



Grade 2 disability at leprosy diagnosis in Brazil: foot involvement and regional distribution

Discapacidad grado 2 al diagnóstico de lepra en Brasil: afectación del pie y distribución regional

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ABSTRACT

Introduction: Grade 2 disability at leprosy diagnosis marks late detection and often begins in the feet, yet its recent national distribution in Brazil is incompletely described. Methods: Retrospective cross-sectional analysis of 221,820 new leprosy cases notified to the Brazilian Notifiable Diseases Information System (SINAN) between 2015 and 2023. The proportion of grade 2 disability at diagnosis was estimated among cases with the disability grade evaluated, and its association with demographic and clinical factors was assessed with multivariable logistic regression. Results: Grade 2 disability was recorded in 9.3% of evaluated cases (95% CI 9.17-9.43) and rose from 7.5% in 2015 to 11.1% in 2023. The proportion was highest in the Southeast (13.3%) and South (13.2%) and lowest in the Central-West (8.2%). Disability was associated with two or more affected nerves (OR 5.91; 95% CI 5.67-6.17), multibacillary classification (OR 2.85; 95% CI 2.63-3.08), age 60 years or older (OR 2.54; 95% CI 2.28-2.83), illiteracy (OR 2.44; 95% CI 2.20-2.71) and male sex (OR 1.54; 95% CI 1.49-1.60). Conclusions: Grade 2 disability at diagnosis increased and concentrated in lower-endemicity regions, where late detection of plantar involvement persists.

Keywords: leprosy; Hansen disease; disability evaluation; foot; Brazil; health status disparities.

RESUMEN

Introducción: La discapacidad grado 2 al diagnóstico de lepra señala detección tardía y suele iniciarse en los pies, pero su distribución nacional reciente en Brasil está descrita de forma incompleta. Métodos: Análisis transversal retrospectivo de 221 820 casos nuevos de lepra notificados al Sistema de Informação de Agravos de Notificação (SINAN) entre 2015 y 2023. Se estimó la proporción de discapacidad grado 2 al diagnóstico entre los casos con grado evaluado y su asociación con factores demográficos y clínicos mediante regresión logística múltiple. Resultados: La discapacidad grado 2 se registró en el 9,3% de los casos evaluados (IC 95 % 9,17-9,43) y aumentó del 7,5% en 2015 al 11,1% en 2023. La proporción fue mayor en el Sudeste (13,3%) y el Sur (13,2%) y menor en el Centro-Oeste (8,2%). La discapacidad se asoció con dos o más nervios afectados (OR 5,91; IC 95 % 5,67-6,17), clasificación multibacilar (OR 2,85; IC 95 % 2,63-3,08), edad de 60 años o más (OR 2,54; IC 95 % 2,28-2,83), analfabetismo (OR 2,44; IC 95 % 2,20-2,71) y sexo masculino (OR 1,54; IC 95 % 1,49-1,60). Conclusiones: La discapacidad grado 2 al diagnóstico aumentó y se concentró en regiones de menor endemidad, donde persiste la detección tardía de la afectación plantar.

Palabras clave: lepra; enfermedad de Hansen; evaluación de la discapacidad; pie; Brasil; disparidades en el estado de salud.

INTRODUCTION

Leprosy persists in Brazil as a disease of unequal geography. The country notifies tens of thousands of new cases every year and contributed a large share of the global burden during the last decade, even as the national detection rate declined.^(1,2) Grade 2 disability occupies a central place in the World Health Organization strategy for leprosy, because it is the most objective measure of how late the disease is being recognized and the most direct link between surveillance and preventable deformity.⁽³⁾ Within the national decline in detection, that marker has not behaved as expected. Grade 2 disability at diagnosis signals that the disease was recognized only after irreversible nerve damage, and it is meant to fall as services improve, yet national and state series show it stable or rising.^(4,5) This disconnection between falling incidence and persistent disability is the starting point of the present study.

The geography of that marker is disputed. Analyses of hyperendemic areas of the North, Northeast and Central-West describe grade 2 disability as a burden of high-transmission territories, where many cases accumulate and some are diagnosed late.^(6,7) Whereas other studies report the opposite gradient: the highest proportions of grade 2 disability appear in the South and Southeast, regions of low endemicity where the few cases that occur are found only after nerve damage has begun.^(8,9) The two readings lead to different conclusions about where podiatric and surveillance action should be directed, and the contradiction has not been resolved at the national level. The first reading would concentrate resources in already-saturated hyperendemic municipalities. The second would redistribute attention toward states whose programs are considered successful precisely because they notify few cases. Choosing between them requires a national estimate that neither camp has provided, because state series cannot by themselves resolve a national gradient.

The foot carries much of the clinical weight of that burden. The World Health Organization grading classifies disability as grade 1 when there is loss of protective sensation without visible deformity, and grade 2 when visible damage to the eyes, hands or feet is already present; the plantar manifestations of grade 2, ulceration, foot drop, claw toes and bone resorption, are among the most disabling and the most preventable.⁽³⁾ A meta-analysis estimated a high pooled prevalence of plantar ulcer in leprosy, with sensory loss and foot deformity among its principal determinants.⁽¹⁰⁾ Neuropathic ulcers of the foot demand prolonged offloading and progress to infection, osteomyelitis and amputation when untreated.⁽¹¹⁾

Pure neural forms of the disease, which present with nerve thickening and few or no skin lesions, are especially prone to escape early recognition.⁽³⁾ Even after bacteriological cure, plantar lesions persist as lasting marks of the disease.⁽¹²⁾ For podiatric practice, the grade 2 disability recorded at diagnosis therefore signals that the foot has already been exposed to the consequences of untreated neuropathy.

National estimates exist but their period is limited. A cohort of one hundred million beneficiaries of Brazilian social programs described physical disability in a large but selected population.⁽¹³⁾ State-level series in Maranhão and in low-endemicity southern states showed grade 2 disability stable or increasing, but each covered a single state or a narrow period.^(5,8) Indicator analyses at the national level have tracked detection and operational quality, yet they have not dissected the disability outcome with individual-level correlates.^(2,14)

No recent national description has combined the temporal trend, the regional and state distribution, and the demographic and clinical correlates of grade 2 disability at diagnosis for the years 2015 to 2023. This gap matters because the distribution of the indicator determines where case-finding and foot screening should be intensified.

This study aimed to describe the proportion of new leprosy cases diagnosed with grade 2 disability in Brazil from 2015 to 2023, its temporal and regional distribution, and the factors associated with grade 2 disability at diagnosis. Consistent with the surveillance literature, we hypothesized that grade 2 disability would be higher in the South and Southeast, regions of lower detection intensity, and would be associated with male sex, older age, lower schooling and multibacillary disease.⁽¹⁵⁾ The findings are intended to inform foot-care prioritization in leprosy reference services and in the podiatric community that increasingly manages the sequelae of the disease.

METHODS

Study design and data source

A retrospective cross-sectional analysis of anonymized individual records of leprosy notifica-

tions was conducted. The records came from the Brazilian Notifiable Diseases Information System (Sistema de Informação de Agravos de Notificação, SINAN), the nationwide compulsory surveillance database maintained by the Ministry of Health through DATASUS.⁽¹⁶⁾

This source was chosen because the native DATASUS file-transfer service is not retrievable as a plain dataset over HTTP without a portal session, and because the deposited microdata preserve the original SINAN fields, including the disability grade recorded at diagnosis. The data dictionary accompanying the deposit corresponds to the SINAN NET version 5.0 leprosy module. The study followed the STROBE statement for the reporting of observational studies, and, given the use of routine records, the RECORD extension where applicable.

Population and outcome

New leprosy cases notified between 2015 and 2023 were included, defined by the mode of entry field as new cases, to exclude transfers, relapses and re-entries and to ensure that each record represented a single episode of recently diagnosed disease. The study period was fixed a priori to match the availability of complete notification years and the bibliographic window of the target journal, and no exclusion was applied on the basis of age, sex or clinical form. The outcome was grade 2 disability at diagnosis, recorded in SINAN as grade zero, grade I, grade II or not evaluated. The notification record registers the overall grade without specifying the anatomical site; grade II denotes visible deformity or damage to the eyes, hands or feet. Because plantar involvement is the most frequent presentation of grade 2 disability in leprosy, foot impairment was treated as the clinical frame of the outcome and interpreted against the literature on plantar ulcer and foot deformity. The denominator for the main proportion was the set of cases with the grade evaluated at diagnosis, and the share of cases not evaluated was reported separately as a completeness indicator rather than imputed.

Demographic covariates were sex, age group, skin color and schooling. Age in completed years was recovered from the numeric age field, which encodes age with an offset of 4000, and cross-checked against the year of birth; implausible values outside 0 to 120 years were corrected from the birth year. Clinical covariates were operational classification (paucibacillary or multibacillary), number of skin lesions, number of affected nerves, mode of detection and region of notification. Region and federative unit were derived from the state of notification, and the twenty-seven federative units were grouped into the five official macro-regions.

Statistical analysis

The proportion of grade 2 disability was summarized with its 95% confidence interval using the Wilson method, chosen because the outcome is a proportion bounded between zero and one and the Wilson interval behaves well when the event is uncommon. Annual proportions were computed overall and by macro-region, and the temporal trend was tested with logistic regression using year of notification as a continuous predictor, expressed as an odds ratio per additional year. To test whether the COVID-19 pandemic period changed the trend, a sensitivity analysis repeated the trend model after excluding the years 2020 and 2021, when detection was transiently depressed.⁽¹⁷⁾ The state distribution was summarized across the whole period and compared with the five official macro-regions to place state-level variation in context.

Factors associated with grade 2 disability were assessed with univariable and multivariable logistic regression among cases with the grade evaluated, with results expressed as odds ratios and 95% confidence intervals. The multivariable model included sex, age group, skin color, schooling, operational classification, skin lesions, affected nerves, mode of detection, region and year of notification, selected because each is either a documented correlate of disability or a marker of detection intensity.^(15,18)

Age was categorized into five groups with children under 15 as the reference. Skin color followed the official census categories, and schooling was grouped into illiterate, elementary, secondary, higher and ignored categories. Skin lesions were grouped into none, one to five, and six or more, and affected nerves into none, one, and two or more, following the cut-points used in Brazilian surveillance analyses. Reference categories were chosen as the clinically least exposed group. Records with an uninformative category, such as ignored schooling, were retained as their own category rather than discarded, to avoid selection bias from complete-case restriction.

An alternative indicator that includes cases not evaluated in the denominator was computed as a sensitivity check of the main proportion, because the not evaluated group could hide disability and inflate or deflate the estimate.

RESULTS

Between 2015 and 2023, 221,820 new leprosy cases were notified in Brazil. Their demographic and clinical characteristics are summarized in (Table 1). The disability grade at diagnosis was evaluated in 194,957 cases and not evaluated in 26,863 cases (12.1%).

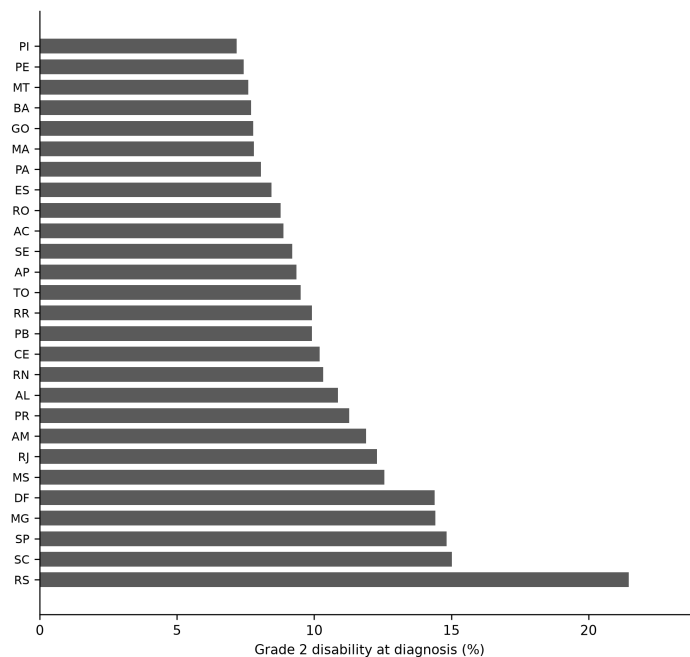
Table 1. Demographic and clinical characteristics of new leprosy cases by grade 2 disability at diagnosis, Brazil, 2015-2023.

Characteristic	Category	Total (n=221820)	Grade 0-1 (n=176825)	Grade 2 (n=18132)	Not evaluated (n=26863)
Sex	Female	98563 (44.4)	81667 (46.2)	5524 (30.5)	11372 (42.3)
Sex	Male	123247 (55.6)	95152 (53.8)	12607 (69.5)	15488 (57.7)
Age group (years)	<15	12657 (5.7)	11023 (6.2)	392 (2.2)	1242 (4.6)
Age group (years)	15-29	32243 (14.5)	26780 (15.1)	1849 (10.2)	3614 (13.5)
Age group (years)	30-44	55466 (25.0)	45328 (25.6)	3443 (19.0)	6695 (24.9)
Age group (years)	45-59	64383 (29.0)	51131 (28.9)	5447 (30.0)	7805 (29.1)
Age group (years)	>=60	57071 (25.7)	42563 (24.1)	7001 (38.6)	7507 (27.9)
Skin color	White	53261 (24.0)	42893 (24.3)	4753 (26.2)	5615 (20.9)
Skin color	Black	27062 (12.2)	21283 (12.0)	2443 (13.5)	3336 (12.4)
Skin color	Brown	130632 (58.9)	104514 (59.1)	10031 (55.3)	16087 (59.9)
Skin color	Indigenous	1078 (0.5)	846 (0.5)	110 (0.6)	122 (0.5)
Skin color	Other/ignored	9787 (4.4)	7289 (4.1)	795 (4.4)	1703 (6.3)
Schooling	Illiterate	18474 (8.3)	13728 (7.8)	2431 (13.4)	2315 (8.6)
Schooling	Elementary	102184 (46.1)	82214 (46.5)	8938 (49.3)	11032 (41.1)
Schooling	Secondary	44874 (20.2)	37861 (21.4)	2616 (14.4)	4397 (16.4)
Schooling	Higher	12428 (5.6)	10670 (6.0)	552 (3.0)	1206 (4.5)
Schooling	Ignored/NA	43860 (19.8)	32352 (18.3)	3595 (19.8)	7913 (29.5)
Operational classification	Paucibacillary	51455 (23.2)	44928 (25.4)	794 (4.4)	5733 (21.3)
Operational classification	Multibacillary	170339 (76.8)	131885 (74.6)	17338 (95.6)	21116 (78.6)
Skin lesions (n)	0	13337 (6.0)	9720 (5.5)	2182 (12.0)	1435 (5.3)
Skin lesions (n)	1-5	110853 (50.0)	93222 (52.7)	5545 (30.6)	12086 (45.0)
Skin lesions (n)	>=6	85134 (38.4)	66745 (37.7)	9118 (50.3)	9271 (34.5)
Affected nerves (n)	0	95411 (43.0)	85046 (48.1)	1800 (9.9)	8565 (31.9)
Affected nerves (n)	1	24603 (11.1)	20822 (11.8)	1795 (9.9)	1986 (7.4)
Affected nerves (n)	>=2	77402 (34.9)	57980 (32.8)	13125 (72.4)	6297 (23.4)
Mode of detection	Referral	99248 (44.7)	77340 (43.7)	9283 (51.2)	12625 (47.0)
Mode of detection	Spontaneous demand	86520 (39.0)	70219 (39.7)	6403 (35.3)	9898 (36.8)
Mode of detection	Contact examination	20356 (9.2)	17469 (9.9)	1108 (6.1)	1779 (6.6)
Mode of detection	Other	15696 (7.1)	11797 (6.7)	1338 (7.4)	2561 (9.5)

Note: Percentages within each column. Grade 0-1 and Grade 2 restricted to cases with disability grade evaluated at diagnosis; the not evaluated group (grade not assessed or missing) is shown for completeness. Source: Elaborated from SINAN leprosy notification microdata (DATASUS), 2015-2023.

The proportion of new cases with grade 2 disability at diagnosis stood at 9.3% (95% CI 9.17-9.43), corresponding to 18,132 of 194,957 evaluated cases. The geographic distribution inverted the endemicity gradient. The Southeast presented the highest proportion (13.3%), followed by the South (13.2%), whereas the North, Northeast and Central-West presented lower values (8.9%, 8.3% and 8.2%). The state distribution spanned a wide range. Rio Grande do Sul reached 21.5%, and Santa Catarina, São Paulo, Minas Gerais and the Federal District all exceeded 14.4%. Piauí, Mato Grosso, Goiás and Bahia stood below 7.8% (Figure 1).

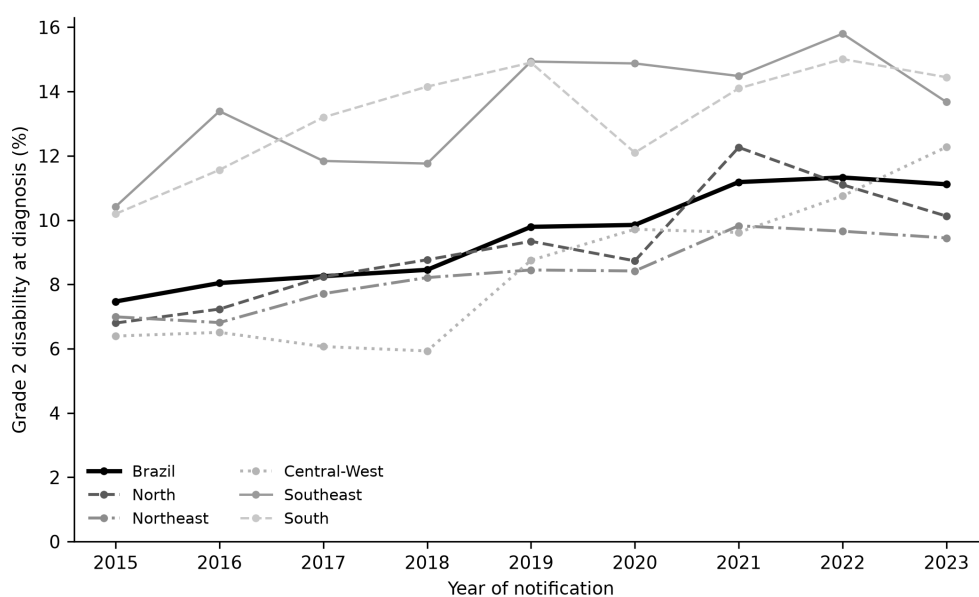
Figure 1. Proportion of new leprosy cases with grade 2 disability at diagnosis by federative unit, Brazil, 2015-2023.



Note: Proportion among cases with the disability grade evaluated at diagnosis. Source: Elaborated from SINAN leprosy notification microdata (DATASUS), 2015-2023.

The annual proportion rose over the period, from 7.5% in 2015 to 11.1% in 2023, a difference of 3.6 percentage points, with an odds ratio of 1.06 per additional year (95% CI 1.06-1.07; $p < 0.001$). The increase reached every macro-region but was sharpest in the Central-West, which passed from 6.4% to 12.3%, and in the South, which passed from 10.2% to 14.4% (Figure 2). Notifications moved in the opposite direction during the pandemic: the annual number of new cases fell from 28,856 in 2019 to 18,340 in 2020 and 18,773 in 2021, and reached only 23,206 by 2023. Excluding 2020 and 2021 left the trend essentially unchanged (OR 1.06 per year; $p < 0.001$).

Figure 2. Annual proportion of new leprosy cases with grade 2 disability at diagnosis, Brazil and macro-regions, 2015-2023.



Note: Proportion among cases with the disability grade evaluated at diagnosis. Source: Elaborated from SINAN leprosy notification microdata (DATASUS), 2015-2023.

Nerve involvement was the strongest clinical correlate of grade 2 disability. Two or more affected nerves raised the odds almost sixfold (OR 5.91; 95% CI 5.67-6.17), and one affected nerve raised it more than twofold. Multibacillary classification (OR 2.85; 95% CI 2.63-3.08), age of 60 years or older relative to children under 15 (OR 2.54; 95% CI 2.28-2.83) and illiteracy relative to higher schooling (OR 2.44; 95% CI 2.20-2.71) were also associated with the outcome. Male sex (OR 1.54; 95% CI 1.49-1.60) and Indigenous skin color (OR 1.34; 95% CI 1.08-1.67) remained associated after adjustment. Six or more skin lesions were inversely associated with disability (OR 0.61; 95% CI 0.58-0.64), and cases detected through contact examination showed the lowest odds relative to referral. After adjustment, the North, Northeast and Central-West kept lower odds of disability than the Southeast (OR 0.60, 0.70 and 0.43, respectively) (Table 2).

Table 2. Crude and adjusted odds ratios for grade 2 disability at diagnosis among new leprosy cases, Brazil, 2015-2023.

Variable	Category	Crude OR (95% CI)	Adjusted OR (95% CI)	p
Sex	Male	1.96 (1.90-2.02)	1.54 (1.49-1.60)	<0.001
Age group (years)	15-29	1.94 (1.74-2.17)	1.63 (1.45-1.84)	<0.001
Age group (years)	30-44	2.14 (1.92-2.38)	1.52 (1.36-1.70)	<0.001
Age group (years)	45-59	3.00 (2.70-3.33)	1.89 (1.69-2.10)	<0.001
Age group (years)	>=60	4.63 (4.17-5.13)	2.54 (2.28-2.83)	<0.001
Skin color	Black	1.04 (0.98-1.09)	1.09 (1.03-1.15)	0.003
Skin color	Brown	0.87 (0.84-0.90)	1.01 (0.97-1.05)	0.708
Skin color	Indigenous	1.17 (0.96-1.43)	1.34 (1.08-1.67)	0.007
Skin color	Other/ignored	0.98 (0.91-1.07)	1.09 (0.99-1.18)	0.066
Schooling	Illiterate	3.42 (3.11-3.77)	2.44 (2.20-2.71)	<0.001
Schooling	Elementary	2.10 (1.92-2.30)	1.89 (1.72-2.07)	<0.001
Schooling	Secondary	1.34 (1.22-1.47)	1.43 (1.29-1.58)	<0.001
Schooling	Ignored/NA	2.15 (1.96-2.36)	2.01 (1.83-2.22)	<0.001
Operational classification	Multibacillary	7.44 (6.92-7.99)	2.85 (2.63-3.08)	<0.001
Skin lesions (n)	1-5	0.26 (0.25-0.28)	0.47 (0.45-0.50)	<0.001
Skin lesions (n)	>=6	0.61 (0.58-0.64)	0.61 (0.58-0.64)	<0.001
Affected nerves (n)	1	4.07 (3.81-4.36)	2.48 (2.33-2.63)	<0.001
Affected nerves (n)	>=2	10.70 (10.17-11.25)	5.91 (5.67-6.17)	<0.001
Mode of detection	Spontaneous demand	0.76 (0.73-0.79)	0.80 (0.77-0.83)	<0.001
Mode of detection	Contact examination	0.53 (0.50-0.56)	0.53 (0.49-0.56)	<0.001
Mode of detection	Other	0.94 (0.89-1.00)	0.96 (0.90-1.02)	0.170
Region	North	0.64 (0.61-0.67)	0.60 (0.57-0.64)	<0.001
Region	Northeast	0.59 (0.56-0.61)	0.70 (0.67-0.73)	<0.001
Region	South	0.99 (0.91-1.07)	0.84 (0.77-0.92)	<0.001
Region	Central-West	0.59 (0.56-0.61)	0.43 (0.40-0.45)	<0.001

Note: Adjusted for all variables shown plus year of notification. Reference categories: female sex, age <15 years, White skin color, higher schooling, paucibacillary classification, zero skin lesions, zero affected nerves, referral mode of detection, and Southeast region. OR = odds ratio; CI = confidence interval. Source: Elaborated from SINAN leprosy notification microdata (DATASUS), 2015-2023.

Completeness of disability assessment differed across groups. The not evaluated category reached 12.1% of new cases and was larger among cases with unknown schooling and in the Northeast and Central-West. When the cases not evaluated were included in the denominator, the national proportion stood at 8.2%, consistent with the main estimate.

DISCUSSION

The discrepant authors can be named at the outset. Monteiro et al.,⁽⁶⁾ working in a hyperendemic area, and analyses of the North and Northeast ⁽⁷⁾ framed grade 2 disability as a burden of high-transmission territories. Our national data contradict that framing. The proportion of grade 2 disability at diagnosis was highest in the South and Southeast, the regions with the lowest case-detection rates, and lowest in the Central-West.

This inversion, rather than an anomaly, reproduces the expectation that late diagnosis concentrates where transmission is low and clinical suspicion has weakened.(8,9)

The overall proportion of 9.3% and its rise from 7.5% to 11.1% align with national and state reports. A cohort of one hundred million Brazilians found that physical disability remained frequent despite treatment access;(13)that cohort drew on beneficiaries of cash-transfer programs, a population poorer than the national average, so its estimates cannot be taken as representative, and our notification-based series, which covers all new cases regardless of income, complements it by showing that the problem is no less real at the national level. In Maranhão, a hyperendemic state, the proportion of new cases with grade 2 disability oscillated without a sustained decline. (5)Municipal and state trend analyses likewise recorded a slow improvement or a plateau in the indicator.(14,19)

Unlike those series, our data show a monotonic increase driven mainly by the South and Southeast, where detection fell most sharply during and after the pandemic.(17)The finding is sobering for a country that has invested for decades in leprosy elimination, because it shows that the most preventable disability continues to be produced in the places where the disease is least visible. Delayed detection is the common mechanism: reviews of case-detection delay consistently link patient and health-system delay to a higher risk of disability at diagnosis,(18,20) and disability once established tends to progress after treatment rather than resolve.(21,22) Underreporting in low-endemicity areas compounds the apparent concentration of disability among the few cases that do reach notification.(23)

The Brazilian proportion also sits within a wider international pattern. Series from China, India and Indonesia report grade 2 disability proportions among new cases that range broadly, and all identify diagnostic delay, male sex, older age and multibacillary disease as the same recurring correlates.(20,24,25)Long-term cohorts in India show that disability risk accumulates after treatment as well, which makes the proportion at diagnosis a conservative snapshot of the eventual burden. (22,26) The rise we document in Brazil, from 7.5% to 11.1%, therefore reflects a problem that is measurable and shared, but its regional inversion is a Brazilian particularity that deserves explanation.

The regional inversion has a coherent operational explanation. In the South and Southeast, where leprosy is rare, primary care clinicians see few cases, the index of suspicion is low, and patients are referred after neuropathy and deformity have appeared, a pattern documented by active case-finding in Rio Grande do Sul and by delayed-diagnosis studies in the Northeast.(9,27) In the hyperendemic North, Northeast and Central-West, sustained case-finding and contact examination bring in earlier, less damaged cases, which lowers the disability proportion even though the absolute burden remains large.(28)The finding in Piauí, the state with the lowest proportion, is consistent with its intense surveillance and high detection of early cases.(29)

The Central-West illustrates a third dynamic. Its overall proportion remained the lowest in the country, yet it increased the most in relative terms over the period, from 6.4% to 12.3%. Mato Grosso and Goiás combine high detection with an epidemiological risk that has been rising in recent years. (19)The coexistence of a low absolute proportion with a rising trajectory suggests that even strong case-finding programs are beginning to miss the earliest cases, a warning sign for services long regarded as models of control. Monitoring the grade 2 indicator together with detection, rather than detection alone, is what exposes this drift.

The high proportions in the South rest on comparatively few cases. Rio Grande do Sul notified 870 new cases over the period and Santa Catarina 1,298, whereas Piauí notified 7,986. The elevated proportions therefore describe a small absolute number of patients with established deformity, which sharpens rather than weakens the finding. In low-endemicity states the challenge is not the volume of disability but its concentration among the rare cases that escape early detection, and each of those patients carries a heavy individual burden of foot deformity.

The foot emerges as the clinical bridge between the indicator and its podiatric meaning. Grade 2 disability in leprosy is most often a plantar phenomenon: plantar ulcer, foot drop, claw toes and resorption.(10)Neuropathic plantar ulcers, once established, require prolonged offloading and are complicated by infection, osteomyelitis and deformity.(11)The elevated proportions in Rio Grande do Sul, Santa Catarina and São Paulo therefore describe populations in which sensory loss in the foot had already gone unrecognized at diagnosis. Surveys of the foot at risk in Brazilian municipalities show that a large share of patients under treatment carry plantar sensory deficits that predispose to ulceration.(30)

These states maintain structured health services, which suggests the residual gap is one of clinical suspicion rather than access alone. For the podiatrist, the operational consequence is direct: a new case with grade 2 disability is frequently a patient who already needs plantar offloading,

footwear adaptation and ulcer prevention beyond chemotherapy alone. The plantar reading of the indicator therefore converts an epidemiological marker into a concrete clinical workload and a measurable target for prevention. Prevention of plantar ulceration in leprosy rests on three pillars that the present data make actionable: early detection of sensory loss by monofilament testing, education on self-inspection of the feet, and appropriate footwear that redistributes plantar pressure. (10,11) Where the disability grade is already 2 at diagnosis, these measures arrive late, which is precisely why the geographic distribution of grade 2 disability doubles as a map of missed prevention.

The correlates of disability reproduced established risk factors and extended them to the national level. Nerve involvement was the dominant determinant, a finding expected because grade 2 disability is itself a neuropathic endpoint and because the count of affected nerves approximates the extent of neural damage at presentation.(31,32) The gradient across the number of affected nerves was steep: the odds doubled with one nerve and rose almost sixfold with two or more, which places neural assessment at the center of early detection. Multibacillary disease remained associated after adjustment with an odds ratio of 2.85, attenuated from a crude odds ratio above seven once lesion count, nerve involvement and mode of detection were taken into account, indicating that bacillary load operates partly through clinically visible severity. Older age showed a monotonic gradient from young adulthood to old age, and illiteracy and male sex each remained independently associated, in agreement with the systematic review and meta-analysis of de Paula et al.(15)and with series from China, India and Indonesia.(20,24,25)

The age gradient deserves specific comment. Disability rose steadily with age, and the oldest group carried odds of 2.54 relative to children. Older patients accumulate sensory loss over years of undiagnosed disease, may attribute plantar changes to aging, and seek care later, a pattern consistent with the age effect reported in the meta-analysis of risk factors.(15)The concentration of grade 2 disability among older people matters for podiatry because the same population already carries age-related foot pathology, and the superposition of leprosy neuropathy on diabetic or vascular foot disease complicates management.

Male sex remained associated after adjustment, a finding that recurs across Brazilian and international series.(15,33) The explanation is partly behavioral, men seek care later than women, and partly occupational, with manual work placing the hands and feet of men at higher exposure to injury and ulceration. Gender-sensitive case-finding aimed at men in productive age groups has been proposed in Brazilian analyses of the gender gap in leprosy,(33)and the persistence of the gap in our national data suggests the proposal remains relevant.

The inverse association of six or more skin lesions with disability is plausible rather than paradoxical. Cases with few or no lesions, including pure neural forms, are harder to recognize early, whereas multibacillary cases with many lesions are visible and detected sooner despite a higher bacillary load.(3)The mode of detection corroborates this reading: cases found through contact examination, which reaches asymptomatic people early, showed the lowest odds of disability, whereas spontaneous demand and referral, which capture people who already perceive symptoms, showed higher odds. Long-term follow-up studies in India indicate that the risk of disability extends well beyond the moment of diagnosis, which reinforces the value of the grade recorded at presentation,(26,34) and survival analyses after treatment show that disability continues to progress once established.(22)

The protective association of contact examination carries an operational lesson. Cases detected by examining household contacts of known patients showed the lowest odds of grade 2 disability, which indicates that active search reaches people before symptoms and before nerve damage. This finding aligns with reviews showing that contact tracing and early case-finding lower the share of late diagnoses.(18)It also suggests that the low proportion of disability in hyperendemic areas is partly a reward of sustained contact examination rather than an intrinsic property of those regions.

Indigenous skin color and lower schooling signal the socioeconomic gradient that persists in Brazilian leprosy control. Occupation, schooling and social vulnerability have been linked to disability and to delayed detection in Brazilian cohorts,(35,36) and gender differences in access to diagnosis persist in endemic areas.(33)Spatial studies likewise place disability risk within socially vulnerable territories.(37)The gradient by schooling, from illiteracy to higher education, was monotonic in our data and independent of clinical severity, which points to information and access as modifiable mediators. The excess risk among Indigenous people, although based on a small number of cases, is consistent with the difficulty of reaching dispersed populations with specialized dermatoneurological assessment and deserves attention in services that cover Indigenous territories.

The schooling gradient has a mechanistic reading. Illiterate patients and those with incomplete elementary education may not recognize early sensory symptoms, may not understand the

need to complete treatment, and may face greater barriers in reaching specialized assessment, a pathway documented in studies of delayed diagnosis.⁽²⁷⁾ The monotonic dose-response we observed, with each lower level of schooling carrying a higher odds, argues that health literacy and access operate jointly and could be addressed through targeted community education and active search in areas of low schooling.

Strengths of this study are its national scope, the use of complete notification records rather than aggregated tabulations, and multivariable adjustment across demographic and clinical domains. The inclusion of all twenty-seven federative units over nine consecutive years allowed the regional inversion to be documented with precision, and the sensitivity analyses showed that the main findings were robust to the pandemic years and to the inclusion of cases without a recorded grade. Assessment of the disability grade was complete in nearly nine of every ten cases, a level of field completeness adequate for national surveillance, and the alternative denominator that incorporated the unevaluated cases changed the estimate only marginally.

Nonetheless, limitations warrant emphasis. The notification record grades disability without specifying the anatomical site, so the foot could not be isolated empirically from eye or hand involvement; the plantar reading relies on the literature, and a dedicated field for foot assessment in future surveillance would resolve this. The grade was not evaluated in 12.1% of cases, and although the alternative denominator that includes them yielded a similar picture (8.2%), residual misclassification cannot be excluded. Administrative data lack income, occupation and distance to care, and the cross-sectional design precludes causal inference between the correlates and disability. Each limitation points to a concrete remedy: site-specific disability recording, completeness audits in low-endemicity states, and cohort designs that link diagnostic delay to plantar outcomes.

The indicator itself deserves a more prominent place in national monitoring. The World Health Organization strategy for 2021 to 2030 sets the prevention of disability as an explicit pillar of leprosy control and calls for a reduction in the rate of new cases with grade 2 disability.⁽³⁸⁾ Our national series shows that Brazil moved away from that aim during the study period, and that the distance from the target was widest in the regions where leprosy is least expected. The grade 2 proportion is reported in Brazilian epidemiological bulletins, but it is seldom interpreted as a map of missed opportunities. When detection and the disability proportion move in opposite directions, as they did here, the disability proportion is the more informative measure of program performance, because it cannot be lowered by increasing the number of notifications. Treating it as a primary rather than a secondary indicator would focus attention on the states where late diagnosis is most concentrated.

The podiatric role in leprosy is underexploited in Brazil. Most disability prevention is carried out by nurses and physicians in primary care, while podiatrists are concentrated in private urban practice, and leprosy patients are seldom referred for structured foot care before ulceration occurs. Integrating podiatric assessment, offloading and footwear provision into leprosy reference services would target the very deficit this study documents: plantar sensory loss that remains unrecognized until deformity is established. The regional map of grade 2 disability can guide where such integration should begin.

For podiatric and public health practice, the findings redirect attention to the South and Southeast of Brazil, where low incidence coexists with a high share of late diagnosis. Foot screening of suspected cases, monofilament testing of the plantar surface, and surveillance of the grade 2 indicator in states with falling detection rates are measures that could shorten the interval between first symptom and diagnosis and prevent plantar deformity.

CONCLUSIONS

Grade 2 disability at diagnosis increased among new leprosy cases in Brazil between 2015 and 2023 and concentrated in the South and Southeast, the regions of lowest endemicity. The temporal rise persisted after excluding the pandemic years, and every macro-region followed the same upward course. The proportion of new cases with grade 2 disability was associated with nerve involvement, multibacillary disease, older age, illiteracy and male sex, a profile that identifies the patients most likely to arrive with established deformity. The concentration of disability in the feet of patients diagnosed late supports early plantar assessment, monofilament testing and protective footwear as priorities for podiatric involvement in leprosy control.

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