These hamlets are further structured into 12 community units (RW) and 121 neighborhood units (RT).

The village is characterized by fertile agricultural land and a strong sense of community. It plays an important role in supporting local food production and sustaining rural livelihoods in the region. Lojejer also reflects the cultural richness and traditional values of rural East Java, with farming activities being closely linked to the daily lives and social structures of its residents. Some farmers wear boots while working. This village is predominantly inhabited by farmers who work in rice fields, often in direct contact with water and mud for extended periods. Generally, farmers do not wear footwear like boots. They frequently allow their toenails to be submerged in the damp mud, causing the nails to change color, turning black or yellow, becoming uneven, and in some cases, causing a foul odor. With this condition, the aim of this study is to determine the relationship between the use of shoes as personal protective equipment (PPE) and the incidence of Tinea unguium in Lojejer Village.

METHODS

This study employed an observational design with a cross-sectional approach, conducted in Lojejer Village, Wuluhan Subdistrict, from October to December 2024. The study sample consisted of farmers meeting the inclusion criteria: working as farmers, residing in Lojejer Village, and willing to participate as respondents. Exclusion criteria included a history of immunocompromising conditions such as diabetes mellitus, HIV, or chemotherapy. According to 2024 BPS data, Lojejer Village had 5,125 farmers. Using Slovin's formula with a 10 % margin of error, a sample size of 98 respondents was determined. The sampling method used was purposive sampling.

Primary data were collected after obtaining approval from the Faculty of Medicine Ethics Committee, University of Jember (No. 5325/UN25.1.10/2/KE/2024). Respondents provided informed consent before being interviewed using questionnaires about using footwear as PPE, footwear hygiene, and personal hygiene. Additionally, toenail samples were collected from respondents showing symptoms of Tinea unguium for laboratory analysis.

Direct examination using Potassium Hydroxide (KOH) and fungal culture remains the primary

method for diagnosing tinea unguium (Tsuboi *et al.*, 2021). Dextrose Agar (SDA) medium was used to culture fungi, which were incubated for seven days at room temperature. Staining was performed using NaCl solution and lactophenol cotton blue, followed by microscopic examination at 10x and 40x magnifications to identify fungal species .

The study variables included footwear usage as PPE (independent variable), the incidence of Tinea unguium (dependent variable), and personal hygiene and footwear hygiene (confounding variables). To determine the relationship between the variables, the Fisher's Exact Test was used for analysis, with a significance level of 0.05. Data processing was carried out using the Statistical Package for the Social Sciences (SPSS).

RESULT

Tinea unguium incidence was determined by analyzing toenail clippings cultured using SDA (Mufida *et al.*, 2024). Respondents were declared positive if clinical manifestations were found on the toenails and dermatophyte fungi were detected. Doctors from the laboratory confirmed the diagnosis. Based on Table 1 seven farmers tested positive for Tinea unguium.

A total of 23 nail samples with clincal manifestations of tinea unguium were analyzed through fungal culture and microscopic examination. Results showed seven samples infected with dermatophytes (Trichophyton rubrum) are shown in Figure 1 and 16 samples infected with non-dermatophyte fungi (Aspergillus sp.), which were identified as contaminants, are shown in Figure 2.

Table 1. Distribution of Farmers with Positive Tinea Unguium based on Gender and Age

Characteristics	Frequency	Percentage (%)
Gender		
Male	6	85.8%
Female	1	14.2%
Age (year)		
15-24	0	0%
25-34	1	14.2%
35-44	1	14.2%
45-54	2	28.6%
55-64	2	28.6%
≥ 65	1	14.2%
Total		100%

The analysis of the relationship between footwear usage as PPE and the incidence of Tinea unguium is shown in Table 2, revealed a p-value of 1 ($p > 0.05$), indicating no significant relationship.

The relationship between footwear hygiene and personal hygiene and the incidence of Tinea unguium also showed p-values > 0.05. Indicating no significant relationships. Table 3 and Table 4 shown the analysis results.

DISCUSSION

This study's results indicated that most farmers were male, totaling 69 individuals (70.4%). Among the farmers who tested positive for Tinea unguium, six individuals (85.7%) were male, while one (14.3%) was female. These findings align with research which stated that men are more likely to experience Tinea unguium. The high prevalence of Tinea unguium in men can be attributed to occupational activities that frequently expose them to moist environments and increase the risk of nail trauma, thus elevating their susceptibility to Tinea unguium (Anggraeni, Krisnarto and Arfiyanti,

Figure 1. a) Culture of Trichophyton rubrum b) Microscopis of Trichophyton rubrum (Source: Author's documentation, 2024).

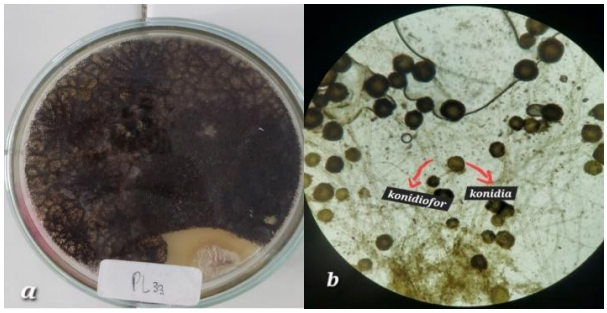

Figure 2. a) Culture Aspergillus sp. b) Microscopis of Aspergillus sp. (Source: Author's documentation, 2024)

2023). In contrast, research found that women had a higher prevalence of Tinea unguium. However, this difference does not show significant disparity, as numerous predisposing factors influence the occurrence of Tinea unguium. Variations in the results may be due to factors such as the frequency of exposure to moist environments and differing levels of personal hygiene (Rachmawati, Nursidika and Fitrianingsih, 2022).

The results of this study indicate that farmers aged 45-64 constitute the latgest group affected by Tinea unguium, with a total four individuals. Cases of Tinea unguium are commonly found in the age group between 15-64 years. This age associated with the long working hours spent in fields, where individuals in this age group frequently come into contact with damp, wet, and dirty environments, which also trigger excessive sweating. Prolonged exposure to such conditions increases the risk of developing Tinea unguium (Nurfadilah *et al.*, 2021). Another study indicated that workers are diagnosed with Tinea unguium are predominantly between the ages of 30-60. As age increases, nail growth slows down, making nails more prone to trauma, fragility, and dryness, facilitating fungal infections (Pang *et al.*, 2018; Hasan *et al.*, 2022). Furthermore, individuals over 45 are more susceptible to infections due to declining physical condition, weakened immune systems, and the potential presence of comorbidities that can encourage fungal colonization (Shankar and Thomas, 2021).

The laboratory examination showed seven samples infected with dermatophyte fungi, namely Trichophyton rubrum. Trichophyton rubrum has better virulence adaption and is anthropophilic fungus, meaning it infects only humans and spreads through direct contact. Trichophyton rubrum can produce mannan which has a more substansial immunosuppressive effect compared to other dermatophyte fungi, grows quickly, and can survive in air, water, soil, and damp environments (Kamil *et al.*, 2021; Hasan *et al.*, 2022). Trichophyton rubrum, a type of dermatophyte fungus responsible for Tinea unguium, has the ability to break down keratin and form the outer layer of the epidermis or nails (Husen, Khasanah and Ina Ratnaningtyas, 2024).

Trichophyton rubrum typically presents as a white to cream colored discoloration on the proximal part of the nail plate, which progressively extends to involve of the entire nail. Over time, this can lead to subungual hyperkeratosis, white spots on the nail (leukonychia), proximal onycholysis, and potentially complete nail damage (Ayu *et al.*, 2024). This infection most commonly occurs on toenails, but fingernails can also become infected, especially when environmental conditions are favorable.

Figure 3. Clinical manifestation of Tinea unguium (Source: Author's documentation, 2024).

Table 2. Analysis of the Relationship between using Footwear as Personal Protective Equipment (PPE) and the Incidence of Tinea Unguium

Footwear as PPE	Tinea Unguium		Total	p-value
	Positive	Negative		
Not using	4	50	54	1
Using	3	41	44	
Total	7	91	98	

Table 3. Analysis of the Relationship between Footwear Hygiene in People who Wearing Footwear and the Incidence of Tinea Unguium

Footwear Hygiene	Tinea Unguium		Total	p-value
	Positive	Negative		
Poor	1	22	23	0.599
Good	2	19	21	
Total	3	41	44	

Table 4. Analysis of the Relationship between Footwear Hygiene in People who Wearing Footwear and the Incidence of Tinea Unguium

Personal hygiene	Tinea Unguium		Total	p-value
	Positive	Negative		
Poor	6	43	49	0.111
Good	1	48	59	
Total	7	91	98	

Toenail infections are considerably more common, most likely because they are more frequently exposed to moist enclosed conditions that favor fungal development. Although the infection can affect several nails, it usually does not involve all of them (Husen, Khasanah and Ina Ratnaningtyas, 2024; Karunarathna *et al.*, 2024; Rahmayanti, Hadijah and Darmawati, 2024).

Additionally, Aspergillus sp. was found to be a contaminant fungus in 16 samples that can pollute the environment through spores dispersed in the air. Environments that are damp an unhygienic contribute the presence of this fungus. Aspergillus sp. can grow in various places and at different times as long as the environmental conditions and available nutrients support its growth. This fungus is also known as a saprophytic fungus (Suhartini, Aina and Rahayu, 2022). The clinical features imclude a chalky white appereance of the nail, rapid involvement of the nail plate, and painful perionyxis without presence of the pus (Merad *et al.*, 2021).

Based on the Fisher's Exact test analysis, no relationship was found between the use of footwear as personal protective equipment (PPE) and the occurrence of Tinea unguium. This finding is consistent with a study which stated that farmers who work with or without footwear have the same risk of Tinea unguium. Fungal infections can cause nails to become brittle, damaged, and discolored. This condition is more common among individuals working in damp and dirty environments, which increases the risk of fungal infection. Tinea unguium infections can worsen if rice farmers have poor habits, such as not regularly cleaning their toenails or rarely trimming them, causing the nails to remain dirty from mud exposure while working in the fields. This condition, with nails being submerged in mud for extended periods, can trigger fungal infections (Naqsyabandi, 2021). On the other hand, wearing closed footwear for prolonged periods can cause heat, maceration, and hyperhidrosis, which support fungal development. Farmers who work using PPE but do not maintain proper personal hygiene have a high risk of Tinea unguium infection (Mufida *et al.*, 2024). Both farmers who wear footwear and those who do not wear have the same risk of dermatophyte infections that cause Tinea unguium (Kamil *et al.*, 2021).

Inaddition to footwear usage, the analysis results regarding the relationship between footwear hygiene and the occurrence of Tinea unguium showed a p-value of 0.599. Good footwear hygiene is essential for preventing fungal infections such as tinea unguium, especially among workers who are often exposed to damp or dirty environments. Based on the questionnaire, the criteria for good footwear hygiene include: (1) washing feet with soap before wearing shoes, (2) drying feet with a towel or tissue before wearing shoes, (3) cleaning work boots at least twice a week, and (4) storing boots in an open area where they can dry properly after use. These practices help reduce moisture and prevent fungal growth in the footwear, which is a common source of reinfection.

Based on the questionnaire responses, some farmers who wore footwear did not wash their feet with soap, leading to poor hygiene and an increased risk of fungal infection. Some respondents did not dry their feet before wearing footwear, keeping them damp. This can affect an individual's foot hygiene (Suhartini, Aina and Rahayu, 2022). Irregularly washing and drying footwear can reduce airflow inside the footwear, creating an environment conducive to fungal growth (Riyadi, Batubara and Pratiwi Lingga, 2020). Lack of footwear hygiene can impact foot cleanliness. Poor foot hygiene can increase the risk of fungal infections by up to four times (Umar *et al.*, 2023). Other risk factors that can cause Tinea unguium include poor footwear hygiene, damaged footwear condition, and inappropriate footwear materials (Suhartini, Aina and Rahayu, 2022; Umar *et al.*, 2023).

The analysis of personal hygiene behavior, including foot and nail hygiene, showed a significance value of 0,111. This finding differs from another study on farmers in Jember Regency, which found a significant relationship between personal hygiene and the occurrence of Tinea unguium infection (Mufida *et al.*, 2024). Good personal hygiene plays an important role in preventing fungal infections such as tinea unguium. In our questionnaire given to the respondents, there were four questions related to daily personal hygiene during work. The criteria for good hygiene include washing the feet immediately after work, using soap and water for cleaning, trimming toenails regularly (at least once a week), and keeping the nails short and clean. These practices help remove sweat, dirt, and potential fungal spores that may accumulate during daily activities. On the other hand, poor hygiene is indicated by infrequent foot washing, not using soap, rarely trimming nails, or allowing dirt to accumulate under the nails. These conditions create a moist and dirty environment that

supports the growth of fungi and increases the risk of infection. Questionnaires results showed that six individuals with poor personal hygiene had Tinea unguium. Some of the respondents habits that could increase the risk of Tinea unguium include a lack of attention to foot and nail hygiene. The habit of not washing the feet and not using soap to clean them can increase the risk of fungal infections. Farmers with poor personal hygiene, dirt or debris on their feet and nails are often not thoroughly cleaned. Dirt left for a long time can cause an unpleasant odor and decay, which supports fungal growth (Kamil *et al.*, 2021; Triana *et al.*, 2020). Additionally, six respondents did not keep their nails trimmed and clean because they did not cut them regularly, thus increasing the risk of injury and infection. Clean and short nails can prevent the accumulation of dirt such as soil or mud, which becomes a medium for fungal growth (Anggraeni, Krisnarto and Arfiyanti, 2023). By making hygiene a habit, farmers can protect themselves from fungal infections (Nurfadilah *et al.*, 2021). Good personal hygiene can reduce the risk of dermatophytosis, although not all individuals with poor hygiene will experience the infection. Poor personal hygiene remains a primary risk factor. Furthermore, the pathogenesis of dermatophytosis is influenced by environmental factors such as hot climates, infection sources, the invasiveness of organisms, immunogenicity, and an individual's immune response (Triana, Nawaliya and Sinuhaji, 2020). Despite the lack of statistical significance, good personal hygiene remains important in reducing the overall risk of tinea unguium. While not every individual with poor hygiene will develop an infection, poor hygiene continues to be recognized as a primary risk factor that increases susceptibility, especially when combined with other conditions favorable for fungal growth.

Although the results did not show statistically significant correlations, this may be due to overlapping risk behaviors within the same group. For instance, farmers who wore protective footwear may still have practiced poor foot hygiene, such as not drying their feet or cleaning their boots regularly, which weakens the protective effect of footwear alone. Similarly, Tinea unguium is a multifactorial disease affected by environmental exposure, organism virulence, and individual immune response. These factors may obscure the direct impact of personal hygiene in statistical analysis, especially in populations with varied practices and limited sample sizes. Thus, the lack of significance does not eliminate the clinical importance of good hygiene practices in preventing infection.

The management of Tinea unguium depends on various factors, such as the severity of nail damage, the effectiveness of the treatment, and the potential for side effect. Oral antifungal therapy is required when the infection involves the nail matrix, or when a shorter treatment duration or a higjer chance of cure is desired (Ayu *et al.*, 2024). Tinea unguium affects the quality of life of those who suffer from it, due to physical, functional, and psychological problems that arise. These problems include pain, difficulty wearing footwear and performing tasks, secondary infections, and aesthetic concerns (Rahmawati, Oktavia and Saftarina, 2024).

Although statistical analysis revealed no significant correlation between hygiene behaviors and fungal infection rates, several contextual factors may explain this outcome. First, based on the questionnaire responses, participants who reported wearing footwear or practicing good hygiene often still engaged in inconsistent behaviors — such as not using soap when washing feet, not drying feet thoroughly, or neglecting to clean their footwear. These partial or improper practices could reduce the contrast in exposure between groups, thereby diminishing the strength of association detectable in the analysis.

Second, both groups — those who reported good hygiene and those who did not — were similarly exposed to environmental risk factors such as prolonged contact with wet soil, high humidity, and limited foot ventilation due to prolonged use of closed shoes or rubber boots. This homogeneity of environmental exposure likely resulted in comparable infection risks across groups, which would weaken the correlation statistically.

Therefore, while the absence of statistically significant associations may suggest limited predictive value for individual hygiene variables in this sample, it does not negate the importance of comprehensive and consistent foot hygiene in fungal infection prevention.

CONCLUSION

Based on the research findings in Lojejer Village, most of the farmers involved were male. The fungus Trichophyton rubrum was identified as the dermatophyte species infecting the farmers' nails. The lack of a significant relationship between footwear use, footwear hygiene, and personal

hygiene with the incidence of Tinea unguium suggest that relying solely on these factors may not be sufficient for effective prevention in this population. Therefore,it is recommended that future preventive strategies adopt a multifactorial approach, which may include improving environmental conditions such as reduced prolonged exposure to moisture or contamined soil, promoting behavioral intervention, and providing healt education. In further research needed to explore other contributing factors, such as immunes status, footwear material, work duration, and genetic predispositions, to develop more comprehensive prevention and control measures.

This study found no significant relationship between the use of footwear as personal protective equipment (PPE) and the occurrence of Tinea unguium, with a p-value greater than 0,05. Additionally, the cleanliness of footwear usage and personal hygiene did not show a significant relationship with the occurrence of Tinea unguium, as reflected in the test results with p-values greater than 0.05.

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