



Leprosy Epidemiology According to Leprosy Type in 13 Teaching Hospitals in Indonesia between 2018 and 2020

Ramona Dumasari Lubis^{1*}, Mila Darmi¹, Cita Rosita Sigit Prakoeswa^{2,3}, Regitta Indira Agusni^{2,3}, Bagus Haryo Kusumaputra^{2,3}, Medhi Denisa Alinda^{2,3}, Muhammad Yulianto Listiawan^{2,3}, Qaira Anum⁴, Fifa Argentina⁵, Sri Linuwih Menaldi⁶, Hendra Gunawan⁷, Renni Yuniati⁸, Nur Rachmat Muliando⁹, Agnes Sri Siswati¹⁰, Dhelya Widasmara¹¹, Luh Made Mas Rusyati¹², Enrico Hendra Mamuja¹³, Vitayani Muchtar¹⁴

¹Department of Dermatology and Venereology, Faculty of Medicine, Universitas Sumatera Utara, Adam Malik General Academic Hospital, Medan, Indonesia; ²Department of Dermatology and Venereology, Faculty of Medicine, Universitas Airlangga, Dr. Soetomo General Academic Hospital, Surabaya, Indonesia; ³Leprosy Study Group, Institute of Tropical Disease, Universitas Airlangga, Surabaya, Indonesia; ⁴Department of Dermatology and Venereology, Faculty of Medicine, Universitas Andalas, M. Djamil General Academic Hospital, Padang, Indonesia; ⁵Department of Dermatology and Venereology, Faculty of Medicine, Universitas Sriwijaya, Dr. Mohammad Hoesin General Academic Hospital, Palembang, Indonesia; ⁶Department of Dermatology and Venereology, Faculty of Medicine, Universitas Indonesia, Dr. Cipto Mangunkusumo General Academic Hospital, Jakarta, Indonesia; ⁷Department of Dermatology and Venereology, Faculty of Medicine, Universitas Padjadjaran, Dr. Hasan Sadikin General Academic Hospital, Bandung, Indonesia; ⁸Department of Dermatology and Venereology, Faculty of Medicine, Universitas Diponegoro, Dr. Kariadi General Academic Hospital, Semarang, Indonesia; ⁹Department of Dermatology and Venereology, Faculty of Medicine, Universitas Sebelas Maret, Dr. Moewardi General Academic Hospital, Solo, Indonesia; ¹⁰Department of Dermatology and Venereology, Faculty of Medicine, Universitas Gadjah Mada, Dr. Sardjito General Academic Hospital, Yogyakarta, Indonesia; ¹¹Department of Dermatology and Venereology, Faculty of Medicine, Universitas Brawijaya, Dr. Saiful Anwar General Academic Hospital, Malang, Indonesia; ¹²Department of Dermatology and Venereology, Faculty of Medicine, Universitas Udayana, Sanglah General Academic Hospital, Denpasar, Indonesia; ¹³Department of Dermatology and Venereology, Faculty of Medicine, Universitas Sam Ratulangi, Dr. RD Kandou General Academic Hospital, Manado, Indonesia; ¹⁴Department of Dermatology and Venereology, Faculty of Medicine, Universitas Hasanuddin, Dr. Wahidin Sudirohusodo General Academic Hospital, Makassar, Indonesia

Abstract

Edited by: Slavica Hristomanova-Mitkovska
Citation: Lubis RD, Darmi M, Prakoeswa CRS, Agusni RI, Kusumaputra BH, Alinda MD, Listiawan MY, Anum Q, Argentina F, Menaldi SL, Gunawan H, Yuniati R, Muliando NR, Siswati AS, Widasmara D, Rusyati LMM, Mamuja EH, Muchtar V. Leprosy Epidemiology According to Leprosy Type in 13 Teaching Hospitals in Indonesia between 2018 and 2020. *Open Access Maced J Med Sci.* 2022 Nov 26; 10(E):1812-1817. <https://doi.org/10.3889/oamjms.2022.10816>

Keywords: Epidemiology; Leprosy; Multidrug Therapy; WHO leprosy type

***Correspondence:** Ramona Dumasari Lubis, Faculty of Medicine University of Sumatera Utara. E-mail: ramonadlubis02@gmail.com

Received: 19-Aug-2022

Revised: 07-Nov-2022

Accepted: 16-Nov-2022

Copyright: © 2022 Ramona Dumasari Lubis, Mila Darmi, Cita Rosita Sigit Prakoeswa, Regitta Indira Agusni, Bagus Haryo Kusumaputra, Medhi Denisa Alinda, Muhammad Yulianto Listiawan, Qaira Anum, Fifa Argentina, Sri Linuwih Menaldi, Hendra Gunawan, Renni Yuniati, Nur Rachmat Muliando, Agnes Sri Siswati, Dhelya Widasmara, Luh Made Mas Rusyati, Enrico Hendra Mamuja, Vitayani Muchtar

Funding: This research did not receive any financial support

Competing Interests: The authors have declared that no competing interests exist

Open Access: This is an open-access article distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (CC BY-NC 4.0)

BACKGROUND: Leprosy or Hansen's disease is an infectious disease caused by *Mycobacterium leprae* (*M. leprae*) bacilli which results in chronic infections in humans that affect the peripheral nerves, skin, and other organs such as the eyes, mucous membranes, bones, and testicles. Leprosy has a variety of clinical presentations, depending on the cell-mediated immunity of the host. Leprosy is classified by the World Health Organization (WHO) as paucibacillary type (PB) and multibacillary type (MB) depending on the number of lesions. This multicenter study aims to provide representation of leprosy types and its epidemiology in Indonesia.

AIM: The purpose of this study is to find out the epidemiology according to the leprosy type in 13 teaching hospitals in Indonesia between 2018 and 2020.

METHODS: This is a descriptive study with cross-sectional design. All patients with the diagnosis of PB or MB type of leprosy who underwent Multidrug Therapy (MDT) treatment between 2018 and 2020 were included in this study. Data collection was carried out by tracing medical records data in 13 teaching hospitals in Indonesia.

RESULTS: A total of 2129 leprosy patients were included in this study. There were 232 cases (10.8%) of PB leprosy and 1897 cases (89.1%) of MB leprosy. The average age of the patients is 38.7 years (SD ± 16.2 years). Males are more affected by leprosy (n = 1,441; 67.7%) compared to female (n = 688; 32.3%).

CONCLUSION: Leprosy remains as a national health problem. The increasing cases of MB leprosy in Indonesia are caused by several factors including the lack of knowledge about leprosy, the delay in diagnosis of leprosy, and the stigma of leprosy within the community; therefore, it becomes a challenge to eliminate leprosy in Indonesia.

Introduction

Leprosy, also known as Hansen's disease, is an infectious disease caused by *Mycobacterium leprae*

bacilli which results in chronic infections in humans that affect the peripheral nerves, skin and other organs such as the eyes, mucous membranes, bones, and testicles. Leprosy has a variety of clinical presentations, depending on the cell-mediated immunity of the host.

Leprosy has been classified by the World Health Organization (WHO) as paucibacillary type (PB) and multibacillary type (MB) depending on the number of lesions. Ridley-Jopling's classification divides leprosy into five groups: Tuberculoid leprosy (TT), borderline tuberculoid (BT), mid-borderline (BB), borderline lepromatous (BL), and lepromatous lepromatous (LL) [1], [2], [3]

Transmission of leprosy can occur through inhalation of droplets containing pathogenic *M. leprae* bacteria and through prolonged skin contact with the patient. Infection from *M. leprae* causes anesthetic skin lesions, enlargement of peripheral nerves accompanied by impaired nerve function and the discovery of acid-resistant bacilli on skin smear are the characteristic clinical findings in leprosy. Delayed diagnosis can cause nerve damage, leading to loss of motoric function or paralysis, even permanent defects. Hence, early diagnosis is very important, especially in individuals below the age of 15 years old [2], [3], [4], [5], [6]

Leprosy is a disease that persistently causes health problems in several countries including Indonesia. A significant reduction in new cases of leprosy after the regiment of multidrug therapy (MDT) was used as a treatment in the 1980s. Data from the WHO demonstrated that in 2020, there were 129,192 registered cases of leprosy in the world, with a general detection coefficient of 2.74/1,00,000 population. India, Brazil, and Indonesia are among the countries that are responsible for 79.6% of new leprosy cases worldwide, making them the three countries with the highest leprosy rates worldwide. The WHO Global Strategy for Leprosy 2016–2020 aimed to accelerate a leprosy-free world to reduce the global burden of leprosy. The target of the global strategy is that there is no level 2 disability in children with a leprosy diagnosis, lowering new cases with level 2 disabilities to below 1/1,000,000 population and no discrimination against leprosy in any country [2], [3], [4], [7], [8], [9], [10], [11], [12], [13], [14].

According to the data from WHO, Brazil, India, and Indonesia contributed up to 72.5% of registered cases and 74% of new cases detected in 2020. Twenty-seven countries reported a high proportion (> 90%) of MB leprosy. Most adult patients (age ≥ 15 years) suffer from MB leprosy, while most children (age < 15 years) suffer from PB-type leprosy (53.2% of all pediatric cases) [14].

Due to the high prevalence of leprosy in Indonesia and the increasing proportion of PB leprosy and MB leprosy each year, it is necessary to know the number of leprosy cases found in teaching hospitals in Indonesia. Research in teaching hospitals in Indonesia aims to find out the proportion of the number of leprosy cases and types of leprosy according to the WHO classification which can then be used as fundamentals data for further leprosy research.

Materials and Methods

This study protocol has been reviewed and approved by the Health Research Ethics Committee of Dr. Soetomo Surabaya Hospital (No. 0261/KEPK/IX/2021). This is a descriptive study with cross-sectional design with data gathered from data 13 teaching hospitals in Indonesia from 2018 to 2020. The data collection was carried out by tracing medical record at 13 teaching hospitals in Indonesia with the inclusion criteria: Patients diagnosed with PB leprosy and MB leprosy aged ≥ 14 years old in 13 teaching hospitals in Indonesia in 2018–2020 and patients diagnosed with PB leprosy and MB leprosy received multidrug therapy (MDT) within 2018–2020 using total sampling, including all patients whom were diagnosed with leprosy who underwent *Multidrug Therapy* (MDT) treatment in 2018–2020, as many as 2129 leprosy patients.

Results

A total of 2129 leprosy patients who were treated in 13 teaching hospitals in Indonesia from 2018 to 2020 were involved in this study, it was observed that there were 232 cases (10.8%) of PB leprosy and 1897 cases (89.1%) of MB leprosy. The average age of the patients is 38.7 years (SD ± 16.2 years). It is known that males are more commonly affected by leprosy (n = 1,441; 67.7%) compared to female (n = 688; 32.3%).

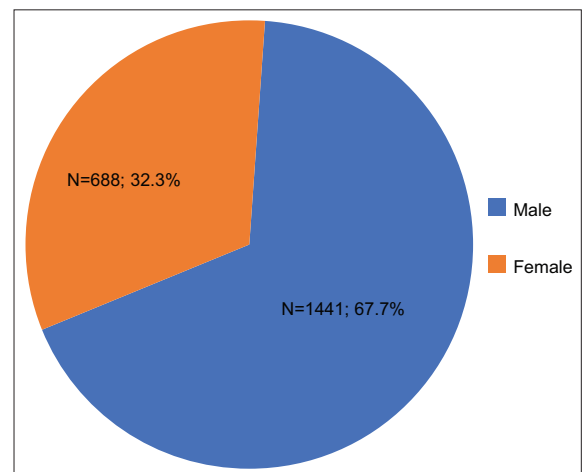


Figure 1: Distribution of Leprosy Patients according to Sex in 13 Teaching Hospitals in Indonesia in 2018–2020

The number of male patients with PB leprosy in this study is 128 people (55.2%) and the number of female patients with from PB leprosy is 104 people (44.8%). MB leprosy in male was found in 1313 patients (69.2%) and female suffering from MB leprosy was 584 patients (30.8%). The average age of male patients suffering from PB leprosy is 39.8 years (SD ± 12.2 years) and the average age of female patients suffering from

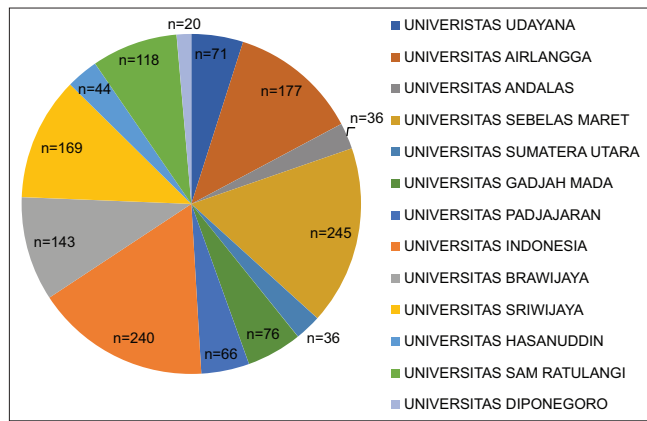


Figure 2: Distribution of Male leprosy patients in 13 teaching Hospitals in Indonesia in 2018–2020

PB-type leprosy is 39.5 years (SD ± 14.5 years). The average age of male patients suffering from MB-type leprosy is 39.1 years (SD ± 15.7 years) and the average age of female patients suffering from MB type leprosy is 41.1 years (SD ± 17.2 years) The demographic data can be seen in Table 1.

The distribution of sex (Figures 1-3) and type of leprosy (Figures 4-6) can be accessed in the supplementary information.

Discussion

The average age of the patients in the study was 38.7 years old with SD ± 16.2 years, with the most age range in the 22- to 55-year-old group with the youngest age in the study being 15 years old and the oldest age being 93 years. This finding is similar to the results of a study conducted by Arif *et al.* in North India, with the average age of leprosy patients is 35 years, with the youngest is 8 years old, and the oldest is 80 years old. More than 80% of the study's patients were in the age range between 11 and 50 years old, with the highest rates occurring at the age of 31–40. [1]

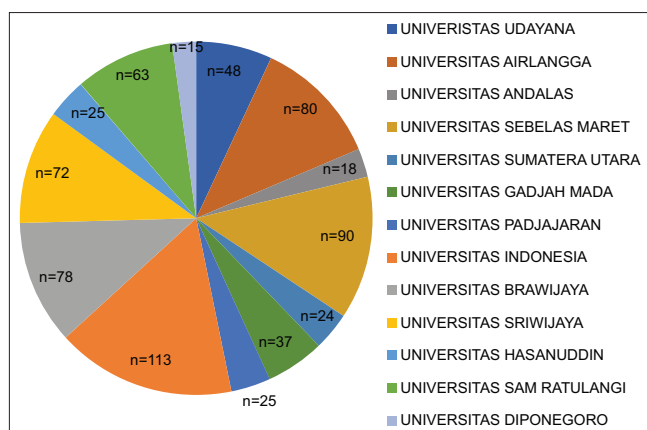


Figure 3: Distribution of Female Leprosy Patients in 13 Teaching Hospitals in Indonesia in 2018–2020

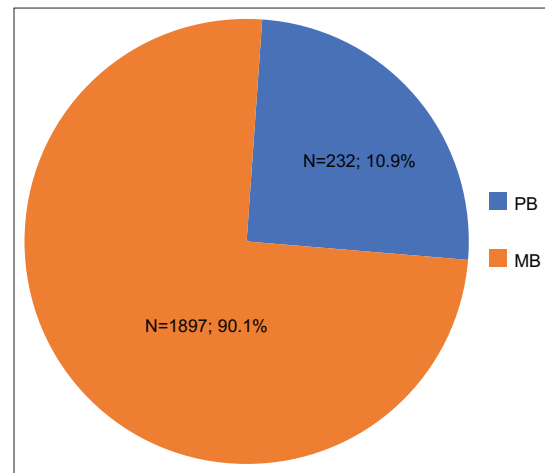


Figure 4: Distribution of Leprosy Patients according to Leprosy Type in 13 Teaching Hospitals in Indonesia in 2018–2020

Similar results were also found in studies conducted by Thakkar *et al.* and Adil *et al.* The majority of patients are middle age with the age range of 21–40 years [15], [16].

These results are different from the findings obtained in Brazil. According to the study, people aged > 50 years are more vulnerable to leprosy. In that study, the risk of developing leprosy increases with age, which is related to the elderly population in Brazil, as well as hormonal factors, and the possibility of functional disorders, which can affect social life and access to health facilities [10]. Other studies have also stated that immunological deregulation is associated with age. Changes in the immune system in the elderly population may contribute to increased susceptibility to infections and degenerative diseases, including leprosy [17].

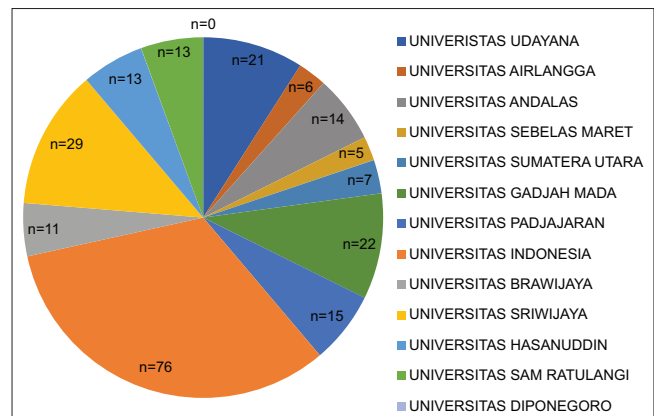


Figure 5: Distribution of Paucibacillary (PB) Leprosy in 13 Teaching Hospitals in Indonesia in 2018–2020

Leprosy is more common in male than female, whereas the ratio of men and women with leprosy is 2.08:1 [15]. Studies in India and Brazil also show similar results with the ratio of male suffering from leprosy as much as 1.5–3 x compared to female [1], [8], [16], [18]. The high prevalence in male is associated with higher mobility and contact with the wider population as well as easier access to health-care facilities [1], [15]. A study in Brazil also states that male has a more severe clinical prognosis [10].

Table 1: Demographic data of leprosy patients in 13 teaching hospitals in Indonesia in 2018–2020

Characteristic	Mean ± SD
Age (year old)	38.7 ± 16.2
Sex, n (%)	
Male	1441 (67.7)
Female	688 (32.3)
Leprosy type, n (%)	
PB	232 (10.8)
MB	1897 (89.1)
Mean age of PB leprosy (year old)	39.3 ± 14.1
Mean age of MB leprosy (year old)	38.9 ± 15.9
Mean age of PB leprosy according to sex (year old)	
Male	39.8 ± 12.2
Female	39.5 ± 14.5
Mean age of MB leprosy according to sex (year old)	
Male	39.1 ± 15.7
Female	41.1 ± 17.2
Frequency of PB leprosy according to sex, n (%)	
Male	128 (55.2)
Female	104 (44.8)
Frequency of MB Leprosy according to sex, n (%)	
Male	1313 (69.2)
Female	584 (30.8)

PB: Paucibacillary, MB: Multibacillary, SD: Standard deviation.

Male is more susceptible to MB leprosy than female with the ratio of 2.3:1 (as many as 1313 cases in male vs. 584 cases of female leprosy) where in PB leprosy, the frequency of male and female has a ratio of 1.2:1 (128 cases of leprosy in men and 104 cases of leprosy in women). Studies in Brazil also showed that men are more often exposed to MB leprosy than PB leprosy, [3], [17], whereas the sex ratio in MB leprosy is higher up to 2× in male than female, and for the sex ratio in PB leprosy is slightly below 1 [18]. There is a possible link between hormones in men and the occurrence of MB leprosy, due to male hormones stimulate a less effective immune response to control the disease, especially during puberty [16]. Studies comparing physiological hypotheses (sex hormones and genetic architecture) and behavioral hypotheses (differences in exposure to gender-related stress) to determine the causes of gender bias in the epidemiology of infectious diseases show that adolescent and reproductive age female tend to experience tuberculoid leprosy, while male tend to experience more severe form of lepromatous leprosy especially after puberty and during reproductive up to 2–3x compared to female which increases with age, as it is known that the immunity of the host plays an important role in the clinical progress of the disease. Through

analysis of physiological hypotheses, various forms of leprosy are predicted to have patterns that are sex-biased; whereas milder form of tuberculoid leprosy is associated with Th1 response efficiency, and lepromatous leprosy is associated with a less protective Th2-type response. The study also explained that exposure to *M. leprae* was less likely to have a bias against a particular sex, and analysis of behavioral hypothesis and disease progression showed behavior-independent results [19].

Another factor that may be associated with the high number of leprosy in male is that intensive and active tracing of leprosy cases are usually done in places frequented by men, such as military headquarters and prisons [17]. Another thing is that male tend to pay less attention to their health, in addition to the high stigma, it can also be caused by practical problems such as the time of service of health facilities that coincide with working time, making it impractical for the working population to seek treatment. As a result, late diagnosis of leprosy is more commonly found in males, taking into account the social aspects of the disease based on gender perspective [10].

The most common type of leprosy is MB (1. 897 cases; 89.1%) compared to PB leprosy (232 cases; 10.9%), with the average age for PB leprosy is 39.3 years old (SD ± 14.1 years), and for MB leprosy is 38.9 years old (SD ± 15.9 years) with the most common age range in all types of leprosy are within the productive age. This is in accordance with the previous research in India which stated that the prevalence of cases of MB leprosy is higher (73.2%) than PB leprosy in India [1]. The predominance of the MB leprosy is observed in workers individuals, which may indicate the presence of working environment conditions that increase exposure to leprosy bacillus; however, the importance of social contact and transmission of the disease cannot be ruled out [17].

The average age of PB and MB leprosy groups in both the male sex group [PB = 39.8 years old (SD ± 12.2 years); MB = 39.1 years old (SD ± 15.7 years)]; as well as PB leprosy in female [39.5 years old (SD ± 14.5 years)] showed a similar age range, but the older age range was found in the group of female suffering from MB leprosy [41.1 years old (SD ± 17.2 years)]. This result is different from the study conducted by Gaschignard *et al.*, in which the average age range of MB leprosy is higher than those seen in PB leprosy, as the common explanation is the length of incubation period of MB leprosy is longer compared to PB leprosy. However, the comparison does not represent the average age ranges of patients suffering from PB and MB leprosy in adult patients (> 14 years old) [18]. An independent study in Brazil conducted by Silveira *et al.* demonstrates the proportion of MB leprosy continuously increase with age, from <10% before the age of 10 to >50% for patients over 60 years old [19]. The influence of age on the prevalence of MB leprosy patients is said to be higher in male than female, and a multivariate analysis shows that the effects of both factors (age and gender) on leprosy polarization are independent. In

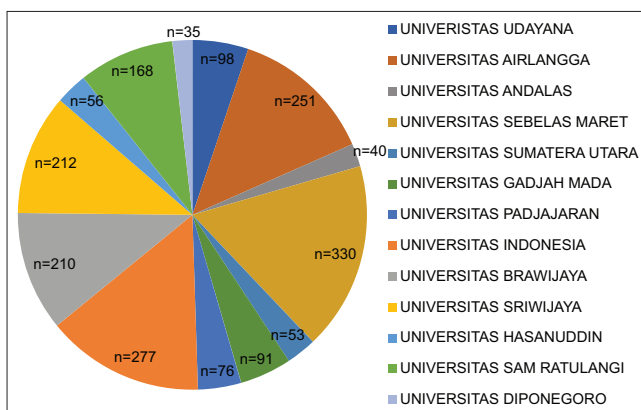


Figure 6: Distribution of Multibacillary (MB) Leprosy in 13 Teaching Hospitals in Indonesia in 2018–2020

a sample study in Vietnam, it was observed that age correlated with a higher proportion in MB-type leprosy patients, and it was said that this correlation was more strongly observed in men than women [18].

The high incidence of MB leprosy is a finding that is often found in studies from tertiary hospitals and it also indicates the inability of health-care facilities to diagnose early cases of leprosy, or due to lack of access to health services, as well as low awareness of the population to leprosy. In addition, patients also often hide their lesions due to the stigma associated with leprosy [1], [8], [15]. A Brazilian study suggests that lower education level is one of the factors that is associated with the occurrence of MB leprosy. In contrast, the higher level of education contributes to more adequate knowledge of the early signs and symptoms of the disease, which leads to better understanding of individual health. Therefore, people with higher level of education tend to avoid delay in seeking treatment [19].

Study conducted by Ruswan *et al.*, in Kolaka Regency, Indonesia from 2017 to 2021 showed that majority of people with leprosy in Kolaka over the study period had multibacillary leprosy and has been fluctuating and increasing each year over the past 5 years [20]. This is in accordance to the findings on our study that most of the participants in this study are diagnosed with multibacillary leprosy and this may be due to late diagnosis in remote area.

Our study was done with the intention of reporting the epidemiology of leprosy type in Indonesia between 2018 and 2020. The contribution of this study is to provide the data required for future studies regarding leprosy, as this is one of the largest study done in 13 most prominent teaching hospitals in Indonesia; therefore, it should be representative.

Conclusion

Leprosy remains as a national health problem. The increasing cases of MB leprosy in Indonesia are caused by several factors including: The lack of knowledge about leprosy, the delay in diagnosis of leprosy, and the stigma of leprosy within the community; therefore, it becomes a challenge to eliminate leprosy in Indonesia.

Acknowledgment

The authors would like to express their gratitude to all partners and staffs in 13 teaching hospitals in Indonesia for their contribution in this multicenter study.

References

1. Arif T, Syed SA, Mohammad A, Konchok D, Dinesh R. Leprosy in the post-elimination era: A clinico-epidemiological study from a northern Indian tertiary care hospital. *Acta Dermatovenerol Alp Pannonica Adriat.* 2019;28(1):7-10. <https://doi.org/10.15570/actaapa.2019.2>
PMid:30901062
2. Li YY, Sunaula S, Heng L, Lian FS, Yi QK. Factors influencing leprosy incidence: A comprehensive analysis of observations in Wenshan of China, Nepal, and other global epidemic areas. *Front Public Health.* 2021;9:666307. <https://doi.org/10.3389/fpubh.2021.666307>
PMid:34136455
3. Sarode G, Sachin S, Rahul A, Patil S, Jafer M, Baeshen H, *et al.* Epidemiological aspects of leprosy. *Dis Mon.* 2020;66(7):100899. <https://doi.org/10.1016/j.disamonth.2019.100899>
PMid:31806242
4. De Moraes PC, Letícia ME, Alessandra K, Danielle MP, Maria LS. Epidemiological characteristics and trends of leprosy in children and adolescents under 15 years old in a low-endemic State in Southern Brazil. *Rev Inst Med Trop São Paulo.* 2021;63:e80. <http://doi.org/10.1590/S1678-9946202163080>
PMid:34878038
5. Avanzia C, Pushpendra S, Trumane RW, Suffys PN. Molecular epidemiology of leprosy: An update. *Infect Genet Evol.* 2020;86:10458. <https://doi.org/10.1016/j.meegid.2020.104581>
PMid:33022427
6. Santos MB, Dos Santos AD, Barreto AS, Souza AD, Goes MA, Alves JA, *et al.* Clinical and epidemiological indicators and spatial analysis of leprosy cases in patients under 15 years old in an endemic area of Northeast Brazil: An ecological and time series study. *BMJ Open.* 2019;9(7):e023420. <https://doi.org/10.1136/bmjopen-2018-023420>
PMid:31352408
7. Basso ME, Rosemary FA, Rodrigo LF. Trend of epidemiological indicators of leprosy in an endemic state of the Amazon region. *Rev Gaúcha Enferm.* 2021;42:e20190520. <https://doi.org/10.1590/1983-1447.2021.20190520>
PMid:33787762
8. Mushtaq S, Naina D, Devraj D, Nafis F. Trends and patterns of leprosy over a decade in a tertiary care hospital in Northern India: A retrospective analysis. *Indian J Dermatol Venereol Leprol* 2019;86:141-50. https://doi.org/10.4103/ijdv.IJDVL_377_18
PMid:31736465
9. Santos DA, Salete BD, Naira RS, Letícia SG, Ricardo AD. Trends of Leprosy in Children Under Fifteen Years in Rondonópolis-MT (2007 to 2016). Vol. 42. São Paulo: *Mundo da Saúde*; 2018. p. 1032-49. <https://doi.org/10.15343/0104-7809.2018420410321049>
10. De Souza EA, Anderson FF, Jorg H, Reagan NB, Carlos HA, Alberto NR. Epidemiology and spatiotemporal patterns of leprosy detection in the state of Bahia, Brazilian northeast region, 2001-2014. *Trop Med Infect Dis.* 2018;3(3):79. <https://doi.org/10.3390/tropicalmed3030079>
PMid:30274475
11. Hasanuddin A, Achmad H, Risnawati, Ekawati N, Wijaya A, Yuswatningsih E, *et al.* Analysis of epidemiological characteristics associated with non-adherence to treatment leprosy paucibacillary patients in Jeneponto District, South Sulawesi, Indonesia. *Int J Pharm Res* 2020;12(2):1-5. <https://doi.org/10.31838>
12. Wulandari A, Maisya R. Relationship between knowledge and

- family support for self-care for leprosy sufferers at RSUP Dr. Tangerang City Sitanala. *J Ilmiah Kesehatan Masyarakat*. 2021;13(3):113-21. <https://doi.org/10.52022/jikm.v13i3.236>
13. Chokkakulaa S, Tiejun S, Haiqin J, Yang J, Li X, He J, *et al*. Genotyping of *Mycobacterium leprae* for understanding the distribution and transmission of leprosy in endemic provinces of China. *Int J Infect Dis* 2020;96:172-9. <https://doi.org/10.1016/j.ijid.2020.06.032>
PMid:32553715
 14. World Health Organization. Global Leprosy (Hansen Disease) Update, 2020: Impact of COVID-19 on Global Leprosy Control. Geneva: World Health Organization; 2021. Available from: <https://www.who.int/publications/i/item/who-wer9636-421-444> [Last accessed on 2022 Apr 10].
 15. Adil M, Amin SS, Mohtashim M, Mushtaq S, Alam M, Priya A. Clinico-epidemiological study of leprosy from a North Indian tertiary care hospital. *Int J Res Dermatol*. 2018;4(4):518-21. <https://doi.org/10.18203/issn.2455-4529>
 16. Thakkar S, Patel SV. Clinical profile of leprosy patients: A prospective study. *Indian J Dermatol* 2014;59(2):158-62. <https://doi.org/10.4103/0019-5154.127676>
PMid:24700934
 17. Serra MA, Santos C, Neto PM, Oliveira KG, Oliveira FJ, Gordon AS, *et al*. Factors associated with multibacillary leprosy in a priority region for disease control in Northeastern Brazil: A retrospective observational study. *J Trop Med* 2019;2019:5738924.
 18. Gaschignard J, Grant AV, Thuc NV, Orlova M, Cobat A, Huong NT, *et al*. Pauci- and multibacillary leprosy: Two distinct, genetically neglected diseases. *PLoS Negl Trop Dis* 2016;10(5):e0004345. <https://doi.org/10.1371/journal.pntd.0004345>
PMid:27219008
 19. Guerra-Silveira F, Abad-Franch F. Sex bias in infectious disease epidemiology: Patterns and processes. *PLoS One* 2013;8(4):e62390. <https://doi.org/10.1371/journal.pone.0062390>
PMid:23638062
 20. Ruswan RT, Effendy DS. Leprosy epidemiology in the Kolaka Regency, Indonesia, 2017-2021. *KnE Life Sci*. 2022;01:1-6. <https://doi.org/10.18502/kls.v0i0.11762>