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Economic Loss of Leptospirosis: Is It Still Appropriate to be Tropical Neglected Zoonosis Disease?

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Abstract

Leptospirosis is a tropical endemic disease that can reduce the productivity of sufferers. However, research on economic and productivity losses due to leptospirosis is rare. This study aimed to determine economic and productivity losses due to leptospirosis in the Banyumas District, Indonesia, as an endemic area. This study used a cross-sectional design and quantitative methods conducted in October 2022. Secondary data of medical records and billing information from 73 inpatients receiving treatment at a Public Hospital in the Banyumas District from February 2021 to September 2022 obtained from the hospital's archives were used. This study examined the actual costs (direct and indirect costs) of treatment, average length of stay, and patient characteristics. Statistical tools were carried out to check the results. The results showed that over half of leptospirosis patients used insurance with an economic loss of USD 289.64 and a productivity loss value of USD 388,499. Patients infected with leptospirosis vary in age. Leptospirosis results in loss of patient productivity during treatment. Increasing prevention and control to prevent deaths and economic burdens on society and local governments is proposed to local governments.

Keywords: economic loss, leptospirosis, productivity loss, tropical zoonosis disease

Introduction

Leptospirosis is a significant zoonotic disease because it can reduce the patient's productivity.[1] *Leptospira interrogans* bacteria cause leptospirosis. *Spirochaeta* bacteria are obligately aerobic and exhibit flexuose movement, i.e., they move about in the cell membrane.[2] This disease is prevalent in the tropics, such as Southeast Asia and Latin America[3], as the bacteria which causes it thrives at tropical temperatures.[2] The brown rat (*Rattus norvegicus*)[4] and mouse house (*Ratus tanezumi*) are reported as the main reservoir. However, it is also found in reservoirs such as foresail[5] cows, buffaloes, horses, sheep, goats, pigs, dogs, and other rodents.[6] Leptospirosis significantly impacts the sufferer and cattle's lost income production. In humans, this disease is frequently associated with organ damage that leads to death and high maintenance costs. In contrast, in cattle, it includes reproductive disturbances such as embryonic resorption, fetus mummification, stillbirth, and neonatal death that result in a significant economic loss.[7]

A study quantifying the global disease burden showed that the global productivity cost of leptospirosis in 2019 was USD 29.3 billion.[8] A study in New Zealand found that the median number of Disability-Adjusted Life Years (DALYs) of patients with leptospirosis was 0.42 per 100,000 people in the population.[9] The costs incurred by the state due to Leptospirosis on community farms in New Zealand are estimated to be USD 12.63 million.[9] A study in China indicated that the number of DALYs decreased concurrently with the total incidence of leptospirosis, and the productivity of the young age group increased.[10] The study carried out at a hospital in Semarang City, Indonesia, reported the amount number of economic loss due to leptospirosis was USD 40,130 (IDR 651,317,284) in 2020.[11]

Leptospirosis is endemic in some provinces in Indonesia, such as Central and East Java.[12] In Indonesia, the incidence, incidence rate, and prevalence of disease have continued to rise over the past five years (2018-2022).[13] In

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2021, there are 734 new cases of leptospirosis were reported in Indonesia, 84 of which are fatal. Moreover, this case fatality rate (CFR) due to leptospirosis in 2021 increased by 2.4% compared to 2020 (9%) levels. The Central Java Province ranks the highest in the total leptospirosis number in the 2021 National Reports. Kebumen, Demak, and Banyumas are three districts with a high number of leptospirosis patients. In particular, Banyumas District, with 159 cases of leptospirosis, is one of the districts with the highest incidence of new cases and deaths in Central Java in 2021.[13] Undiagnosed and unreported cases of leptospirosis contribute to the CFR in patients.[14,15]

Leptospirosis diagnostic examination requires comprehensive, laboratory-based, and expensive examination tools, thereby increasing the risk of problems occurring. The large amount of health spending, reflecting economic losses of leptospirosis sufferers, forms the basis of evidence for the authorities to propose a policy. However, studies focusing on calculating economic losses due to leptospirosis are rarely carried out in Indonesia. Therefore, this study aimed to determine economic and productivity losses due to leptospirosis in the Banyumas District, Central Java Province, Indonesia.

Method

This study was a cross-sectional quantitative-methods study conducted in Banyumas District, Central Java Province, Indonesia. This study was conducted in October until December 2022. Due to the resource constraint, this study examined the economic loss from health facilities. The study included a total population of 73 leptospirosis patients treated in inpatient and outpatient care in two B-type public hospitals in Banyumas District and complied with the inclusion criteria. The inclusion criteria were patients completing the treatment in February 2021 until September 2022, being diagnosed with leptospirosis, and being alive until completing the treatment. Meanwhile, the exclusion criteria were patients who terminated the treatment or patients who died during the treatment. The data was obtained from the public hospital's archives. The hospital medical records and billing information of leptospirosis patients were collected retrospectively from February 2021 to September 2022 (20 months) for this study.

This study's variables included the actual costs of treating leptospirosis, the average length of stay, the prevalence rate (PR) of leptospirosis, the population of Banyumas District in 2021, and Banyumas District minimum wage in 2021. Leptospirosis inpatients were charged fees for registration, laboratory, doctor services; as well as action, medical supports, non-medical supports, consumables, nursing care, medicine, accommodation, food service, and support costs. In addition to the patient's characteristics, such as age, sex, distance from the hospital, length of stay, and payment method, research data also included patient demographics.

This study divided age into five categories: a) 20 years, b) 21–35 years, c) 36–50 years, d) 51–65 years, and e) > 65 years. The respective age groups performed the patients that had a productivity activity. Sex was categorized as male and female. The distance between the residence and the B-type public hospitals where the leptospirosis patient was treated was classified as either close (10 kilometers) or far (>10 kilometers). The treatment classification was three categories: a) first class, b) second class, and c) third class. There were two categories for length of stay: seven days and more than seven days.

The sampling method consisted of collecting all inpatient data from the hospital information and management system using the International Code of Disease (ICD) code for leptospirosis. Patients with leptospirosis were categorized according to their payment method: insurance and out-of-pocket. The actual cost data was processed, cleansed, and tabulated using Excel tools for descriptive analysis. Processes of editing, coding, processing, cleaning, and tabulation were used to generate characteristic data. A descriptive analysis of actual costs was conducted to calculate economic and productivity losses due to leptospirosis.

The formula of economic loss or cost of illness, adding all components of the actual cost of leptospirosis treatment, was performed to figure the number of economic losses. Productivity loss analysis used a multiplication formula between the average length of stay (ALOS), the leptospirosis PR, the total population in Banyumas District in 2021, and the total of Banyumas District minimum wage in 2021. A statistical tool for descriptive data analysis was used to determine the frequency and percentage of each category. The geospatial tool was performed to show the distribution of rats containing leptospirosis bacteria in the Banyumas District.

Results

This study was conducted in the lowland area of Banyumas District, with an average elevation of more than 108 meters above sea level. Banyumas District has a land area of 1,327.59 km^2 and 27 subdistricts. In terms of elevation (height

above sea level), the plains in Banyumas consist of 0 to 100 meters (54.86%) and 101 to 500 meters (45.14%). This district is a tropical region with distinct dry and wet seasons. The population of Banyumas District in 2021 was estimated to be 1,789,630, with 900,919 male and 888,711 female residents.[16] Most leptospirosis cases in Banyumas were reported in the hill area and increased significantly in the middle and the end of the year.

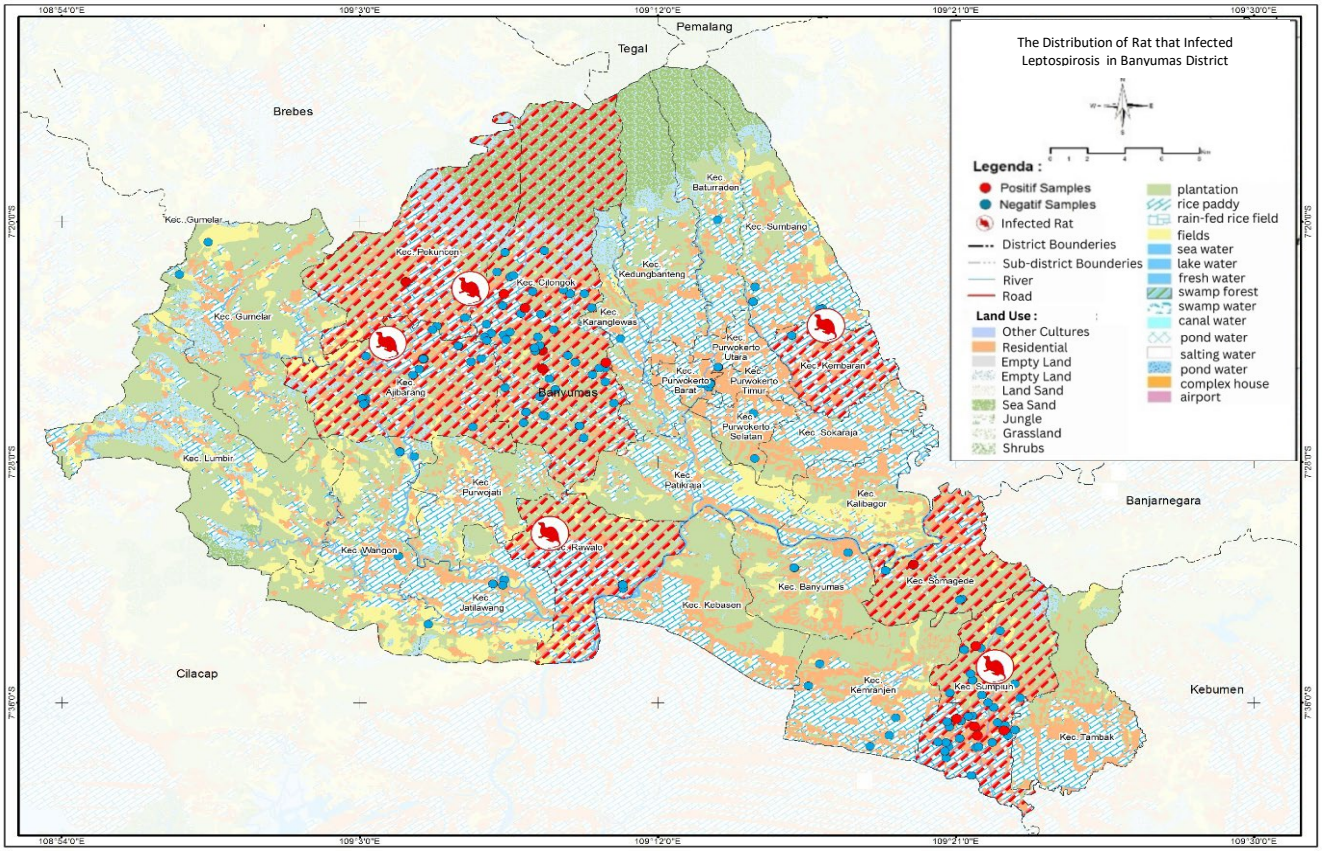

Figure 1. Distribution of Rat that Infected Leptospirosis in Banyumas District, 2018-2021

Figure 1 shows that rats with positive leptospirosis bacteria live in rice paddy, plantation, and residential areas. This study's population consisted of 73 leptospirosis patients in Banyumas District from February 2021 to September 2022, or in a period of 20 months. This study's samples comprised the entire case population, or all leptospirosis patients in the Banyumas District, totaling 73 inpatients. The distribution of leptospirosis patients based on patient characteristics is shown in Table 1.

This study involved leptospirosis patients receiving inpatient and outpatient care. Most samples consist of patients between aged 36-50 years (28.77%) and 51-65 years (27.00%), and male was dominant (57.53%). Most patients (57.53%) fell into the close category (10 km) between their home and the advanced health facility (General Hospital), and more than half of inpatients belong to first class (47.32%), second class (47.32%), and third class (43.84%). Patients receiving leptospirosis treatment mostly stayed less than seven days (79.45%). Most inpatients in this study (82.19%) paid with insurance. The cost of leptospirosis in Banyumas District was determined by calculating the amount of money spent on leptospirosis treatment. Table 2 outlines the results of the analysis.

The economic losses associated with leptospirosis were the sum of inpatient and outpatient costs. This amount produced an average of USD 289.64 (IDR 4,701,074) per period of illness. The average result exceeded the Banyumas District minimum wage of USD 121.37 (IDR 1,970,000). Leptospirosis, a zoonotic disease, is a financial burden for the Banyumas District. The components of leptospirosis hospitalization costs were analyzed using cases selected based on predetermined criteria, namely patient payments. The results of the analysis are depicted in Figure 2 below.

Table 1. Distribution of Leptospirosis Patient's Characteristics

Patient Characteristics	Frequencies (n)	Percentage (%)
Age (years)		
<20	2	2.74
21-35	19	26.03
36-50	21	28.77
51-65	20	27.04
>65	11	15.07
Total	73	100
Sex		
Male	42	57.53
Female	31	42.47
Total	73	100.00
Distance to Health Facilities		
(<=10 km)	42	57.53
(>10 km)	31	42.47
Total	73	100.00
Treatment Classification		
First Class	35	47.32
Second Class	5	6.85
Third Class	33	45.21
Total	73	100.00
Length of Stay		
≤7 Days	58	79.45
>7 Days	15	20.55
Total	73	100.00
Payment Method		
Out-of-Pocket/General Patient	13	17.81
Health Insurance	60	82.19
Total	73	100.00

Table 2: Economic Loss Due to Leptospirosis in Banyumas District

Payment Method	N	ALOS patient	Minimum (USD)	Maximum (USD)	Average (USD)
Out-of-Pocket	13	3	74.26	372.37	200.87
Health Insurance	60	6.01	82.11	1,361.83	308.88
Economic Loss of patient's leptospirosis	73	5.04	74.26	1,361.83	289.64

Notes: ALOS = average length of stay, USD = United States Dollar (USD 1 = IDR 16,230.20)

Figure 2 shows that leptospirosis patients with full coverage who receive inpatient treatment tend to have higher maximum costs than patients who pay standard rates. The average cost of hospitalization for leptospirosis for those with insurance was greater than for those without insurance. The cost of inpatient care for leptospirosis patients consisted of several components: registration, laboratory, consultation, doctor service, service, medical support, non-medical support, disposable stuff, accommodation, food service, medicines, and other fees. The highest components on average and considered out-of-pocket were medicine, accommodation, procedure, and laboratory costs. Meanwhile, the highest average component covered by insurance was medicines, laboratory, medical support, and accommodation costs.

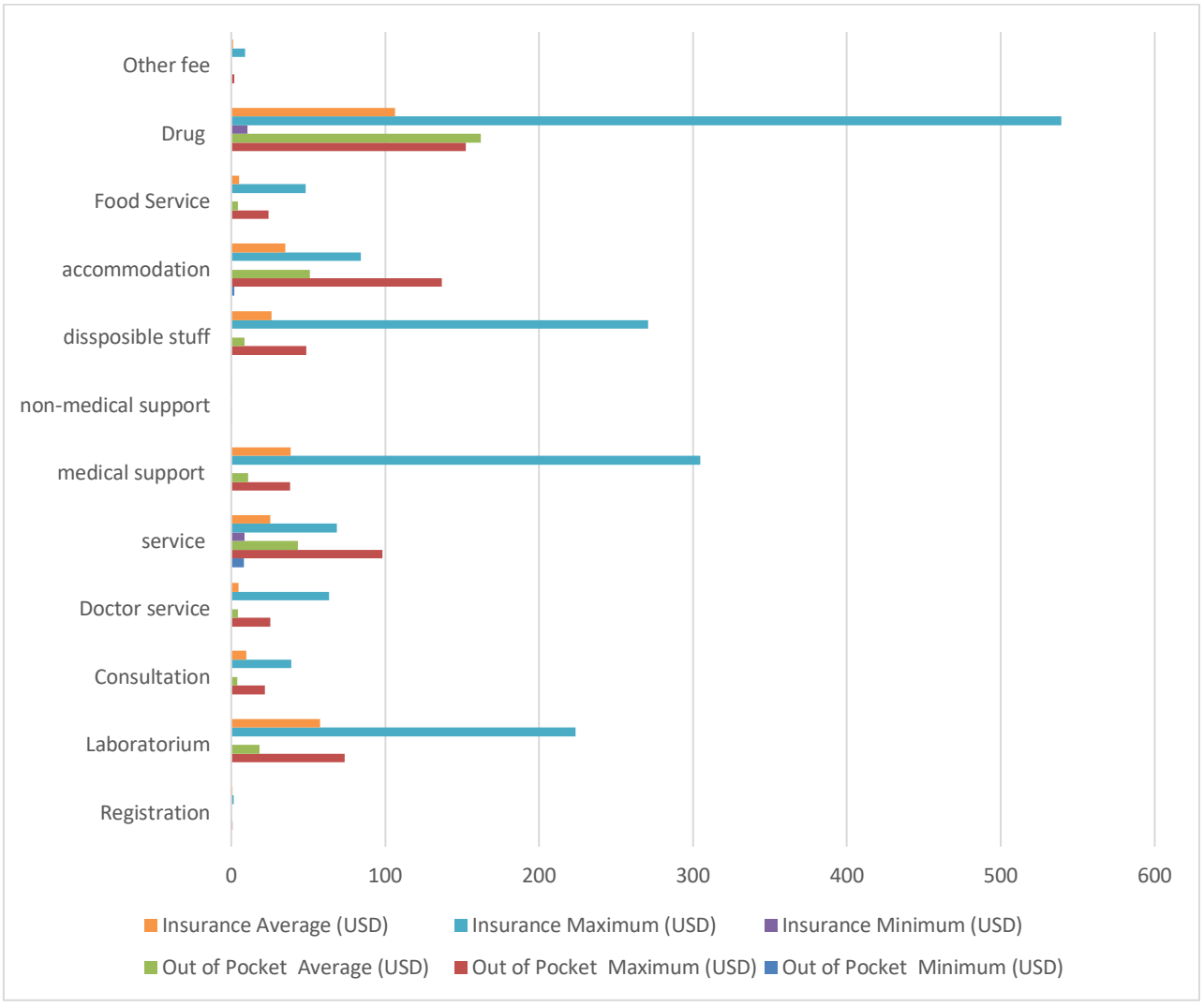

Figure 2. Cost Components for Leptospirosis Patient Care Based on Payment Method

Table 3. Cost of Productivity Losses Attributable to Leptospirosis in Banyumas District

Leptospirosis	Prevalence Rate	Population Number of Banyumas District (2021)	Average Length of Stay of Leptospirosis Patient	Minimum Wage of Banyumas District in 2021 (USD)	Total Productivity Loss (USD)
Icteric	2.76‰	1,789,630	5.4	121.37	388,499

Notes: USD = United States Dollar (USD 1 = IDR 16,230.20)

Table 3 shows the costs of productivity losses due to leptospirosis in Banyumas District since this study also examined its impact. The proportional loss of productivity due to leptospirosis in Banyumas District was USD 388,499 (IDR 6,305,413,401) in 2021. The formula for productivity loss was the multiplication of the prevalence rate for Banyumas District in 2021, the average length of stay for leptospirosis sufferers, and the minimum wage for Banyumas District in 2021. The productivity loss represented the proportion of costs related to lost productivity due to Leptospirosis and hospitalization in Banyumas District.

Discussion

Based on the findings, there were 128 cases of leptospirosis in Banyumas District in 2021. Compared with the national number of leptospirosis cases in 2021, of 555 cases, 77 people died; this number is relatively high.[16] In 2021, the incidence of leptospirosis in Banyumas District was 2.76 per 100,000 population, with a case fatality rate of 4.17%. In contrast to Surakarta City (CFR 100%), Kebumen District (CFR 39.13%), and Karangayar District (CFR 33.33%), the CFR was relatively low (the data was taken by one of the authors from the unpublished reports of Central Java Provincial

Health Office). This is because medical personnel in Banyumas District have been trained to detect cases of leptospirosis, but deaths still occur every year. This is a factor that must be considered when reviewing leptospirosis control programs in the field. Leptospirosis is a zoonotic disease with mild to severe symptoms (damage to the kidneys, lungs, heart, liver, and brain). Leptospirosis can potentially be fatal, and its eradication is impossible because *Leptospira* bacteria containing various pathogenic serovars can live freely in the environment. Moist soil and water, and almost all mammals are potential reservoir hosts.[17,18] The main reservoir host for leptospirosis is rats, a source of serovars that are highly lethal to humans.[7,19]

This study showed that rats infected with leptospirosis live in rice fields, plantations, and residential areas. The area is at risk of being flooded if rainfall is heavy.[20] Heavy rainfall may diffuse *Leptospira* from the soil, resulting in higher concentrations of bacteria in the media to which humans are exposed (sewer water) and so to a higher inoculum dose, thus increasing hospitalized disease incidence and perhaps decreasing the environmental exposure risk in and around households (mud and exposed soil) and decreasing infection risk.[21] The significant environmental factor that is associated with leptospirosis transmission is flooding.[22] Climate change or extreme weather events should also be modeled to predict the severity of future leptospirosis outbreaks. The leptospirosis outbreaks impacted the number of economic losses.

This study attempted to quantify Leptospirosis incidence and monetary burden in the Banyumas District by calculating the average cost of hospital treatment and lost productivity due to leptospirosis. The primary findings of this study indicated that leptospirosis imposes a substantial economic burden on patients and governments that provide health services. Based on hospital billing data and medical records, it was determined that the average cost of hospitalization for leptospirosis patients was USD 289.64 (IDR 4,701,074). When the cost of treatment was differentiated between general patients and those with insurance, the cost of treating leptospirosis in the hospital was significantly higher, amounted USD 62.45 (IDR 1,013,265). In detail, the average cost for insured patients was USD 308.88 (IDR 5,013,265), and for non-insured patients or out-of-pocket payment was USD 200.87 (IDR 3,260,190).

Given the high cost of care for insured patients compared to non-insured patients, it can be assumed that most insured patients in this study were leptospirosis patients with comorbidities. Leptospirosis patients who experience tissue damage, organ damage, and comorbidities are categorized as having a severe form of the disease.[23] Similarly, a study in Bulgaria found that patients with severe leptospirosis incurred the highest average service costs, at USD 952.09 per day, compared to moderate and low leptospirosis patients, who incurred an average fee of USD 216.06 and USD 186.60, respectively.[24] In New Zealand, patients with severe leptospirosis incur average out-of-pocket expenses of USD 8,330 per disease period covered by insurance. In cases of mild leptospirosis, patients spend an average of USD 35 per period of illness for which they file an insurance claim.[9]

Several complications, such as disease complications, length of stay, number and type of medicines and medical devices consumed, and the number of supporting examinations performed while hospitalized, influence the magnitude of the cost factor for hospitalization of leptospirosis patients.[25] This study revealed that most leptospirosis patients (79.45%) were hospitalized for less than seven days. The total cost of leptospirosis treatment was directly proportional to the duration of treatment. According to a study in Jamaica, the number of days spent in a hospital significantly impacts the costs incurred by patients. Accessing services and laboratory results show that mild leptospirosis patients spend approximately three to five days receiving the medicine, incurring costs of USD 122 and 49 cents per day. Treatment for patients with severe leptospirosis lasts longer than five days and costs USD 535.3127.[26]

The second economic impact of leptospirosis is the loss of patient productivity resulting from the condition. This study showed that the average patient hospitalized due to leptospirosis will lose productivity for five days. Patients could not work or carry out other productive activities. The average length of stay was determined by tracing the medical record data of 73 people in two hospitals in Banyumas District. In 2021, leptospirosis caused Banyumas District to lose productivity of USD 388,499 (IDR 6,305,413,401). This amount is quite large compared to the total health budget for Banyumas District in 2021, USD 6.93 million (IDR 112,507,053,384).[27] Considering the large decline in productivity due to leptospirosis in the Banyumas District, an immediate evaluation is needed to accelerate leptospirosis control and reclassify leptospirosis as a zoonotic disease that cannot be ignored.

Global productivity costs are estimated at USD 29.3 billion, particularly in Indonesia at USD 2.8 billion.[8] In this study, assuming that the regional minimum wage for leptospirosis patients in Banyumas District in 2021 was USD 121.37 (IDR 1,970,000) per month or USD 1,456.54 (IDR 23,640,000) annually,[28] then that patients would incur substantial economic losses. The trend per year is that the minimum wage for each region has increased; consequently, the total costs due to

lost productivity would also increase over time.[29] This number indicates that leptospirosis can increase the poverty rate in a region. According to a study in India, leptospirosis causes patients to fall into poverty because hospitalization costs a median of USD 67.54 at a public hospital and USD 260.36 at a private hospital.[30]

Leptospirosis is the world's most widespread zoonosis.[31,32] It is challenging to diagnose leptospirosis in both clinic and laboratory. Consequently, this disease is frequently unrecognized in many countries, including Indonesia, and consequently, it is severely neglected.[33,34] Leptospirosis has received particular attention in India because it causes death and has a significant economic impact on patients and the nation. There is a provision in the leptospirosis control program for using ambulance services and an annual unrestricted grant to refer suspected cases of leptospirosis to individuals in need. However, a previous study revealed that despite these efforts, patients still paid travel expenses during the referral process.[30]

The Indonesian Ministry of Health, particularly the Directorate General of Infectious Disease Control and Management, district/city health offices, and primary health care (PHC) in Indonesia are responsible for leptospirosis prevention, in which the Ministry of Health and the Provincial Health Office play a role as facilitator and coordinator, and the District/City Health Office and PHC as technical action determiners. The leptospirosis control and management program consists of epidemiological investigations around the patient's residence, leptospirosis clinical lectures for PHC and hospital doctors, leptospirosis prevention meetings for Animal Source Disease Control officers and PHC surveillance officers, providing rapid detection tests and training for officers, health education on leptospirosis to the community, leptospirosis screening, and coordination meetings at the district/provincial level. Even though the above leptospirosis prevention activities have been implemented, leptospirosis cases still continue to run rampant, causing public disturbances and deaths. Besides, leptospirosis control is still being implemented in several districts and cities in Indonesia where there are indications of endemic leptospirosis.[35]

Important policies for a leptospirosis control program include 1) passive and active surveillance, both at PHC and other public health services; 2) hospital or community-based methods for determining or finding cases of leptospirosis; 3) establishing a definition of a leptospirosis outbreak, including population, location, and duration; 4) establishing a diagnosis by determining suspect, probable and confirmed cases based on clinical manifestations and laboratory examination; 5) analyze the number of fatalities and fatality ratio; and 6) epidemic response includes a description of the type of outbreak investigation and identification of the causative agent.[36] Although the results of the leptospirosis cost of illness study revealed that the productivity loss rate due to leptospirosis was relatively high, the sample was limited to the healthcare facility perspective.

Further study is needed to overcome some of the limitations of this study, such as the fact that the average rate of productivity loss may only apply to leptospirosis patients who live modestly and have a certain level of education (low-middle economic level) and the majority of patients with leptospirosis nephritis disease. Another limitation of this study is that it only captures direct costs during hospital treatment. In contrast, indirect medical costs (travel costs, caregiver costs, and other costs related to treatment that are not captured in the billing information) are not shown in the billing information. However, this study provides billing information for leptospirosis patients. Thus, the costs are based on real patient data during treatment at health facilities (public hospitals).

Conclusion

Leptospirosis infects female and male patients in each age group without boundaries. In leptospirosis treatment, the cost of leptospirosis medicines is relatively high compared to other cost components, and patients eventually lose productivity. Leptospirosis is thought to cause poverty among the patients, especially workers, and burden the regional economy. Priority is given to the prevention and control of leptospirosis to prevent diagnosed complications, deaths, and economic burdens on society and local governments. Specifically, in the endemic areas where leptospirosis is frequently reported, appropriate strategies need to be created to reduce leptospirosis cases.

Abbreviations

DALYs: Disability-adjusted Life Years; CFR: case fatality rate; PR: prevalence rate; ALOS: Average Length of Stay; PHC: primary health care.

Ethics Approval and Consent to Participate

This study has obtained an ethical clearance approved by the Health Ethics Commission of the National Research and Innovation Agency, with Ethical Clearance Decree number 001/KE.03/SK/10/2022. The informants of this study were informed of the research objectives and purpose. All of the informants submitted verbal consent to participate in this study.

Competing Interest
All authors declare that this study has no competing financial or personal interests.

Availability of Data and Materials
The authors stated that the secondary data was available to anyone interested in this study.

Authors' Contribution
All of the authors had equal contributions to this study. WPN, SDL, and WGP conceptualized this study. WPN, R, SDL, and WGP created the methodology, analyzed the data, wrote, reviewed, and edited the original draft and manuscript. IP, SN, LMP, DRF, AEN, and MAM wrote, reviewed, and edited the original draft and manuscript.

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