

Risk Factors for Disability Upgrading Among Leprosy Patients During Treatment: Multilevel Modeling Analysis

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Abstract

Background: Leprosy not only brings about bodily incapacity but also creates a nasty image of affected individuals, triggering discrimination and social stigma. The purpose of this study was to evaluate the status of leprosy disability in patients registered at the All African TB and Leprosy Rehabilitation and Training Center.

Methods: The study consists of 205 leprosy patients who were undergoing treatment at the All African TB and Leprosy Rehabilitation and Training Center from January 2015 to December 2019. Regional states of the patients were used as a clustering effect in the multilevel logistic regression model.

Results: In total, 205 (66.3%) completed records revealed patients with leprosy were disabled. Among these, 64.88% of them were males. In multilevel binary logistic regression analysis, the individual-level variables, such as median age (AOR = 1.1; 95% CI: 1.043, 1.13) of patients, patients with duration of symptom [7–12 months (AOR = 2.26; 95% CI: 1.50, 3.39), 13–24 months (AOR = 2.13; 95% CI: 1.44, 3.15), and more than 24 months (AOR = 2.67; 95% CI: 1.8, 4.02)], the absence of sensory loss (AOR = 0.84; 95% CI: 0.72, 0.96), and patients with asymmetry lesion distribution (AOR = 0.74; 95% CI: 0.65, 0.85), were the most significant determinant factors of disability. The default leprosy patient (AOR = 15.53; 95% CI: 1.82, 134.96) and new leprosy patient (AOR = 0.51; 95% CI: 0.33, 1.68) were the significant determinant factors of disability due to leprosy patients.

Conclusion: An individual-level factor on the risk of disability was higher as age increased and for patients with a longer duration of symptoms. The risk of disability was lower for patients who do not lose their sensation and for patients whose lesion distribution is asymmetrical. The community-level factor, patient categories, was also a significant factor in disability due to leprosy. Furthermore, programs should emphasize raising community awareness, focusing on key messages and early case detection campaigns, such as active surveys, as well as the availability of leprosy care in a public health facility.

Keywords

risk factors, disability, leprosy, patients, multilevel logistics, ALERT

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Background

Leprosy is one of the oldest illnesses recognized by mankind; however, there are large gaps in our perception of it, especially in terms of how it spreads. Leprosy is a persistent infectious disease precipitated by the *Mycobacterium leprae* pathogen (Shumet et al., 2015). It typically affects the skin and peripheral nerves, but it can manifest in a variety of clinical ways. Depending on the bacillary load, the disease is classified as paucibacillary (PB) or multibacillary (MB). PB leprosy is a less extreme structure of leprosy characterized by a few

(up to five) hypopigmented, anesthetic skin lesions (pale or reddish). Multiple (more than five) skin lesions, nodules,

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plaques, thickened dermis, and skin infiltration are associated with MB leprosy, as the involvement of the nasal mucosa results in nasal congestion and epistaxis. Certain peripheral nerves can also be involved, resulting in attribute patterns of incapacity (Ranque et al., 2007; Schreuder et al., 2016).

Leprosy is the most common infectious cause of disability. Although the prevalence of leprosy has decreased extensively over the last 50 years, transmission continues, and leprosy remains a public health concern (Merle et al., 2010; Sarkar et al., 2012; Shumet et al., 2015). Leprosy is transmitted through nasal droplets, but its exact mode of transmission is unknown. It is unknown how many contaminated humans improve scientific ailment and whether reactivation of previous infections is significant. Although making a clinical diagnosis is usually simple, there is no true point of care to take a look at to confirm it. Delays in diagnosis can have serious consequences, such as an increased chance of nerve damage. Delay is caused by a variety of factors; however, stigma is a considerable characteristic in many cultures (Penna, 2011; Shetty & Doshi, 2008; WHO, 2020).

The assessment of disability is an important indicator of the control of leprosy. If diagnosed early, leprosy-related disability is avoidable; however, many cases are identified late, resulting in well-sized bodily impairment. The damage does not stop with a physical disability (PD); it also creates a bad image, leading to discrimination and social stigma toward affected men and women and their households (The Salsa Collaborative Study Group & The Salsa Collaborative Study Group, 2007). PD can appear before the analysis of leprosy, throughout treatment, and after therapy is executed (Withington et al., 2003). About 15% of the sector's workforce is disabled in some way. The Worldwide Leprosy Method 2016–2020 emphasizes early case detection to prevent the development of disabilities (WHO, 2020). In 2019 and 2020, all major stakeholders participated in a broad consultation process to develop the Global Leprosy Strategy 2021–2030. Managers of the national leprosy programs, technical organizations, public health and leprosy specialists, financing organizations, and residents of the communities who were directly impacted contributed greatly. It is intended to contribute to the Sustainable Development Goals through this plan. Implementing the Sustainable Development Goals and the WHO Roadmap for Neglected Tropical Diseases 2021–2030 will enable all countries with endemic leprosy to make rapid and sustained progress toward leprosy control and elimination. Leprosy, infection, illness, and disability can all be eliminated in the future, along with stigma and prejudice related to leprosy (WHO, 2021).

The prevalence of leprosy-related disabilities varies according to the country's aid. The range of humans living with disabilities as a result of leprosy is nonetheless unknown; however, estimates of the number of humans living with disabilities are reachable (Alberts et al., 2015). In 2013, 4,374 new leprosy cases (4,028 MB and 346 PB) were reported in Ethiopia. Of the 4,374 new leprosy cases, 361 (8.25%) had a

disability grade 2 (Bhat & Prakash, 2012). As 1 of the 22 leprosy high-burden countries (HBCs), Ethiopia has a high prevalence of the disease. During the past two decades, the number of cases in Ethiopia has remained approximately 3,000–5,000, with no significant decline. Within the last 5 years, the grade 2 disability rate among new cases has increased after initially declining for the first 10 years. The national program received 3,426 cases of leprosy in 2018/2019, of which 96.2% were newly diagnosed. In the same period, 68% of new cases were MB. In total, 15% of the cases diagnosed were younger than 15 years old, and 14% had disabilities classified as grade 2. Patients with MB completed the program at an 87% rate, and patients with PB completed the program at a 99% rate (Letta, 2020). Thus, understanding the major risk factors for the development of PD is critical for disability prevention programs because it provides access to important predictors of better surveillance (Nsagha et al., 2011).

Review of the Literature

The infectious disease leprosy is caused by the bacterium *M. leprae* and is one of the leading causes of disability. In Ethiopia, the number of new leprosy patients with a disability has increased recently. As a result of its crippling consequences, leprosy often leads to severe stigmatization. Despite the availability of health facilities, diagnosis and early treatment remain challenging (Letta, 2020; Shumet et al., 2015). There may be a variety of factors responsible for the presence of a disability at the time of registration. Disability assessment is an important indicator of leprosy control. It is routinely the case in our healthcare system that only grade 2 records are maintained, whereas grade 1 assessment, as important as it is in preventing disability, is neglected. Consequently, a timely diagnosis of grade 1 disability is essential for reducing and limiting disability mitigation and limitation (Sarkar et al., 2012). No doubt finding associated factors will ease the suffering of many patients with leprosy. The integration of leprosy services with general health services makes it essential to assess disability risk factors. This study identified risk factors related to patients and healthcare providers to develop effective strategies for promoting early diagnosis and preventing disability (Srinivas et al., 2019).

Even though leprosy can be cured, PD can occur after the infection has been treated. Although patients may be exposed to risk factors that can contribute to the development of more severe PD, they generally stop being evaluated after active leprosy has been treated. After treatment has ended, any worsening of leprosy patients' PD is troublesome, and the lack of systematic and comprehensive follow-up support can leave cured leprosy patients vulnerable (Barbosa et al., 2014; Monteiro et al., 2013; Sales et al., 2013). Leprosy patients released from treatment as cured are more susceptible to worsening of the condition, especially those who experienced complications during multidrug therapy (MDT).

Even after the successful completion of MDT, leprosy patients should be periodically monitored (Costa et al., 2015; Dos Santos et al., 2020).

To investigate the risk factors for disability upgrade among leprosy patients, various countries conducted studies (Dos Santos et al., 2020; Monteiro et al., 2013; Moschioni et al., 2010; Sarkar et al., 2012, 2015; Shumet et al., 2015; Srinivas et al., 2019). The analyses in these studies looked at descriptive, binary logistic, and survival factors. Even though several studies have been conducted in Ethiopia on leprosy and the factors that contribute to the development of PDs and deformities, no study has been conducted that documents the area of leprosy disability using multilevel, multivariate models, except for studies conducted using binary logistic regression. As a result, this study provided a multilevel model, accounting for any extra heterogeneity in the data, to investigate the factors associated with disability among leprosy patients registered at the All African TB and Leprosy Rehabilitation and Training (ALERT) Center in Addis Ababa, Ethiopia. Consequently, this study aimed to determine the risk factors for disability improvement among patients with leprosy at the ALERT Center.

Methods

Design

A retrospective cohort study was conducted to retrieve relevant information from medical records of leprosy patients registered at the ALERT Center in Addis Ababa, Ethiopia, between January 2015 and December 2019.

Research Questions

- (I) Is disability related to the age of a leprosy patient?
- (II) Is disability related to the long duration of symptoms?
- (III) Is the sensory loss of a leprosy patient related to disability?
- (IV) Is there a relationship between the disability of leprosy patients and their treatment?

Sample

Medical professionals reviewed all medical records of registered leprosy patients at the ALERT Center in Addis Ababa, Ethiopia, from January 2015 to December 2019 G.C. The data are comprised of patients who were admitted to the center with leprosy. There were 807 leprosy patients registered during this study. Two hundred and five patients with leprosy with complete information on their cards were included in this study.

Inclusion and Exclusion Criteria

Only patients with leprosy who were registered for MDT at the ALERT Center between January 2015 and December 2019 were included in this study. All patients with incomplete data, those who were transferred to other locations during treatment, and those with a history of grade 2 disability before the start of the MDT during the study period were excluded. According to the eligibility criteria in this study, the appropriate sample size was determined based on the availability of the required data in the hospital records.

Data Collection Procedure

The data used in the current investigation were previously collected by the health staff for treatment purposes to diagnose leprosy and to start follow-up treatment.

Ethical Approval and Consent to Participate

The ethical approval certificate was obtained from the Ethical Clearance Review Committee of the Faculty of Natural and Computational Sciences, Debre Tabor University. In data collection, there was no written or verbal consent from participants. Researchers obtained secondary data from clinic records since they were unable to recruit participants. The ethics approval committee approved the use of these secondary data for the current investigation.

Study Variables

Dependent Variable. The dependent variable in this study was the upgrading of the disability classified as follows: 0 = no leprosy-related disability or 1 = there was disability (grade 1 or 2 disability). Depending on the severity of their disability, a leprosy patient may have a G1D or G2D score. Patients may begin treatment with G0D, G1D, or G2D, but we regarded the disability grade as occurring during treatment for patients starting their treatment with G0D and G1D (Dos Santos et al., 2020; Letta, 2020; Masresha et al., 2022; Shumet et al., 2015; Srinivas et al., 2019).

Independent Variables. The independent variables in this study are divided into two categories: individual-level variables and community-level variables associated with a multi-level logistic approach.

Individual-Level Variables. Patients' sex (1 = male, 2 = female), age (continuous), regions (all 9 regions and 2 city administration), contact (exposure) history (1 = do not have contact with the leprosy patient, 2 = by contact out patient, 3 = family), locations of the lesion (1 = hand, 2 = leg, 3 = hand and leg, 4 = face), sensory loss (1 = moderate, 2 = marked, 3 = absent), symptom duration (<6 months, 7–12 months, 13–24 months, >24 months), distribution of skin lesion

(1 = symmetric, 2 = part symmetric, 3 = asymmetric), type of leprosy (0 = PB, 1 = MB), smear result (0 = positive, 1 = negative), and thickened nerve (0 = yes, 1 = no) (Lambert et al., 2016; Masresha et al., 2022; Sarkar et al., 2012; Shumet et al., 2015).

Community-Level Variables. The treatment categories of leprosy patients (1 = relapse, 2 = defaulter, 3 = new) were considered as community-level variables (Masresha et al., 2022; Shumet et al., 2015; Srinivas et al., 2019).

Data Management and Analysis

In this study, SPSS software version 23 was used to extract and decode the data, and STATA version 14 was used to analyze the decoded data. Descriptive statistics, such as frequencies and percentages, were used to characterize the study participants. Individual observations were not considered independent of one another in a multilevel study design. In this study, the patients were nested by region. In this case, the standard regression model is inapplicable. As a result, a multilevel logistic regression model was used to identify the associated predictors of disability in Ethiopian leprosy patients.

The first of the four successive multilevel model analyses is the null model, which is outfitted without any explanatory variable at the individual and community levels to detect the presence of a possible contextual effect. The second model was fitted by including all individual-level variables (model I). This step assesses the importance of each explanatory variable, the significance of each predictor, and changes in the variance terms at the first and second levels. The third model was developed by incorporating community-level variables (model II). This model allows us to test whether the explanatory variables at the community level explain the variation in the dependent variable. All individual-level variables and community-level variables were incorporated into model III (Hopkinson et al., 2020).

Multilevel Logistic Regression Analysis

As a result, given the hierarchical nature of the data, multilevel logistic regression methods were used to identify factors associated with the disability of patients with leprosy (Hopkinson et al., 2020). A two-level, multilevel model was used to model the log of the likelihood of disability as follows: $\log \frac{\pi_{ij}}{1-\pi_{ij}} = \beta_0 + \beta_1 X_{ij} + \beta_2 X_{ij} + u_j + e_{ij}$, where i and j are the level 1 (individual) and level 2 (community) units, respectively; X_{ij} refers to individual- and community-level variables; π_{ij} is the probability of disability for the i^{th} patient in the j^{th} community, and β indicates the fixed coefficients. β_0 is the intercept—the effect on the probability of disability due to leprosy patients in the absence of influence of predictors; u_j showed the random effect (effect

of the community on disability for the j^{th} community, and e_{ij} showed random errors at the individual level. Assuming each community had different intercepts (β_0) and fixed coefficients (β), the hierarchical (clustered) nature of the data and the within and between community variations were taken into account. There were no explanatory variables in the null model. Instead, it was fitted to decompose total variance into individual- and community-level components. The second model (model I) included individual-level factors. Household-level factors were included in the third model (model II). Individual- and community-level factors were included in the fourth model (model III). Model comparison was made using deviance information criterion (DIC), Akaike information criterion (AIC), and Bayesian information criterion (BIC) (Merlo et al., 2009). The model with the lowest information criterion value was chosen as the final model of the analysis. The statistical significance of the fixed effect was determined by odds ratios (OR) with 95% confidence intervals (CI). The P -value of $\leq .05$ is considered statistically significant. To measure the variation between the enumeration areas, the measures of variation (random effects) were summarized using the intraclass correlation coefficient (ICC), the median odds ratio (MOR), and proportional change in variance (PCV) (clusters). The following formula was used to calculate ICC, which is a measure of variation and variation between individuals within the same cluster: $ICC = \frac{V_A}{V_A + \pi^2/3} = \frac{V_A}{V_A + 3.29}$, where V_A represents the estimated variance. For each model, the total variation attributed to an individual- or community-level factors was measured using a PCV calculated as: $PCV = \frac{V_A - V_B}{V_A}$, where V_A is the initial model's variance and V_B is the model's variance with more terms (Hrițcu, 2015). The MOR between a person with a higher propensity and a person with a lower propensity, which compares two people from two different randomly chosen clusters, measures unexplained cluster heterogeneity as well as variation between clusters by comparing two people from two different randomly chosen clusters. The following formula was used to compute it: $MOR = \exp(\sqrt{2} \times V_A \times 0.6745) \approx \exp(0.95\sqrt{V_A})$, where V_A represents the variance at the cluster level, the MOR is always ≥ 1 . If the MOR is 1, there is no distinction between clusters (Merlo et al., 2021).

Results

Sample Characteristics

The study included patients who had been admitted to the hospital from 2015 to 2019. In total, 205 completed records were examined. Of them, 136 (66.3%) patients were disabled due to leprosy. Among these, 64.9% were males, and the proportion (49.7%) of new leprosy patients with disability was quite high. Of the 205 leprosy patients, 174 (84.9%) were MB leprosy cases, and the rest 31 (15.1%) were PB patients. The Amhara region had the

highest disability rate for leprosy patients (29.8%) among Ethiopian regions, followed by Oromiya (25.4%). SNNPR (Southern Nations, Nationalities, and People Region) had the fewest disabled leprosy patients (11.7%), followed by Addis Ababa city administration (20.5%). 90.2% of leprosy patients' exposure history was noncontact. The majority (79.5%) of the disabled patients were outside of Addis Ababa (20.5%), which indicates that most leprosy patients are migrants (Table 1).

Research Question Results

Individual-Level Variables. In multilevel binary logistic regression analysis, median age (AOR = 1.1; 95% CI: 1.043, 1.13) of leprosy patients, patients with duration of symptom [7–12 months (AOR = 2.26; 95% CI: 1.50, 3.39), 13–24 months (AOR = 2.13; 95% CI: 1.44, 3.15), and more than 24 months (AOR = 2.67; 95% CI: 1.8, 4.02)], patients those who presented with the absence of sensory loss (AOR = 0.84; 95% CI: 0.72, 0.96), and patients with asymmetry lesion distribution (AOR = 0.74; 95% CI: 0.65, 0.85) were the most significant determinant factors of disability due to leprosy patients (Table 2).

Community-Level Variables. In the community-level variable, patient categories, such as defaulter patients (AOR = 15.53; 95% CI: 1.82, 134.96) and new patients (AOR = 0.51; 95% CI: 0.33, 1.68), were the significant determinant factors of disability (Table 2).

Random-Effects Measures of Variation

The distribution of disability among leprosy patients was not consistent across clusters (Table 3). A two-level mixed-effects binary logistic regression model was used to analyze the effect of individual characteristics and community-level factors in determining disability among leprosy patients. The intraclass correlation coefficient (ICC) value was 39.4%, indicating that about 39.4% of the total variability of disability among leprosy patients was attributed to community-level factors, whereas the individual variation explained the remaining 60.6% of the total variability. According to the PCV results, the full model explained approximately 79.2% of the disability in clusters. Moreover, the MOR confirmed that disability was attributed to community-level factors. In the null model, the MOR for disability due to leprosy patients was 4.5, indicating that there was variation between communities. When all individual- and community-level factors were included in the model, the unexplained community variation in disability due to leprosy patients was reduced to 1.994. This meant that even when all factors were taken into account, the effects of clustering remained statistically significant in the full models (Table 3). AIC,

Table 1. Socio-Demographic and Clinical Characteristics of Leprosy Patients Registered at the ALERT Hospital Center (Dataset, LPAC, 2015–2019).

Variable	Categories	Number of patients with leprosy patients (n = 205)	Percentage (%)
Disability status	Disabled	136	66.3
	Not disabled	69	33.7
Disability status	Not disabled	69	33.7
	Grade 1 or 2 disability	136	66.3
Sex	Male	133	64.9
	Female	72	35.1
Patient category	Relapse	86	42
	Defaulter	17	8.3
Leprosy type	New	102	49.7
	Multibacillary	174	84.9
First lesion	Paucibacillary	31	15.1
	On hand	83	40.5
First lesion	On feet	53	25.9
	Both on hand and feet	17	8.3
Sensory loss	On face	52	25.3
	Marked	95	46.3
Lesion type	Moderate	27	13.2
	Absent	83	40.5
Lesion type	Macules	133	64.9
	Plaques	28	13.7
Lesion distribution	Nodules	41	20
	Papules	3	1.4
Lesion distribution	Symmetry	83	40.5
	Asymmetry	29	14.2
Thickness of nerve	Part symmetry	93	45.3
	Yes	76	37.1
Exposition history for the disease	No	129	62.9
	Family	9	4.4
Smear result	Contact	11	5.4
	Non-contact	185	90.2
Smear result	Zero	8	3.9
	Positive	183	89.3
Region	Negative	14	6.8
	Addis Ababa	42	20.5
Region	Amhara	61	29.8
	Oromia	52	25.4
Region	SNNPR	24	11.7
	Others	26	12.6

Note. ALERT = All African TB and Leprosy Rehabilitation and Training Center; LPAC = leprosy patients ALERT Center; SNNPR = Southern Nations, Nationalities, and People Region.

BIC, and DIC were checked (Table 3), and the multilevel logistic regression model III was chosen because of the

Table 2. Results of Multilevel Logistic Regression With Disability Upgrading in Leprosy Patients Registered at the ALERT Hospital Center From 2015 to 2019, Addis Ababa, Ethiopia.

Individual- and community-level variables	Models			
	Null model AOR (95% CI)	Model I AOR (95% CI)	Model II AOR (95% CI)	Model III AOR (95% CI)
Sex				
Male		1		1
Female		0.5 (0.06, 0.99)*		0.30 (0.05, 1.992)
Median age of patients		1.073 (1.4, 1.12)***		1.1 (1.043, 1.13)***
Symptom duration (months)				
<6		1		1
7–12		1.75 (1.23, 2.49)**		2.26 (1.50, 3.39)***
13–24		1.98 (1.41, 2.78)***		2.13 (1.44, 3.15)***
>24		2.28 (1.59, 3.26)***		2.67 (1.8, 4.02)***
Leprosy type				
MD		1		1
PB		0.21 (0.11, 1.52)		0.32 (0.21, 3.40)
First lesion				
On hand		1		1
On feet		0.4 (0.10, 1.52)		0.32 (0.10, 2.1)
Both on hand and feet		0.59 (0.52, 0.69)***		0.66 (0.58, 0.76)
On face		0.68 (0.59, 0.78)***		0.74 (0.65, 0.85)
Lesion type				
Macules		1		1
Plaques		1.08 (0.95, 1.23)		1.09 (0.95, 1.24)
Nodules		1.15 (0.98, 1.35)		1.15 (0.98, 1.35)
Papules		1.09 (0.95, 1.25)		1.11 (0.96, 1.34)
Lesion distribution				
Symmetry		1		1
Asymmetry		0.75 (0.66, 0.86)***		0.74 (0.65, 0.85)**
Part symmetry		1.12 (0.80, 1.55)		1.2 (0.77, 1.63)
Sensory loss				
Marked		1		1
Moderate		0.91 (0.78, 1.04)		0.91 (0.78, 1.04)
Absent		0.84 (0.73, 0.97)*		0.84 (0.72, 0.96)**
Thickness of nerve				
Yes		1		1
No		0.90 (0.81, 1.02)		0.91 (0.82, 1.02)
Exposition history for the disease				
Family		1		1
Contact		0.4 (0.05, 3.01)		0.6 (0.06, 6.605)
Non-contact		8.6 (0.31, 237.2)		26.43 (0.65, 1074.3)
Smear result				
Zero		1		1
Positive		1.60 (0.095, 4.145)		1.31 (0.07, 18.1)
Negative		1.23 (0.06, 0.74)**		1.20 (0.043, 26.81)
Community-level variable				
Patient category				
Relapse			1	1
Defaulter			2.32 (0.85, 12.20)	15.53 (1.82, 134.96)*
New			0.29 (0.09, 3.9)***	0.51 (0.33, 1.68)**

Note. ALERT, All African TB and Leprosy Rehabilitation and Training Center; AOR = adjusted odds ratio; CI = confidence interval; MD = multibacillary; PB = paucibacillary.

1 = reference; *significant at P -value $< .05$; **significant at P -value $< .01$; ***significant at P -value $< .001$.

Table 3. Measures of Variation in Individual- and Community-Level Factors Associated With Disability Upgrading in Leprosy Patients Registered in ALERT Hospital Center from 2015 to 2019, Addis Ababa, Ethiopia.

Measure of variation	Models			
	Null model	Model I	Model II	Model III
Community variance (SE)	2.5 (2.4)	0.51 (0.92)	2.14 (2.04)	0.52 (1.21)
ICC (%)	39.4	13.4	43.3	13.7
PCV (%)	1	79.6	14.4	79.2
MOR	4.5	1.97	4.02	1.994
Model fit statistics				
−2*LL (DIC)	238.1	106.98	204.64	86.7
AIC	242.1	148.98	212.64	132.7
BIC	248.7	218.76	225.93	209.13

Note. AIC = Akaike information criterion; ALERT, All African TB and Leprosy Rehabilitation and Training Center; BIC = Bayesian information criterion; DIC = deviance information criterion; ICC = intraclass correlation coefficient; MOR = median odds ratio; PVC = proportional change in variance; SE = standard error.

smallest values of AIC, BIC, and DIC since the models were nested.

Discussion

This study found that 66.3% of leprosy patients were disabled (a disability grade of 1 or 2). Multilevel multivariable analysis showed there were significant variables related to disability. 39.4% of the variation in disability due to leprosy patients could be attributed to community-level factors.

The prevalence of disability in this study was very high, with more than half of the leprosy patients presenting with some form of disability. This high prevalence of disability due to leprosy suggests that there are issues with early case detection and treatment. If leprosy patients had been diagnosed early, they could have been cured before complications arose. The majority (79.5%) of the patents in this study came from outside of the capital city, Addis Ababa (20.5%). The possible cause could be a misdiagnosis of patients in peripheral health facilities, or patients may lack the knowledge to seek health care at an early stage; by the time they develop a disability, they usually prefer to travel far from their residence to seek medical help because they do not want to be recognized in their communities due to the stigma associated with the disease. This result is consistent with the findings of an Ethiopian study, which found that 36.6% of respondents came from the Oromia Region, 32.4% from the Amhara Region, and only 16% came from Addis Ababa (Shumet et al., 2015).

The odds of median age of patient disability due to leprosy were 1.1; this implies that for a unit increase in age, the

disability of patients due to leprosy was significantly increased by 10%, keeping all variables constant. This study is consistent with other studies (Moet et al., 2006; Shumet et al., 2015), which show that the prevalence of disability increases with age. This study also confirms the study that was done in India (Srinivas et al., 2019) and Brazil (Dos Santos et al., 2020), which showed, in adults with leprosy, that hard-to-treat diseases may be worsened by aging and delayed diagnosis and treatment. This also implies that patients may have had symptoms for a long time without being diagnosed or treated. It is also possible that the older age groups had the disease for a long time without realizing it was leprosy; the only time they realized it was leprosy was when they noticed the damage in their bodies.

The current study found a higher risk of disability in patients who had symptoms for 7–12 months (AOR = 2.26), 13–24 months (AOR = 2.13), and more than 24 months (AOR = 2.67). This implies that the risk of disability of patients was increased for a unit increase in the duration of disease before treatment. Although we observed an increased occurrence of disability in patients seeking treatment late after the onset of the disease (long symptom duration), a long duration of symptoms for a leprosy patient before seeking treatment has been a significant risk factor for disability among leprosy patients. Possibly, this may occur as a result of patients ignoring the initial symptoms, believing they would go away on their own. This study is in line with the study done in Ethiopia (Shumet et al., 2015), which showed that patients who had symptoms for more than 24 months were at a higher risk of developing a disability. The result of the current study was also in agreement with the findings in India (Srinivas et al., 2019) and other countries (Moschioni et al., 2010), which revealed a higher risk of disability in patients who had symptoms for 6–12 months and more than 24 months. The longer the symptoms last, the more likely it is that nerve injury and sensory loss will occur, both of which will result in disability.

This finding also confirms that patients with the absence of sensory loss (AOR = 0.84) have a lower risk of disability. Due to the fact that repetitive injury, ulceration, and limb shortening are all caused by sensory function loss, the loss of corneal sensation can lead to unnoticed corneal injuries and significant vision loss. There is a loss of motor characteristics that causes finger and toe clawing, lagophthalmos failure, foot drop, and wrist drop. This is also consistent with the findings of a previous study in Ethiopia (Nicholls et al., 2003; Shumet et al., 2015). Thus, quick diagnosis and case detection mechanisms are essential.

Furthermore, the odds of disability for leprosy patients were increased by 15.53 times for defaulters and decreased by 0.51 times for newly diagnosed cases of leprosy compared to relapse patients. These results were confirmed by the previous studies (Nicholls et al., 2003; Shumet et al., 2015),

which found that disability is very high among registered leprosy patients. The disability rate in newly diagnosed leprosy cases was also very high.

Limitations of the Study

The study involves only one tertiary-level hospital, which poses limitations. In this area, more serious cases are likely to be observed, which implies that the prevalence of handicaps was underestimated. There is a lack of data regarding the patients' history of medication adherence, as well as specific data about the patients' care and specialized medical treatment that can prevent disability.

Implications of the Study

Leprosy is caused by the bacterium *M. leprae* and is believed to be a leading cause of disability worldwide. In this study, leprosy patients with disabilities were found to be extremely prevalent. Detecting disabilities early and preventing them is essential. Nerve damage and sensory loss, which are risk factors for the study, are caused by prolonged illness and a delay in diagnosis. Therefore, the case detection system and diagnosis system must be urgently evaluated. In addition, it is necessary to assess the diagnostic suspicion of health workers at the periphery, as well as public awareness of leprosy's symptoms and signs to ensure that people seek medical care.

Conclusion

Study results showed that disability rates among leprosy patients are extremely high. The majority of these patients are males and they reside in the Amhara region. As patients' age increases and as their symptoms last longer, the risk of disability increases, but it is lower for patients who do not lose their sensation and for patients whose lesions are asymmetrical. Disability due to leprosy is also influenced by patient category features prominently as well. Furthermore, programs should also place a greater emphasis on raising community awareness, focusing on key messages such as symptoms, disability as a result of late detection, the availability of free treatment, and early case detection campaigns, such as lively surveys, as well as the availability of leprosy care in a public health facility.

Abbreviations

AIC	Akaike information criterion
AOR	adjusted odds ratio
CI	confidence intervals
DG	disability degree
DIC	deviance information criterion
ENAPAL	Ethiopian National Association of Peoples Affected by Leprosy

G1D	grade 1 disability
G2D	grade 2 disability
ICC	intra-cluster correlation
HBCs	leprosy high burden countries
LPAC	leprosy patients ALERT Center
MB	multibacillary
MDT	multidrug therapy
MOR	median odds ratio
PAL	peoples affected by leprosy
PB	paucibacillary
PCV	proportional change in variance
SNNPR	Southern Nations, Nationalities, and People Region.

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Authors' Contributions

SSM initiated the research and was involved in the proposal's writing and development, the data collection format, data entry, data analysis, and manuscript writing. BMM, SGW, and YAM contributed to the design and data analysis, as well as critically reading the manuscript and amending constructive comments for the manuscript's improvement.

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