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Research Article

Analysis of water, sanitation, and hygiene programs' impact on leprosy incidence in Indonesia: A secondary data analysis from the WHO Global Health Observatory

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ABSTRACT

Declining rates of neglected tropical diseases, particularly leprosy, highlight the need for comprehensive policies addressing the incidence of this disease in Indonesia. This study aims to investigate the impact of water, sanitation, and hygiene (WASH) programs on the incidence of leprosy in the country's urban and rural areas.Data were collected from the WHO Global Health Observatory using a cross-sectional study design. The independent variables examined included open defecation-free programs, availability of handwashing facilities, and access to basic drinking water and sanitation services. The dependent variable was the incidence of leprosy in urban and rural settings. Data analysis was performed using independent T-tests and Pearson correlation coefficients with SPSS version 23.The findings revealed a significant decline in leprosy incidence in rural and moderately urban areas over a 14-year survey period, reflecting trends similar to those of WASH programs. Overall, WASH programs were found to be correlated with the incidence of leprosy in both urban and rural areas ($p<0.001$), while the significance of open defecation programs decreased ($p=0.46$). The Pearson correlation analysis indicated that the availability of handwashing facilities was positively correlated with leprosy incidence ($r=0.58$, $p<0.001$). In contrast, basic drinking water ($r=-0.62$, $p<0.001$) and basic sanitation services ($r=-0.62$, $p<0.001$) showed a negative association with leprosy incidence. In summary, WASH programs are crucial for controlling the spread of leprosy in Indonesia's urban and rural regions.

Keyword: *Leprosy, WASH programs, urban and rural, Indonesia*

INTRODUCTION

Leprosy, also known as Hansen's disease, is an infectious disease caused by the bacterium Mycobacterium leprae, which Gerhard Armauer Hansen discovered in 1873 (Centers for Disease Control and Prevention, 2022; World Health Organization, 2020a). This acid-fast bacterium primarily affects peripheral nerves, skin, the upper respiratory mucosa, and the eyes (World Health Organization, 2020a). Several countries, including China, Nepal, Indonesia, India, and Brazil, have

experienced a decline in leprosy incidence since its peak in 1984 (Li et al., 2021). However , sociocultural factors, geographical distribution, environmental conditions, and economic circumstances may influence the incidence of leprosy (Li et al., 2021). Therefore, the trends identified in Li et al.'s study could lead to an outbreak if these risk factors are not adequately managed.

According to a WHO report from 2020, there were approximately 155,783 new cases of leprosy reported worldwide, with half of those cases occurring in India (World Health Organization, 2020a). This rise in new cases raises concerns about the potential increase in disability among individuals affected by leprosy, as warned by the WHO in 2020 (World Health Organization, 2020a). In Indonesia, which is endemic for leprosy, there were 6,000 new cases reported in 2020 (Ministry of Health, 2021). Although this figure represents a decline compared to previous years, leprosy remains a significant challenge in Indonesia, particularly in rural areas, where inadequate access to water, sanitation, and hygiene exacerbates the situation (Hidayangsih et al., 2021).

Water, sanitation, and hygiene (WASH) programs prevent neglected tropical diseases (NTDs), including leprosy. These programs focus on providing safe water, promoting good sanitation, and encouraging hygienic behavior to help control the spread of infectious diseases(World Health Organization, 2016). However, significant efforts are needed due to poor practices in rural communities, such as open defecation, hand washing without soap, and bathing in contaminated rivers. Several studies have shown that good WASH practices can reduce the incidence of NTDs (Grimes et al., 2014; Stocks et al., 2014; Strunz et al., 2014). For example, safe water significantly reduced schistosomiasis infections, and the infection rates from Schistosoma mansoni and Schistosoma haematobium declined with adequate sanitation (Grimes et al., 2014). Another study found that good sanitation practices among children were linked to lower odds of trachoma. This research claimed that improving sanitation accessibility could reduce active cases of trachoma by 15% and trachoma infections in the eyes by 33% (Stocks et al., 2014). Additionally, the incidence of soil-transmitted helminth (STH) infections decreased by 33% to 70% when communities had access to and practiced effective WASH measures, such as washing hands with soap after defecation, compared to communities that did not use soap(Strunz et al., 2014).

A WASH study investigating the incidence of leprosy in Ethiopia was conducted by (Emerson et al., 2020). This research explored the correlation between leprosy and schistosomiasis, highlighting that soil-transmitted helminths contribute to the risk of leprosy. These coinciding infections are associated with inadequate water sources, insufficient access to soap and handwashing facilities, and open defecation practices (Emerson et al., 2020). uilding on previous WASH studies, examining the relationship between leprosy and WASH in Indonesia is crucial for two primary reasons. Firstly, Indonesia is an endemic country for leprosy, with many new cases arising in remote areas. Secondly, access to WASH services is limited in Indonesia, particularly in rural regions where risk factors for neglected tropical diseases (NTDs), including leprosy, are prevalent. Consequently, this study aims to reveal the relationship between WASH programs in both rural and urban areas of Indonesia, focusing on aspects such as open defecation free (ODF) initiatives, the availability of handwashing facilities (HWF), basic drinking water services (BDW), and basic sanitation services (BSS) (World Health Organization, 2020b). This research will further explore the determinants of WASH programs on leprosy incidence and the government's efforts to control this disease within the community.

MATERIAL AND METHODS

Study design

A cross-sectional study design was used to assess the impact of the WASH program on the prevalence of leprosy in Indonesia. This study also compared the incidence of leprosy between urban and rural areas and explored the correlations among various factors.

Data collection

Data were obtained from the Global Health Observatory of the World Health Organization (WHO) at https://www.who.int/data/gho/data/indicators. The leprosy data in the database reflected the total prevalence rates for both urban and rural regions in Indonesia. Additionally, WASH data included implementation policies, such as the scope of open defecation-free initiatives, availability of handwashing facilities, access to basic drinking water services, and provision of basic sanitation services. Since the WASH data were presented as percentages, we converted these percentages into actual population figures for urban and rural areas using population data from the World Bank's database at https://data.worldbank.org/indicator/SP.POP.TOTL.

Statistical analysis

Descriptive analysis was conducted to capture the prevalence of leprosy through line graphs and box plots. The normality of the residuals was assessed using the Kolmogorov-Smirnov test. The data in this study were found to be normally distributed; therefore, Pearson correlation was employed to analyze the variables.

RESULTS AND DISCUSSION

We utilized leprosy data from 2006 to 2020 in Indonesia, as illustrated in Figure 1. Notably, the trend in leprosy prevalence has declined in Indonesia's urban and rural areas, dropping from 10,000 to 4,500 cases in rural regions and from 7,900 to 6,000 in urban areas. This reduction in leprosy prevalence in Indonesia represents a significant decrease compared to the initial survey conducted in 2006. Furthermore, in 2016, the number of leprosy cases in rural areas surpassed that of urban areas.

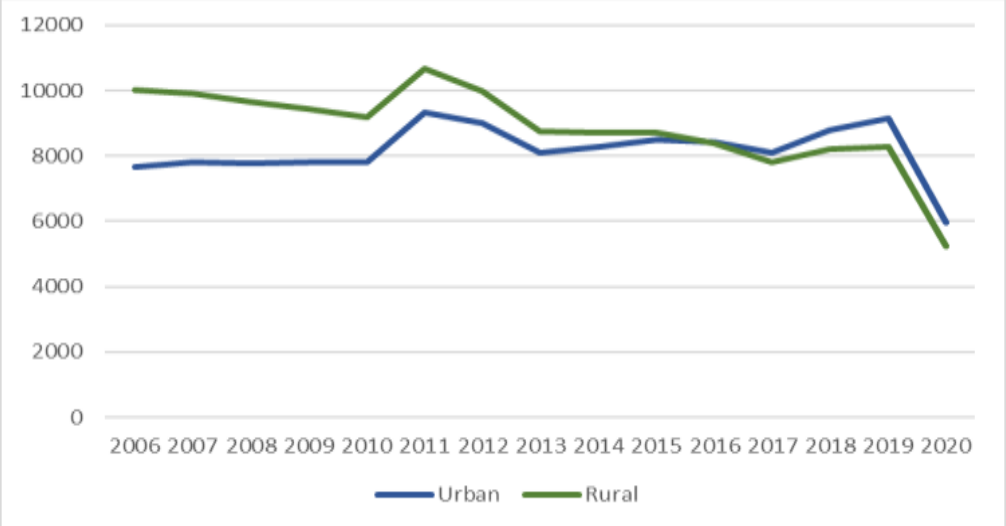

Figure 1. Leprosy Incidence in Urban and Rural in Indonesia from 2006 to 2020

The population percentages in Indonesia utilizing WASH programs are illustrated in Figure 2. It can be concluded that the rate of open defecation has significantly decreased from the start of the survey in 2006 to 2020, both in rural and urban areas. Other programs have also enhanced the availability of WASH services in rural regions compared to their urban counterparts.

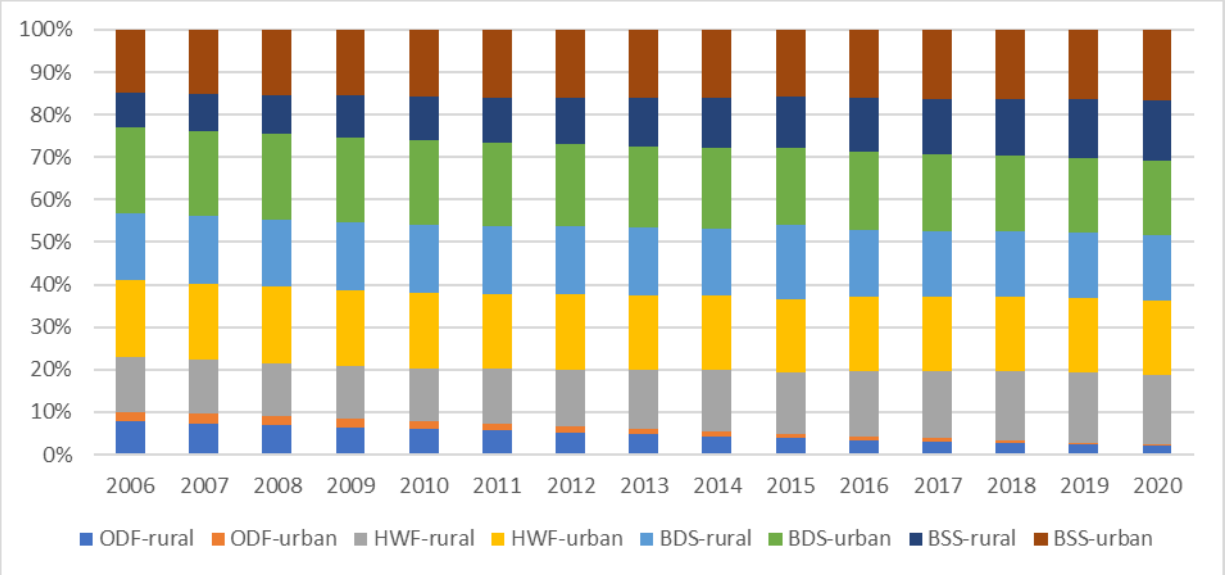

Figure 2. The percentages of using WASH programs in rural and urban Indonesia. ODF is open defecation free, HWF is hand washing facility, BDS is basic drinking service, BSS is basic sanitation services.

Figure illustrates the incidence of leprosy in both rural and urban areas. The incidence of leprosy is higher in rural areas than in urban areas (mean ± SD: 8868 ± 1293 vs. 8170 ± 815; P value = 0.08). This finding suggests that WASH (Water, Sanitation, and Hygiene) conditions in rural areas of Indonesia are challenging due to socioeconomic issues, health behaviors, and environmental factors.

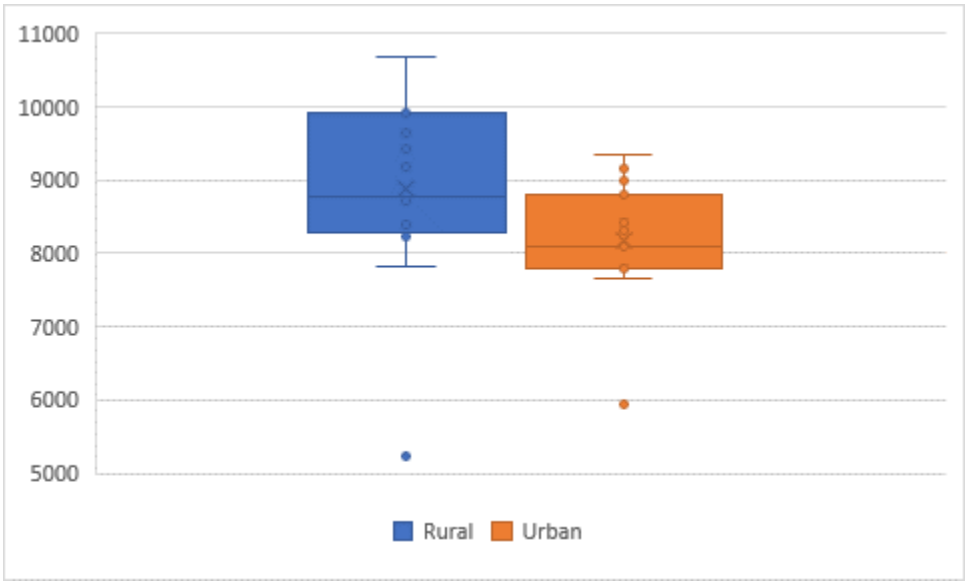

Figure 3. Box plot display prevalence leprosy in Indonesia

Table 1 demonstrates WASH and the incidence of leprosy in rural and urban areas in Indonesia. To obtain actual data, we use total population in both areas over percentages. According to analysis, it can be concluded that overall WASH parameters are correlated with the area ($p< 0.001$), urban and rural, unless open defecation free ($p=0.46$).

Table 1. Baseline characteristic WASH and Leprosy incidence in Rural and Urban Regions

Variables	Effect size	Leprosy	ODF	HWF	BDW	BSS
Leprosy	r	1	0.2	0.58	-0.62	-0.623
	P		0.2	0.001*	0.000*	0.000*
ODF	r	0.2	1	0.176	0.180	0.063
	P	0.2		0.351	0.342	0.739
HWF	r	0.58	0.176	1	-0.852	-0.943
	P	0.001*	0.351		0.000*	0.000*
BDW	r	-0.62	0.180	-0.852	1	0.972
	P	0.000*	0.342	0.000*		0.000*
BSS	r	-0.623	0.063	-0.943	0.972	1
	P	0.000*	0.739	0.000*	0.000*	

*Independent T Test is shown that P value < 0.001

We examined the specific correlation between WASH (Water, Sanitation, and Hygiene) programs and the incidence of leprosy. Our analysis revealed a significant association between leprosy and the availability of handwashing facilities, basic drinking water services, and basic sanitation services ($p < 0.00$; $r = 0.58, -0.62, -0.62$). However, the open defecation-free program was found to lack significance in this context.

Table 2. Correlation WASH on Leprosy Incidence

WASH Programs	Regions	Mean±SD	P Value
Open defecation free	Rural	28027833.9±9111634.5	0.46
	Urban	36890711.1±13645096.3	
Hand washing facilities	Rural	28027833.9±9111634.5	0.00*
	Urban	8862877.2±4546502.5	
Basic drinking water services	Rural	85640008.3±16191740	0.00*
	Urban	114784362.2±7184403.4	
Basic sanitation services	Rural	69737929.3±16823685.7	0.00*
	Urban	102854006.8±2272144.5	
Total populations	Rural	120696974.3±1010445.4	0.01*
	Urban	130938257.5±15292127.3	

*Pearson correlation shown that P values < 0.05; ODF is open defecation free, HWF is hand washing facilities, BDW is basic drinking water services, BSS is basic sanitation services.

The current study examines the trends of leprosy in urban and rural areas of Indonesia. The findings indicate a gradual decline in the prevalence of leprosy, with lower rates observed in rural areas compared to urban ones, according to a survey conducted in 2020. Notably, there has been a significant reduction in leprosy cases in Indonesia over the past two years. The leprosy elimination

campaign, initiated several years ago, is guided by Indonesia's Ministry of Health (MoH) and aims to eradicate leprosy nationwide by 2024. This initiative focuses on health promotion, surveillance, chemoprophylaxis, and rehabilitation (Ministry of Health Republic Indonesia, 2019). The campaign has proven effective, decreasing leprosy cases to 5,200 in 2020 compared to the previous year. Similar declines in leprosy cases have also been observed in India and Bangladesh (Fischer et al., 2008; Mohite et al., 2013). The reduction in rural cases can be traced back to implementing national eradication programs in 1990. These programs emphasized multidrug treatment, screening for hidden cases, accessible healthcare delivery, and strengthening primary care systems (Mohite et al., 2013). Likewise, recent surveys have shown a gradual decline in the trend of leprosy in Bangladesh. Although the decrease has been modest, it is noteworthy that the government employed GPS technology for case detection, effectively reaching patients and facilitating access to health clinics (Fischer et al., 2008).

Leprosy cases in rural areas of Indonesia are reported to be higher than those in urban settings. According to the Indonesian Statistics Bureau (*Badan Pusat Statistik*/BPS), 56.7% of the population lives in urban areas, while the remaining 43.3% reside in rural regions (Badan Pusat Statistik, 2017). Despite the larger urban population, the incidence of leprosy is predominantly observed in rural locations. The World Bank has reported limited access to water and sanitation facilities in these rural areas. Insufficient water supply and poor hygiene conditions significantly increase the risk of communicable diseases like typhoid, diarrhea, and leprosy (Wray, 2019). A systematic review has indicated that leprosy is associated with various socioeconomic factors (Pescarini et al., 2018). Research conducted in Ethiopia has also shown a significant correlation between inadequate water and sanitation conditions and the prevalence of leprosy(Emerson et al., 2020). However, data on leprosy in Indonesia is limited, making it difficult to fully understand the relationship between incidence, socioeconomic status, and sanitation conditions.

We identified several environmental factors that influence the transmission of leprosy within the population, including access to open defecation-free facilities, handwashing stations, basic drinking water services, and essential sanitation services. Our findings indicate that the open defecation-free initiative showed no significant association with leprosy transmission in rural or urban areas. However, it is noteworthy that the trend of open defecation has declined in both urban and rural areas of Indonesia since the survey conducted in 2006. A study by Emerson et al. demonstrated a correlation between leprosy incidence and open defecation practices in Ethiopia, revealing that the risk of contracting leprosy increased significantly—by a factor of 19.86—among individuals who practiced open defecation compared to those who did not(Emerson et al., 2020). This research supports our finding that the risk of leprosy diminishes with the implementation of open defecation-free programs. In Indonesia, the open defecation-free initiative is part of a national policy known as Community Approaches to Total Sanitation (CATS), or Sanitasi Total Berbasis Masyarakat (STBM) (Ministry of Health, 2014). This program has shown effectiveness within communities(Odagiri et al., 2017). However, our study did not evaluate several other factors, such as accessibility to soap, availability of water, and handwashing behaviors.

Our study found a positive correlation between the availability of handwashing facilities and the incidence of leprosy. However, this association lost its significance after we adjusted for confounding variables in the linear regression analysis. A study conducted in Ethiopia highlighted that inadequate handwashing facilities were linked to the incidence of communicable diseases (Odo & Mekonnen, 2021). Additionally, another investigation identified several factors contributing to the limitations of handwashing facilities in Sub-Saharan regions. This latter study concluded that

the location of handwashing facilities, the age of the household head, the number of children, income level, household size, sanitation facilities, community-level media exposure, and education were all influential factors(Endalew et al., 2022). In our survey conducted from 2006 to 2020, the availability of handwashing facilities surpassed 90% in both urban and rural areas of Indonesia. It is important to note that our study did not assess other variables related to handwashing facilities. As Endalew et al. pointed out, multiple factors must be examined to thoroughly evaluate handwashing facilities and their role in addressing communicable diseases, particularly leprosy.

Access to basic drinking water is a critical factor related to leprosy. Research has shown that access to basic drinking water negatively correlates with leprosy incidence in Indonesia. For example, a recent study indicated that individuals affected by leprosy had only 20% access to water in their homes, despite having access to water sources (Emerson et al., 2020). Additionally, untreated water can contribute to the spread of *M. leprae*. While water sources and treatment are important, the time it takes to obtain water also plays a role in the transmission of leprosy (Emerson et al., 2020). A separate study by Gaffan et al. highlighted that gaining access to basic drinking water at the household level is difficult due to socioeconomic factors and the implementation of related policies (Gaffan et al., 2022). They recommended a multifactorial approach to improve basic drinking water services (Gaffan et al., 2022). Our study found that 97% of urban and 85% of rural populations have achieved basic drinking water services. However, as Emerson et al. noted, some aspects of drinking water evaluation were not included in our study. Thus, a more comprehensive assessment of drinking water access is necessary.

Basic sanitation services in Indonesia's rural and urban areas are linked to leprosy incidence. It is important to emphasize that basic drinking water services do not demonstrate a correlation with leprosy incidence in the final linear regression model. Numerous studies have shown that basic sanitation—encompassing aspects such as the home physical environment, water disposal facilities, waste disposal practices, and regular handwashing—correlates with leprosy (Hayana et al., 2020; Prakoeswa et al., 2020). These studies also explored the effects of personal hygiene and nutritional status on leprosy incidence. Our findings indicate that from 2006 to 2020, the availability of basic sanitation services reached 91% in urban areas, compared to 79% in rural regions. However, the scope of sanitation services in Indonesia presents ongoing challenges that persist regardless of socioeconomic conditions. Moreover, poverty exacerbates the sanitation gap between urban and rural households in Indonesia (Unicef Indonesia, 2017).

This study recognizes several limitations. Potential confounding factors, such as nutritional status, environmental conditions, and hygiene practices, were not considered. The WHO Global Health Observatory does not provide data addressing these factors. Furthermore, the WASH (Water, Sanitation, and Hygiene) program lacks complementary variables; for example, the open defecation-free initiative does not include data on latrine availability or the practice of handwashing with soap following defecation. Similarly, handwashing facilities do not ensure access to clean water, and basic drinking water services do not consider the affordability and sources of water. Basic sanitation services also fail to account for the condition of the home environment. Our study advocates for implementing a comprehensive WASH approach that involves a larger sample of respondents from both rural and urban areas to gain a deeper understanding of the WASH program's impact on the prevalence of leprosy in Indonesia.

CONCLUSION AND SUGGESTION

The WASH programs provide crucial indicators to help control the spread of Neglected Tropical Diseases (NTDs), particularly leprosy, in Indonesia's urban and rural regions. Among these indicators, the health workforce (HWF), basic sanitation (BDS), and basic sanitation services (BSS) show a positive correlation with the incidence of leprosy cases. Although all aspects of the WASH program have improved since the survey commenced in 2006, the incidence of leprosy has also declined over the past 14 years. These findings indicate that adequate sanitation and hygiene management can significantly alleviate leprosy in low- and middle-income countries like Indonesia. It is recommended that the government prioritize ensuring water cleanliness, enhancing the availability of sanitation services, and promoting hygienic behaviors to improve community health services.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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