Systematic Review

RISK FACTORS FOR LEPROSY: A SYSTEMATIC REVIEW

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ABSTRACT

Introduction: In 2021, the global prevalence rate of registered leprosy cases stands was 16.9 cases per one million people, with a case detection rate of 17.83 new cases per one million people. This indicates a 10.2% rise in new cases compared to the previous year. **Aims:** This study aims to examine the risk factors associated with leprosy. **Methods:** The inclusion criteria for this study were articles published in the last five years, available in full-text, and written either in Indonesian or English. Articles that were literature reviews, systematic reviews, meta-analyses, or classified as grey literature were excluded. The exclusion criteria were established to determine which studies to include in this study. **Results:** This study found that leprosy is associated with household density, personal hygiene, history of contacts, ventilation, humidity levels, BCG vaccination history, flooring type, house lighting, temperature, and wall type. Personal hygiene was identified as the primary risk factor for leprosy based on individual characteristics and behaviors, while household density was identified as the most significant risk factor based on the physical environment of the occupants. Therefore, poor personal hygiene and high residential density increase the risk of leprosy. **Conclusion:** The key risk factors for leprosy include household density and personal hygiene, while a history of BCG vaccination serves as a protective factor. This study provides valuable information for governments and stakeholders to assess healthy household indicators and promote clean and healthy living practices in communities.

Keywords: leprosy, risk factors, characteristics, behaviors, physical environment

INTRODUCTION

Leprosy, also known as Hansen's disease, is one of the oldest diseases in human history that affects the skin and nerves (Prakoeswa, 2021). It is a chronic infectious disease that is caused by *Mycobacterium leprae*. It has a relatively long incubation period, typically lasting around five years or even longer (World Health Organization, 2020). Leprosy is classified as a neglected tropical disease (NTD), suggesting that it is often overlooked by society and receives insufficient attention. Although NTDs rarely cause mortality, they have a high potential for morbidity. The challenges posed by leprosy remain a significant health problem that needs to be addressed. These challenges extend beyond medical problems, which may hinder productivity and lead to social and cultural problems due to the stigma associated with the incidence of leprosy in some communities (Adrianto and Yuwono, 2018).

Globally, the registered prevalence rate of leprosy is 16.9 cases per one million people. In 2021, the case detection rate increased by 10.2% compared to the previous year, with 17.83 new cases per one million population (128,405 cases in 2020). A total of 143 countries reported new cases of leprosy detected in 2021. Among these countries, 36 reported no new cases, 58 reported less than 100 new cases, 36 reported between 101 and 1000 new cases, and 10 reported between 1001 and 10,000 new cases. Notably, Brazil, India and Indonesia are three out of the 23 global priority countries that reported more than 10,000 new cases of leprosy in 2021 (World Health Organization, 2022).

NTDs are commonly found in rural, conflict, and remote areas with limited access to clean water and sanitation. These conditions are exacerbated by climate change. In addition, NTDs

disproportionately affect poor communities due to inadequate health services (World Health Organization, 2021). Similar to other NTDs, leprosy is often associated with low socioeconomic status (World Health Organization, 2020). Therefore, it is more prevalent in developing countries due to various factors, including limited access to healthcare services, inadequate education and awareness about the disease, and socioeconomic challenges (Prakoeswa, 2022). In line with its status as a neglected disease, leprosy is not considered an infectious disease that requires immediate treatment (World Health Organization, 2021).

Leprosy is often found in developing countries where hygiene standards may not be in place and people may have relatively low incomes (da Conceição et al., 2022). The lower class community is particularly vulnerable to this disease due to a lack of awareness and initiative towards the importance of maintaining personal hygiene and sanitation in residential settlements, as well as difficulties in accessing health services for immunization (Prakoeswa, 2022). Insufficient sanitation increases the risk of leprosy transmission risks among individuals. Impoverished individuals living below the poverty line often resort to makeshift personal hygiene practices and live in inadequate settlements, creating an unhealthy environment conducive to the rapid spread of *Mycobacterium leprae*, ultimately infecting the community.

The physical environment, especially in relation to leprosy, is a significant risk factor that should be taken into account. The physical environment is an environmental component that constantly interacts with humans across time and space, and plays a crucial role in disease transmission within a society (Adrianto and Yuwono, 2018). The background of living in close proximity to leprosy patients, coupled with substandard residential density, temperature, and humidity, facilitates the invasion of *M.*

leprae bacteria into bodies of healthy individuals. The bacteria thrive in inappropriate home environments characterized by improper flooring, walls, ventilation, and lighting (Prakoeswa, 2021). This results in the bacteria continuing to multiply in the bodies of patients and their contacts. If the characteristics of individuals that do not meet health standards are combined with inappropriate environmental factors, more complex problems may arise that increase the transmission of leprosy and lead to new cases of leprosy (Mishra et al., 2017; Prakoeswa, 2022).

Research on risk factors for leprosy has been conducted by a number of researchers. However, there is still a lack of research that summarizes the risk factors for leprosy. One method to summarize it is to synthesize the results of the studies using the systematic review method. In this case, a comprehensive synthesis of the results of the studies will provide relevant facts to the research questions and the identified phenomenon (Pertiwi, 2019). Based on this explanation, the authors are interested in the analysis of risk factors associated with leprosy by reviewing the results of previous studies.

METHODS
Literature Search

This study used a systematic review method to collect data from various electronic databases, including Google Scholar, ProQuest, ScienceDirect, Scopus, and Web of Science. The search process followed the PICOS protocol, which included population (leprosy patients), intervention (physical environment and characteristic/behavior), comparison (non-leprosy patients), outcome (risk factors for leprosy), and study design (cross-sectional, case-control, and cohort). Boolean operators were used to construct keywords to obtain relevant studies. The keywords were adapted to the PICOS rule. The keywords used were "risk factors" AND "leprosy" OR "leprae" OR "morbus Hansen".

Study Selection

The 2020 Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 was used in this study to ensure a transparent and systematic approach to the identification of relevant studies, which was in accordance with the predetermined inclusion and exclusion criteria. The inclusion criteria for this study were articles published in the last five years (from 2018 to 2022), freely accessible full-text articles, and articles written either in Indonesian or English. Articles that were literature reviews, systematic reviews, meta-analyses, and classified as grey literature, such as books, dissertations, theses, and the like, were excluded. In addition, articles that did not use a cross-sectional, case-control, or cohort design, did not discuss risk factors for leprosy (physical environment as well as characteristics and behaviors), and did not present the values of PR/OR/RR and CI were excluded. This approach ensured that only relevant and high-quality studies were included in this study.

Quality Assessment

Figure 1 provides an overview of the data search results based on the predefined keywords. A total of 40,988 studies were initially identified and underwent the screening process. Following the application of the inclusion criteria, 40,920 studies were excluded, leaving 68 studies for full-text screening. After applying the exclusion criteria, 41 studies were further excluded. The reasons for the exclusion of these studies were as follows: seven studies did not use the aforementioned study designs, 20 studies did not discuss risk factors for leprosy in terms of physical environment as well as characteristics and behaviors, and 14 studies did not present the necessary PR/OR/RR and CI values. Finally, 27 studies were included in this systematic review.
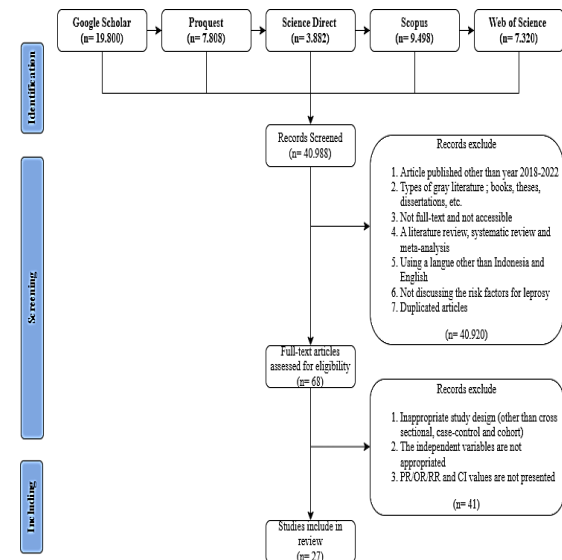
Data Extraction

Figure 1. PRISMA Flowchart

The data synthesis process involved gathering relevant information from each included study and organizing it into a table. The table included details such as the source, location, research design, population, and results of the studies. This approach allows important information from each study to be gathered and presented in a systematic and transparent manner to capture important information about the studies included in this review.

RESULTS
Characteristics of Studies

Table 1 presents the results of the data synthesis stage, which included 27 articles that met the inclusion criteria for the study of risk factors for leprosy. Out of the 27 articles included in this review, the majority (25 articles) used a case-control study design. One article used a cross-sectional study design, and another article used a cohort study design. Based on the results of the studies from the past five years, various factors were found to increase the risk of leprosy. The following table shows the results of the review, which describes the 10 most studied factors causing leprosy in terms of physical environment as well as characteristics and behaviors (see Table 2).

Risk Factors for Leprosy Based on Individual Characteristics and Behaviors

There are three risk factors based on individual characteristics and behaviors. The first is personal hygiene, as shown Table 2. Of the 27 studies found, 11 articles discussed personal hygiene. Eight of them concluded that personal hygiene is a risk factor for leprosy, two of them concluded that it is not a risk factor, and one of them article concluded that personal hygiene is a protective factor for leprosy. The second risk factor is contact history. Of the 27 studies found, nine articles discussed contact history. Seven of them concluded that contact history is a risk factor for leprosy, while two of them concluded that it is not a risk factor for leprosy. The last risk factor based on individual characteristics and behaviors is BCG vaccination history. Of the 27 studies found, 10 articles discussed BCG vaccination history. Five of them concluded that history of BCG vaccine is a risk factor for leprosy, three of them concluded that it is not a risk factor for leprosy, and two of them concluded that it a protective factor for leprosy.

Risk Factors for Leprosy Based on Physical Environment

There are seven risk factors for leprosy based on physical environment. The first is household density, as shown in Table 2. Twelve articles discussed household density. Nine of them concluded that personal hygiene is a risk factor for leprosy, while three of them concluded that it is not a risk factor for leprosy. The second risk factor is humidity. Ten articles discussed humidity. Six of them concluded that humidity is a risk factor for leprosy, while four of them concluded that it is not a risk factor for leprosy. The third risk factor is the presence of ventilation. Nine articles discussed the presence of ventilation. Six of them concluded that the presence of ventilation is a risk factor for leprosy, while three of them concluded that it is not a risk factor for leprosy. The fourth risk factor is

house lighting. Seven articles discussed house lighting. Four of them concluded that house lighting is a risk factor for leprosy, while three of them concluded that it is not a risk factor for leprosy.

The type of floor is also a risk factor. Six articles discussed the type of floor, four of which concluded that the type of floor is a risk factor for leprosy, while two of which concluded that it is not a risk factor for leprosy. Another risk factor is temperature. Five articles discussed temperature, three of which concluded that temperature is a risk factor for leprosy, one of which concluded that it is not a risk factor for leprosy, and one of which concluded that it is a protective factor for leprosy. The last risk factor based on physical environment is the type of wall. Four articles discussed the type of wall, three of which concluded that the type of wall is a risk factor for leprosy, while one of which concluded that it is not a risk factor for leprosy.

DISCUSSION
Risk Factors for Leprosy Based on Individual Characteristics and Behaviors Personal Hygiene

Promoting cleanliness and healthy habits in individuals has been shown to protect against harmful microorganisms, thereby reducing the risk of disease. Maintaining good personal hygiene, such as taking care of the skin, hair, and nails, is crucial in preventing leprosy transmission, as direct contact with these areas can lead to infection. Therefore, maintaining cleanliness in these areas is vital for protection. (Nisa et al., 2018 ; Prakoeswa et al., 2020). Two recent studies conducted in 2020 support the notion that personal hygiene is indeed a risk factor for leprosy, with the most influential factors in leprosy transmission being bathing less than twice a day, borrowing towels and toiletries between families, and handwashing without soap and running water (Akbar, 2020; Marsanti and Ardiani, 2020). Consistent with research in Papua that examined the habits of the respondents in terms of bathing

and borrowing towels that showed a significant risk between personal hygiene and the incidence of leprosy, individuals who did not practice good personal hygiene, they were 1.537 times more likely to develop leprosy than those who did (Siagian, Pangaribuan and Ulimpa, 2022). Three other studies in 2021 found that poor personal hygiene was associated with a three to six times higher risk of developing leprosy (Fitriya et al., 2021 ; Luthfia et al., 2021; Zaelani et al., 2021). Behavioral changes related to personal hygiene will certainly benefit the individual and even prevent those around them from breaking the chain of disease transmission (Masrizal, Ananda and Ilham, 2020).

Two studies conducted in 2019 and 2021 did not find a significant relationship between personal hygiene and the incidence of leprosy, nor was it a risk factor for the incidence of leprosy. This may be because there are other factors that are more likely to cause leprosy transmission, such as nutritional status and BCG vaccination history (Prakoeswa et al., 2021). In addition, according to the results of the univariate analysis, most of the respondents have good personal hygiene, so the possibility of leprosy transmission rarely occurs (Amsikan, Riwu and Tira, 2019).

BCG Vaccination History

BCG vaccination status is crucial in the prevention and control of leprosy due to its protective effects. Research in India and Brazil has shown that BCG vaccination history protects individuals from leprosy and even provides enhanced protection for those in contact with patients (Hacker et al., 2021; Karotia, Kishore and Kumar, 2022s). Although the BCG vaccine is better known as the tuberculosis vaccine, BCG can also protect a person from the risk of leprosy. The antigens in the BCG vaccine can reduce the risk of leprosy caused by *Mycobacterium leprae* (Harlim, Yulia and Suci, 2019). Two studies conducted in Indonesia concluded that there is an significant correlation between the BCG

immunization status and the incidence of leprosy (Nurzila and Adriyani, 2019; Fahrunnisa et al., 2020). The coverage of BCG vaccination programs in a specific area can serve as an indicator for identifying factors contributing to leprosy transmission among children (Arifin et al., 2022). BCG vaccination strongly correlates with the risk of childhood leprosy, with unvaccinated children having a 22.164 times higher likelihood of contracting the disease (Prakoeswa et al., 2021).

Research conducted on leprosy in endemic areas of Indonesia and Brazil found that BCG vaccination is not a dominant risk factor for leprosy (Oktavian et al., 2018; Rodrigues et al., 2019). This may be because the BCG vaccine works best as an effective protection against leprosy if given when there are no leprosy bacteria in the body. If such bacteria are already present, the BCG vaccine may trigger leprosy activation (Oktavian et al., 2018). Studies in hyperendemic areas of Brazil in 2021 came to the same conclusion that BCG vaccination history is not a risk factor, with researchers citing the lack of samples in the study, which were likely too small to show the effect of BCG vaccination (da Silva et al., 2021).

Contact History

Contact history significantly affects the incidence of leprosy, as leprosy transmission can occur through direct and close skin contacts with an infected individual, as well as through air exchange via the upper respiratory tract. There are three studies in Indonesia that indicate that most leprosy patients have a history of close contact with leprosy patients, including family, neighbors, and friends at work for more than two years (Nurzila and Adriyani, 2019; Akbar, 2020; Tuturop et al., 2022).

This is supported by the results of observations in the Bandarharjo Health Center area in 2018, which concluded that leprosy was more common in the household sphere where a family member was

Tabel 1. Characteristic of Reviewed Studies

Author	Location	Design	Population	Conclusion
Nisa and Nerawati (2018)	Indonesia	Case-control	52 people (26 cases and 26 controls)	Personal hygiene is a protective factor for leprosy
Prakoeswa et al. (2020)	Indonesia	Case-control	74 females (37 cases and 37 controls)	Personal hygiene is a risk factor for leprosy in female
Akbar (2020)	Indonesia	Case-control	60 people (30 cases and 30 controls)	Contact history, household density, and personal hygiene are risk factors for leprosy
Marsanti and Ardiani (2020)	Indonesia	Case-control	60 people (30 cases and 30 controls)	Personal hygiene is a risk factor for leprosy
Siagian, Pangaribuan and Ulimpa (2022)	Indonesia	Case-control	66 people (22 cases and 44 controls)	Personal hygiene is a risk factor for leprosy
Fitriya, Rahayu and Sunarko (2021)	Indonesia	Case-control	68 people (34 cases and 34 controls)	Type of floor, type of wall, house density, ventilation, lighting, humidity, and personal are risk factors for leprosy
Luthfia et al. (2021)	Indonesia	Case-control	86 females (43 cases and 43 controls)	Personal hygiene is a risk factor for leprosy
Zaelani, Sunita and Utami (2021)	Indonesia	Case-control	116 people (29 cases and 87 controls)	Personal hygiene, contact history, ventilation, lighting, humidity, and temperature are risk factors for leprosy
Masrizal, Ananda and Ilham (2020)	Indonesia	Case-control	64 people (32 cases and 32 controls)	Contact history and household density are not risk factors for leprosy, while personal hygiene is a risk factor for leprosy
Prakoeswa et al. (2021)	Indonesia	Case-control	60 children (30 cases and 30 controls)	Personal hygiene is not a risk factor for leprosy in children, while BCG vaccination history and household density are risk factors for leprosy in children
Amsikan, Riwu and Tira (2019)	Indonesia	Case-control	69 people (23 cases and 46 controls)	Personal hygiene, humidity, and household density are not risk factors for leprosy, contact history is a risk

Author	Location	Design	Population	Conclusion
				factor for leprosy, and room temperature is a protective factor for leprosy
Karotia, Kishore and Kumar (2022)	India	Case-control	896 people (448 cases and 448 control)	BCG vaccination history is a protective factor for leprosy
Hacker et al. (2021)	Brazil	Cohort	9,024 contacts, 192 of them developed leprosy	Revaccination of BCG immunization is a protective factor for leprosy
Harlim, Yulia and Suci (2019)	Indonesia	Case-control	84 people (42 cases and 42 controls)	Contact history and BCG vaccination history are risk factors for leprosy
Nurzila and Adriyani (2019)	Indonesia	Case-control	38 people (19 cases and 19 controls)	Contact history and BCG vaccination history are risk factors for leprosy
Fahrunnisa et al. (2020)	Indonesia	Case-control	122 people (61 cases and 61 controls)	BCG vaccination history and humidity are risk factors for leprosy
Arifin et al. (2022)	Indonesia	Case-control	36 children from 3-14 years old (18 cases and 18 controls)	BCG vaccination history is a risk factor for leprosy in children, while type of floor, humidity, ventilation, and house density are not risk factors for leprosy in children
Oktavian et al. (2018)	Indonesia	Cross-sectional	All adult leprosy patients aged over 15 years, sampling period totaling 90 respondents	Contact history and BCG vaccination history are not risk factors for leprosy
Rodrigues et al. (2019)	Brazil	Case-control	204 children under 15 years of age (40 cases and 164 controls)	BCG vaccination history is not a risk factor for leprosy in children
da Silva et al. (2021)	Brazil	Case-control	158 children under 15 years old (30 cases and 128 controls)	BCG vaccination history is not a risk factor for leprosy in children
Tuturop, Adimuntja and Borlyin (2022)	Indonesia	Case-control	50 people (25 cases and 25 controls)	Contact history is a risk factor for leprosy

Table 2. Summary of Research Results on Risk Factors for Leprosy From 2018 to 2022

Risk factor	8	7	5	9	6	6	4	4	3	3
Not a risk factor	2	2	3	3	4	3	3	2	1	1
Protective factor	1	-	2	-	-	-	-	-	1	-
Total	11	9	10	12	10	9	7	6	5	4

Explanation:
PH: Personal Hygiene, CH: Contact History, BCG: BCG Vaccination, HD: Household Density, H: Humidity, V: Ventilation, L: Lighting, F: Floor, T: Temperature, W: Wallpositively

diagnosed with leprosy (Siswanti and Wijayanti, 2018). Three studies that investigate the relationship between the duration of contact with the incidence of leprosy found that respondents who had a history of close contact with leprosy patients for more than two years had a a higher risk of developing leprosy compared to those who had a history of contact with leprosy patients for less than two years. This proves that the history and duration of contact are risk factors for leprosy (Amsikan, Riwu and Tira, 2019; Harlim et al., 2019; Zaelani et al., 2021).

Two studies conducted in 2018 and 2020 revealed that contact history had no significant correlation with the incidence of leprosy and was not a risk factor for leprosy. This may be because there are other factors that are more likely to cause leprosy transmission, such as leprosy patients not taking their medication as prescribed or not taking their medication at all, which is a source of transmission for others (Oktavian et al., 2018; Masrizal et al., 2020).

Risk Factors for Leprosy Based on Physical Environment
Household Density

Leprosy transmission can be facilitated by increased physical contact and airborne exposure between individuals due to overcrowded living conditions that do not meet the standards of a healthy housing. This leads to a lack of oxygen consumption, facilitating leprosy transmission to individuals living in the same place. This

situation supports the optimal development of leprosy bacteria, thereby increasing leprosy transmission rapidly (Siswanti and Wijayanti, 2018; Akbar, 2020). Consistent with the research in Gresik Regency in 2021, it was found household density was the most significant factor associated with the incidence of leprosy in children. Respondents living in overcrowded conditions had a 14.810 times higher risk of developing leprosy than those whose household density met the requirements (Prakoeswa et al., 2021). Another study conducted on the adult population in 2020 and 2022 found that more than two adults occupying a bedrooms that does not meet the requirements are nine or ten times more likely to contract leprosy than those occupying less crowded bedrooms (Lathifah and Adriyani, 2020; Fadlila et al., 2022). Other studies showed similar results, with a house with a density that does not meet the standards for a healthy housing has a three to six times higher risk of leprosy compared to a house with a density that meets the requirements (Prasmadi et al., 2018; Fitriya et al., 2021; Fitriani et al., 2022). The condition of dense occupancy at the research site in Indonesia was found to be multiple houses occupied by more than one family. This increases leprosy transmission by facilitating disease contact between individuals.

Four studies found that household density was not significant and not considered a risk factor for leprosy. This is because there are factors that have a greater

impact on the incidence of leprosy, such as window conditions, lighting, ventilation, and adequate flooring (Masrizal, Ananda and Ilham, 2020). In addition, based on the observations, most of the bedrooms of the respondents were not crowded and met the requirements. Therefore, physical and air contact between individuals resulted in minimal leprosy transmission (Amsikan et al., 2019 ; Rhomdani and Sulistyorini, 2020; Arifin et al., 2022).

Humidity

Mycobacterium leprae, a bacterium that causes leprosy, can survive outside the host for seven to nine days at 77.6% humidity. The presence of elevated humidity levels in a room can be observed by a higher prevalence of various bacterial diseases, suggesting a correlation between increased humidity and the spread of such diseases (Lathifah and Adriyani, 2020; Fahrunnisa et al., 2020). If a housing does not meet the requirements for adequate moisture indicators, it may be a risk factor for various infectious diseases. This is consistent with research in Indragirhilir and Sumenep Regencies, which found that housing that did not meet the requirements for humidity was 6.5 times more likely to cause leprosy than housing that had adequate humidity, and was the most dominant risk factor for leprosy (Prasmadi et al., 2018; Fitriya et al., 2021). This is consistent with two other studies that concluded that a housing with a humidity level of more than 60% has a higher risk of causing leprosy compared to that with a humidity level of between 40% and 60% (Zaelani et al., 2021; Fadlila et al., 2022).

Four studies have indicated that humidity is not considered a risk factor for leprosy. This may be because at the time of observation, the measurement results showed that the air humidity in most of the bedrooms of the respondents, which was below 60%, was not likely to affect the presence of *Mycobacterium leprae*. In other words, the proportion of respondents who had a qualified humidity level was greater than those who did not. Therefore, humidity does not play a significant role in the incidence of leprosy (Siswanti and Wijayanti, 2018; Rhomdani and Sulistyorini, 2020; Amsikan et al., 2019; Arifin et al., 2022).

Ventilation

Ventilation is an indicator of healthy occupancy because it serves as a way to get air out of the house and keep it fresh, so that the airflow continues to increase and the room is free from bacteria and microorganisms that cause disease. Adequate ventilation can prevent the proliferation of leprosy bacteria since *Mycobacterium leprae* thrives in damp environments, but dies when exposed to sunlight (Siswanti and Wijayanti, 2018). Consistent with the three studies that discussed the risk factors for leprosy, the results of the statistical tests concluded that houses with ventilation conditions that do not meet the requirements have a three to 3.6 times higher risk of causing leprosy compared to houses with proper ventilation in accordance with the requirements (Prasmadi et al., 2018; Lathifah and Adriyani, 2020; Fitriya et al., 2021). A bedroom with no or inadequate ventilation interferes with the exchange of air from inside to outside, causing an increase in indoor air humidity which affects the survival of microorganisms. Ventilation should be opened during the day because it determines the air quality in a room. This is done so that the room is not humid and is protected from the potential for the proliferation of microorganisms (Rhomdani and Sulistyorini, 2020; Fitriani et al., 2022).

Three studies conducted in Indonesia have shown no significant correlation between home ventilation and the prevalence of leprosy, indicating that it is not a contributing risk factor for the disease. This is due to the fact that the majority of participants in both the case and control groups had adequate ventilation systems. However, this result could also be influenced by the presence of windows in

the households and the behavior of opening windows to facilitate air circulation. The findings suggest that while home ventilation may not directly affect the likelihood of contracting leprosy, factors such as window availability and ventilation practices could play a role in preventing the spread of the disease (Zaelani et al., 2021; Arifin et al., 2022; Fadlila et al., 2022).

House Lighting

Lighting is the intensity of lighting in a house and is measured using a device called a lux meter. The function of light is very important because it has been proven to eliminate pathogenic bacteria in the house, such as tuberculosis and leprosy bacteria. Therefore, for houses to have healthy conditions, there must be sufficient access to natural light. Research in Indragirihilir Regency in 2018 concluded that inadequate lighting is 5.1 times more likely to increase the incidence of leprosy compared to adequate lighting. Lighting that does not meet the requirements, when exacerbated by living conditions in which leprosy patients reside, can lead to rapid development of leprosy bacteria (Prasmadi, Mulyadi and Zahtamal, 2018). Consistent with two studies conducted in Pasuruan and Sumenep Regencies in 2020 and 2021, it was found that house lighting was a factor that caused leprosy, with houses that did not have lighting that met the requirements posing a greater risk than houses that had adequate lighting (Lathifah and Adriyani, 2020; Fitriya et al., 2021). If a room is used for activities or sleeping and does not have natural light, it is difficult to eliminate bacteria on the floor or bed. In addition, this affects the humidity in the house and indirectly affects the survival of *Mycobacterium leprae* (Rhomdani and Sulistyorini, 2020).

Two studies conducted in the Bandarharjo Health Center area in 2018, the Sukatani Health Center area in 2021, and at Sumberglagah Hospital in 2022 concluded that lighting is not a risk factor for leprosy. This is because the proportion of respondents, both cases and controls, who had lighting levels that met the requirements was greater than the proportion of respondents who had lighting levels that did not meet the requirements. Therefore, lighting does not significantly affect the incidence of leprosy (Siswanti and Wijayanti, 2018; Zaelani et al., 2021; Fadlila et al., 2022).

Type of Floor

Inadequate environmental conditions can cause a variety of diseases that affect the health of the residents. The type of floor used in a house is factor in maintaining a healthy living environment. If the floor is not waterproof, it can absorb water, increasing the humidity of the room and acting as a medium for *Mycobacterium leprae* to spread to humans (Siswanti and Wijayanti, 2018). A study in three districts of East Java Province in 2020, 2021, and 2022 found a significant correlation between the type of floor and leprosy. Respondents with floors that did not meet the necessary standards were found to have a higher risk of developing leprosy compared to those with appropriate flooring (Lathifah and Adriyani, 2020; Fitriya et al., 2021; Fadlila et al., 2022).

Two studies conducted in 2019 in Indonesia concluded that the type of floor is not a risk factor for leprosy. This is because based on univariate analysis, most of the types of floors that respondents had met the standards for a healthy house. Therefore, the type of floor does not significantly affect the presence of *Mycobacterium leprae*.

House Temperature

There is a correlation between temperature and the incidence of leprosy, which can be influenced by various conditions, such as the season, the condition of the ceiling of the house, and ventilation. Inadequate temperatures in residential areas can facilitate the growth of bacteria that cause leprosy. Therefore, respondents residing in room with suboptimal

temperatures was found to be more susceptible to exposure to leprosy bacteria (Amsikan et al., 2019; Zaelani et al., 2021). This is consistent with two studies that found a correlation between house temperature and the incidence of leprosy. The temperature of the surrounding environment is considered a potential risk factor for leprosy, as it can affect the presence of *Mycobacterium leprae* (Lathifah and Adriyani, 2020; Fadlila et al., 2022).

A study conducted in Indonesia in 2019 concluded that temperature is not considered a risk factor for leprosy. This is because the results of measurements of the bedroom air temperature of most of the respondents were appropriate, which did not affect the survival of *Mycobacterium leprae* (Rhomdani and Sulistyorini, 2020).

Type of Wall

The type of wall has a significant impact on the overall health of both the house and its occupants. It is crucial for walls to be waterproof, easy to clean, and meet health standards. This can be achieved by constructing walls with materials such as concrete or bricks, and ensuring they are not damaged (Lathifah and Adriyani, 2020). The type of wall indirectly affects the temperature and humidity of the house, which can promote the proliferation and growth of bacteria or germs. The type of wall that does not meet the requirements can cause the house to be unhealthy. Two studies conducted in Semarang and Sumenep concluded that the risk of developing leprosy is higher in houses with types of walls that does not meet the health requirements compared to those meeting the requirements (Fitriya et al., 2021; Siswanti and Wijayanti, 2018).

Research conducted by Rhomdani and Sulistyorini (2020) in Indonesia concluded that the type of wall is not a risk factor for leprosy. This is because observations showed that most types of bedroom walls of the respondents have met the requirements, namely being made of

permanent structures that are waterproof and easy to clean. Therefore, the type of wall does not affect the survival of bacteria that cause leprosy.

Policy Implications

This research can serve as a basis for efforts to eliminate leprosy by breaking the chain of transmission through increasing access and availability of health services for individuals who have had a history of contact with leprosy patients, strengthening health education programs that focus on promoting personal hygiene and leprosy prevention measures in vulnerable communities, and encouraging more extensive and effective BCG vaccination campaigns, especially for individuals who have had a history of contact with leprosy patients.

In addition, this can serve as a basis for urging the government to implement housing policies and strengthen regulations related to housing standards by paying attention to residential density, humidity, ventilation, lighting, floor type, wall type, and temperature as important factors that can affect the incidence of leprosy. Furthermore, home improvement and housing programs that focus on improving ventilation, lighting, and humidity control can reduce the risk of developing leprosy. It is also important to integrate housing health aspects into existing housing development programs, taking into account leprosy risk factors in house planning and design.

Limitations

Limitations of this systematic review include variations in the methodologies of the included studies, such as differing definitions of variables, data collection methods, and inclusion/exclusion criteria, which may have impacted the consistency of the results. Furthermore, this study is limited to articles written in Indonesian and English, which may have excluded relevant research from other regions and languages.

CONCLUSION

The risk factors associated with leprosy are household density, personal hygiene, history of contacts, presence of ventilation, humidity level, BCG vaccination history, type of floor, lighting, temperature, and type of wall. Based on individual characteristics and behavior, most of the studies on leprosy show that personal hygiene is the primary risk factor, while BCG vaccination history is the protective factor against the disease. Meanwhile, based on the physical environment of the occupants, household density has been identified as the highest risk factor associated with leprosy. It is hoped that this study can serve as a resource for the government and stakeholders to assess the indicators of healthy house related to adequate housing requirements, as well as for the community in promoting clean and healthy living behaviors.

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