RESEARCH PAPER

Body Mass Index and Serum Iron Parameters In Relation To Clinical Status of Leprosy: A Systematic R

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ABSTRACT

Background: Leprosy is a chronic infectious disease characterized by a broad clinical spectrum ranging from paucibacillary (PB) to multibacillary (MB) disease. Nutritional status and iron metabolism have been proposed as potential indicators of disease severity; however, their associations with clinical manifestations remain uncertain. This systematic review synthesized current evidence on the relationship between body mass index (BMI), iron-related biomarkers, and clinical status in patients with leprosy.

Methods: A systematic review was conducted following the PRISMA 2020 guidelines. PubMed, Cochrane Library, PLOS ONE, and grey literature were searched for observational studies published between 2012 and 2025. Eligible studies evaluated BMI and/or iron-related biomarkers in relation to leprosy clinical outcomes, including PB/MB classification, reactional states, deformities, disability, plantar ulcers, or bacillary burden. Methodological quality was assessed using the Newcastle–Ottawa Scale.

Results: Six observational studies met the inclusion criteria. Evidence consistently demonstrated that BMI was not significantly associated with major clinical outcomes, including leprosy reactions, clinical classification, deformities, or plantar ulcers across different populations. In contrast, iron-related biomarkers showed stronger associations with disease severity. Low serum iron concentrations were significantly associated with MB leprosy, while hepcidin expression positively correlated with bacilloscopic index, suggesting increased iron sequestration in patients with higher bacillary loads. These findings indicate that disturbances in iron homeostasis are more closely linked to disease burden than general anthropometric status.

Conclusions: Current evidence indicates that BMI has limited utility as a marker of clinical status in leprosy. Conversely, serum iron parameters, particularly when interpreted alongside inflammation-related biomarkers such as hepcidin, may better reflect multibacillary disease severity. Well-designed prospective studies using standardized nutritional and biochemical assessments are warranted to establish their prognostic and clinical value.

Keywords: Body Mass Index; Hepcidins; Iron; Leprosy; Nutritional Status.

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INTRODUCTION

Leprosy, or Hansen's Disease, is a chronic infection caused by Mycobacterium leprae. This pathogen primarily affects the skin and peripheral nerves, resulting in clinical manifestations such as skin lesions and nerve damage (1). Leprosy can induce granulomatous inflammation, impacting various body parts, and is diagnosed based on clinical signs (2). Despite advancements, this pathological condition remains a public health concern, with approximately 200,000 new cases reported annually, particularly in tropical and subtropical regions (3). The World Health Organization has established goals for leprosy elimination, achieving a prevalence of less than 1 case per 10,000 people in most countries by 2010 (4). Clinically, leprosy is influenced by the immune response, notably involving B-cells, which exhibit reduced memory B-cells and elevated levels of mature B-cells. This is indicative of higher IgG levels and bacterial load (5).

Another metric for evaluation is nutritional status, which is most effectively assessed through body mass index (BMI). In leprosy cohorts, BMI can reveal a "double burden" pattern, characterized by the coexistence of underweight and excess weight. For instance, obesity, as determined by BMI, has been observed alongside broader anthropometric and functional issues in outpatient samples (6). Nevertheless, the relationship between BMI and clinical outcomes is not consistently observed. Longitudinal

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primary-care follow-up studies have found no significant association between BMI categories and reactional states (7). Furthermore, other observational datasets have reported no statistically significant correlation between anthropometric parameters, including BMI, and clinical forms or plantar ulcers (8). Similarly, a BMI of less than 18.5 kg/m² was not linked to reactions, deformities, or PB/MB categories in a treatment-naïve cohort (9).

In addition to anthropometric measures, iron status is a biologically plausible indicator associated with bacillary load and inflammation-related dysregulation. Multibacillary leprosy has been linked to disrupted iron homeostasis, characterized by decreased total iron-binding capacity (TIBC) and altered serum iron indices. This pattern is consistent with both anaemia of inflammation and iron deficiency (10). Furthermore, elevated hepcidin levels have been observed in multibacillary patients, correlating with the bacilloscopic index, which supports the notion of inflammation-driven iron sequestration at infection sites. Clinically, low serum iron levels (<41 µg/dl) have been significantly associated with multibacillary leprosy (9). This systematic review, therefore, synthesizes existing evidence on the relationship between body mass index (BMI) and serum iron parameters with the clinical status of leprosy, including operational classification, reactional states, and severity-related outcomes.

METHODS

This systematic review employs the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines for the search and selection of articles to be included in the studies. Articles considered for inclusion must comply with the following PICOS criteria:

- **Population (P):** Human participants diagnosed with leprosy/Hansen's disease, regardless of age, sex, or treatment stage.
- **Intervention (I)**: Measurement of serum iron or related iron-status markers (e.g., ferritin, transferrin saturation, TIBC, hepcidin) and/or BMI (continuous or categorical nutritional status).
- **Comparator (C):** For correlation studies, not mandatory; if present, comparisons across clinical status groups (paucibacillary vs multibacillary; Ridley–Jopling categories; bacterial index strata; presence vs absence of reactions; WHO disability grades) will be extracted.
- **Outcomes (O):** Reported clinical status/severity of leprosy (WHO PB/MB classification, Ridley–Jopling class, bacterial or morphological index, reaction status such as type-1 or erythema nodosum leprosum, WHO disability grade) and any measures of association (correlation coefficients, regression coefficients, odds ratios, risk ratios, mean differences).
- **Study design (S):** Observational designs (cross-sectional, case-control, cohort) and baseline data from interventional studies if they provide relevant association data.

Inclusion and Exclusion Criteria

Eligible studies were peer-reviewed articles or grey literature reporting original data from human participants with confirmed leprosy. Studies were included if they evaluated serum iron, iron-related biomarkers, and/or body mass index (BMI) in relation to at least one clinical status outcome, including leprosy classification, bacterial index, reaction status, or disability grade. Studies were required to report effect estimates (e.g., correlation coefficients, regression coefficients, odds ratios, or risk ratios) or provide sufficient raw data to calculate these estimates.

Studies were excluded if they were animal or in vitro studies, case reports, or small case series involving fewer than 10 participants. Reviews, systematic reviews, meta-analyses, editorials, commentaries, and study protocols without original data were also excluded. In addition, studies that did not assess serum iron, iron-related biomarkers, or BMI, or that lacked relevant clinical status outcomes, were excluded. When duplicate datasets were identified, only the most comprehensive or most recent publication was retained.

Study selection & data extraction

All retrieved records were imported into a reference management software, and duplicate records were removed before screening. Two reviewers independently screened titles and abstracts, followed by full-text assessment of potentially eligible studies. Any disagreements regarding study eligibility were resolved through discussion or consultation with a third reviewer. Data were extracted using a standardized data extraction form. The extracted information included study characteristics (publication year, country, study design, and setting), participant characteristics (sample size, age, sex, leprosy classification, and treatment status), exposure variables (serum iron concentrations, iron-related biomarkers, and BMI), clinical outcomes (leprosy classification, bacterial index, reaction status, and disability grade), reported effect estimates, and relevant information on potential confounding factors or comorbidities.

Search Strategy

Article searches were conducted using three electronic databases (PubMed, Cochrane Library, and PLOS ONE), and a hand search of grey literature was also performed. Keywords were specifically tailored for each database.

For PubMed, the following search strategy was used:

(("Leprosy"[Mesh] OR leprosy[tiab] OR "Hansen disease"[tiab] OR "Hansen's disease"[tiab] OR hanseniasis[tiab] OR "Mycobacterium leprae"[tiab]) AND (("Iron, Serum"[Mesh] OR "serum iron"[tiab] OR iron[tiab] OR ferritin[tiab] OR transferrin[tiab] OR "transferrin saturation"[tiab] OR TSAT[tiab] OR "total iron binding capacity"[tiab] OR TIBC[tiab] OR hepcidin[tiab] OR "iron deficiency"[tiab] OR anemia[tiab]

OR anaemia[tiab] OR hemoglobin[tiab] OR haemoglobin[tiab]) OR ("Body Mass Index"[Mesh] OR BMI[tiab] OR "body mass index"[tiab] OR "nutritional status"[tiab] OR nutrition*[tiab] OR malnutrition[tiab] OR undernutrition[tiab] OR underweight[tiab] OR overweight[tiab] OR obesity[tiab] OR anthropometr*[tiab] OR "body weight"[tiab])))).

For the Cochrane Library, the search strategy consisted of: (leprosy OR "Hansen disease" OR "Hansen's disease" OR "Mycobacterium leprae") AND ("serum iron" OR ferritin OR transferrin OR TIBC OR "transferrin saturation" OR hepcidin OR "iron deficiency") AND ("body mass index" OR BMI OR "nutritional status" OR underweight OR overweight OR obesity) AND ("clinical status" OR severity OR classification OR paucibacillary OR multibacillary OR "Ridley-Jopling" OR "bacterial index" OR ENL OR "erythema nodosum leprosum" OR disability).

For PLOS ONE, the following search terms were applied: (leprosy OR "Hansen disease" OR "Mycobacterium leprae") AND ("serum iron" OR ferritin OR transferrin OR TIBC OR "transferrin saturation" OR hepcidin) AND ("body mass index" OR BMI OR "nutritional status") AND (severity OR classification OR paucibacillary OR multibacillary OR "bacterial index" OR ENL OR disability OR "clinical status").

For grey literature, two complementary search queries were used. The iron-focused query included the terms *leprosy* OR "Hansen disease" combined with "serum iron", ferritin, and transferrin, together with the outcomes (severity OR classification OR paucibacillary OR multibacillary OR "bacterial index"). The nutritional status-focused query combined *leprosy* OR "Hansen disease" with "body mass index", BMI, and "nutritional status", together with the outcomes (severity OR classification OR multibacillary OR paucibacillary OR "bacterial index").

RESULTS

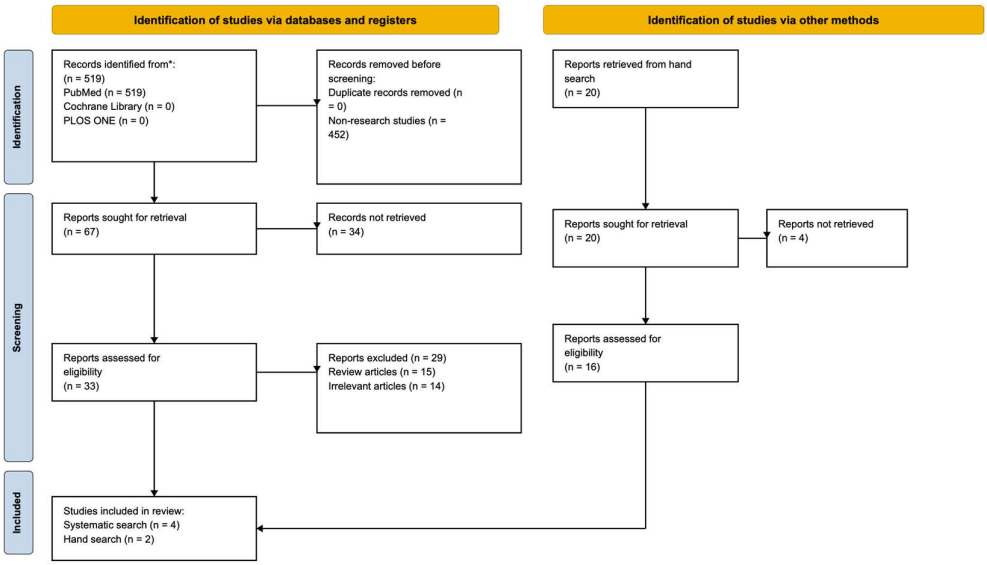

Figure 1. PRISMA Guideline for Article selection process

Table 1. Study Characteristic

Study	Country / Setting	Study Design	Sample Size (N)	Clinical Status / Leprosy Profile	Age	Sex	Treatment Status	Key Variables Relevant to Systematic Review
Montenegro et al., 2012	Greater Vitória, Espírito Santo, Brazil (primary	Longitudinal follow-up (up to 6 months after MDT completion)	151	Operational classification (PB/MB); reaction occurrence assessed	10–74 years; age-group distribution reported	Female: 78 (51.7 %)	Followed until 6 months after MDT completion	BMI and anthropometric indicators; BMI categories

	healthcare clinics)							analyzed according to reaction status
Souza et al., 2012	São Paulo, Brazil (tertiary leprosy referral outpatient clinic)	Observational biomarker study	38 leprosy patients (including 16 MB) plus controls	Multibacillary (BL/LL) subgroup emphasized	Not reported	Gender-matched with controls	Patients enrolled during months 6–12 of MDT	Serum iron metabolism biomarkers, including ferritin, transferrin, TIBC, and hepcidin
Teixeira et al., 2019	Semi-arid municipalities, Bahia, Brazil (Integra Hans cohort)	Cross-sectional (derived from census cohort)	276	Operational classification (PB/MB); reactive episodes and disability reported	Not reported	Not reported	Most participants had completed MDT (RFT)	Nutritional status, overweight/obesity prevalence, sociodemographic and clinical characteristics
Oliveira et al., 2017	Eastern Amazon Region, Brazil	Cross-sectional comparative study	75 (31 with plantar ulcers; 44 without ulcers)	PB/MB classification reported; ulcer subgroup comparison	20–60 years	Female: 10/31 (ulcer group), 17/44 (non-ulcer group)	Not reported	BMI, albumin, transferrin, and C-reactive protein (CRP)
Jindal et al., 2022	Uttarakhand, India (tertiary dermatology outpatient clinic)	Prospective observational study	50	WHO PB/MB and Ridley–Jopling classification	Mean 40.5 ± 15.3 years	Male: 38 (76%); Female: 12 (24%)	Newly diagnosed, treatment-naïve; MDT initiated after enrollment	BMI, serum iron, hemoglobin, albumin, cholesterol, and CRP
Figueiredo et al., 2025	Minas Gerais, Brazil (multidisciplinary leprosy outpatient clinic)	Cross-sectional convenience sample	20	Operational PB/MB classification	Mean 54.35 ± 14.36 years	60% male	Mixed population (7 receiving MDT, 12 released from treatment but under follow-up)	BMI classification, dietary micronutrient adequacy (including iron intake), and

								nutritional assessment

Table 2. BMI with Leprosy Patient Clinical Status

Study	BMI Assessment	Clinical Status Outcome	Main Findings
Montenegro et al., 2012	BMI categories	Reactional state	No significant association was observed between BMI category and reactional state ($p = 0.2408$).
Oliveira et al., 2017	BMI as an anthropometric indicator	Plantar ulcers; PB vs. MB clinical classification	Anthropometric parameters, including BMI, were not significantly associated with clinical forms of leprosy or the presence of plantar ulcers ($p > 0.05$).
Teixeira et al., 2019	Nutritional status assessed using BMI	Operational classification and disability profile (descriptive)	Overweight and obesity were present in 60.1% of participants. Most patients had multibacillary disease (83.0%) and physical disability (75.4%); however, no direct association between BMI and clinical status was reported.
Jindal et al., 2022	BMI categories (underweight, normal weight, overweight)	Leprosy reactions, deformities, and PB/MB classification	Underweight status (BMI <18.5 kg/m²) was not significantly associated with leprosy reactions ($p = 0.95$), deformities ($p = 0.23$), or PB/MB classification ($p = 0.23$).
Figueiredo et al., 2025	BMI categories	Activity limitation (SALSA scale)	BMI distribution, including obesity prevalence, was reported. Although 85% of participants experienced some degree of activity limitation, no inferential analysis evaluating the association between BMI and SALSA scores was performed.

Table 3. Serum Iron Level with Leprosy Clinical Status

Study	Iron-Related Biomarker(s)	Clinical Status Outcome	Main Findings
Jindal et al., 2022	Serum iron (iron deficiency defined as <41 μg/dL)	WHO classification (PB vs. MB)	Low serum iron levels were significantly associated with multibacillary (MB) leprosy (p = 0.03).
Souza et al., 2012	Serum iron and iron-regulatory biomarkers (including hepcidin)	Multibacillary status and bacilloscopic index	Patients with MB leprosy demonstrated elevated serum hepcidin levels, which were positively correlated with the bacilloscopic index (r = 0.482, p = 0.025). Serum iron levels were lower than those of healthy controls, although the difference showed only borderline statistical significance.

Table 4. BMI and Serum Iron Level with Leprosy Patient Clinical Status

Study	BMI Findings	Serum Iron Findings	Additional Notes
Jindal et al., 2022	Underweight status (BMI <18.5 kg/m²) was not significantly associated with leprosy reactions (p = 0.95), deformities (p = 0.23), or PB/MB classification (p = 0.23).	Low serum iron (<41 μg/dL) was significantly associated with multibacillary (MB) leprosy (p = 0.03). Serum iron was not associated with leprosy reactions (p = 0.52) or deformities (p = 0.66).	Mean BMI and serum iron levels were also compared between tuberculoid and lepromatous leprosy. No significant difference in serum iron levels was observed between these clinical forms (p = 0.27).

Risk of Bias

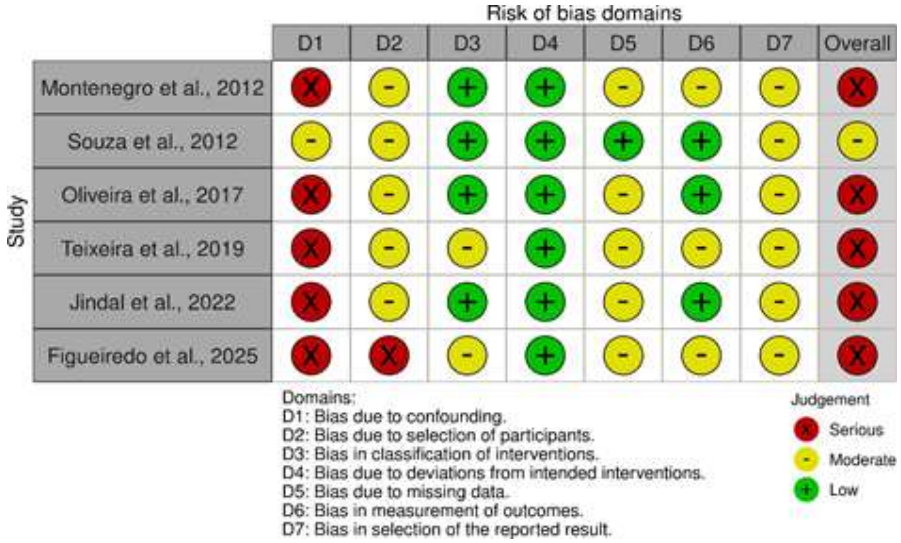

Figure 2. Risk of Bias (Robins-I) Assessment

The risk of bias was evaluated using the ROBINS-I tool across seven domains (D1–D7). Among the six studies included, five were determined to have a serious risk of bias, with only Souza et al. (2012) being rated as having a moderate overall risk. The primary factor contributing to the serious bias across the evidence base was confounding (D1), which was assessed as serious in the studies by Montenegro et al. (2012), Oliveira et al. (2017), Teixeira et al. (2019), Jindal et al. (2022), and Figueiredo et al. (2025). The selection of participants (D2) was generally rated as moderate, but was elevated to serious in Figueiredo et al. (2025), indicating increased concerns regarding participant inclusion in the analysis. Conversely, deviations from intended interventions (D4) consistently exhibited a low risk across all studies, suggesting minimal concern that post-exposure behaviors or co-interventions systematically affected outcomes. The classification of interventions/exposures (D3) was predominantly low risk, with moderate concerns noted in Teixeira et al. (2019) and Figueiredo et al. (2025). Missing data (D5) was mainly moderate across five studies, with only Souza et al. (2012) demonstrating a low risk. Outcome measurement (D6) varied from low risk in Souza et al. (2012), Oliveira et al. (2017), and Jindal et al. (2022) to moderate risk in Montenegro et al. (2012), Teixeira et al. (2019), and Figueiredo et al. (2025). The selection of the reported result (D7) was consistently moderate across all studies, indicating a potential susceptibility to selective reporting

or analytical flexibility, even if not explicitly evident.

At the study level, Montenegro et al. (2012) was assessed as overall serious due to significant confounding (D1), along with moderate concerns regarding selection, missing data, outcome measurement, and selective reporting (D2, D5–D7), despite a low risk in exposure classification and deviations (D3–D4). Souza et al. (2012) received the most favorable evaluation with an overall moderate rating, demonstrating low risk across D3–D6, but maintaining moderate concerns for confounding, participant selection, and selective reporting (D1, D2, D7). Oliveira et al. (2017) was judged as overall serious, primarily due to significant confounding (D1), with additional moderate concerns in selection, missing data, and reporting (D2, D5, D7). Teixeira et al. (2019) was also rated as overall serious, combining significant confounding (D1) with multiple moderate domains (D2, D3, D5–D7). Jindal et al. (2022) remained overall serious due to significant confounding (D1), despite low risk for D3, D4, and D6, and moderate concerns for D2, D5, and D7. Figueiredo et al. (2025) was rated as overall serious, with compounded concerns from both significant confounding (D1) and serious participant selection bias (D2), plus moderate risk in D3 and D5–D7. Collectively, the evidence indicates that pooled or comparative inferences should be interpreted with caution, as residual confounding and, in at least one study, participant selection processes are likely to materially influence observed associations, even when other domains (notably D4) appear robust.

Study Description

Six observational studies published between 2012 and 2025 were included in this review, all conducted in leprosy-endemic settings and involving adult patients receiving treatment or follow-up care. Most studies used cross-sectional designs and classified disease status using operational categories (paucibacillary vs multibacillary), clinical forms, disability grade, or function/activity limitation scales. Anthropometric status was predominantly assessed using body mass index (BMI), complemented in some studies by arm circumference, skinfolds, or bioimpedance parameters, while iron status was evaluated either indirectly through dietary intake estimates or directly through serum and regulatory biomarkers.

Five studies primarily explored nutritional status and BMI in relation to clinical severity or functional impact of leprosy. Hospital- and outpatient-based Brazilian cohorts assessed BMI distributions across operational classification, presence of neuropathic complications such as plantar ulcers, and disability or activity limitation scores, consistently showing a high burden of both undernutrition and excess weight among leprosy patients. One Brazilian cross-sectional study of 20 individuals followed at a multidisciplinary leprosy clinic reported that 40% of patients were obese by BMI criteria, with additional evidence of excess adiposity and reduced muscle mass, and examined how these nutritional alterations clustered with multibacillary disease, activity limitation, and restricted social participation. Another pharmacokinetic study in multibacillary cases evaluated BMI in relation to dapsone exposure, while other surveys linked anthropometric status to the presence of plantar ulcers or higher disability grades, suggesting that both low and high BMI may coexist with more advanced or complicated clinical presentations.

One mechanistic study specifically investigated iron metabolism in multibacillary leprosy, comparing 38 patients with matched controls and integrating hematologic indices, serum iron parameters, inflammatory cytokines, and hepcidin expression in skin lesions and urine. This study demonstrated reduced circulating iron and total iron-binding capacity alongside elevated ferritin, soluble transferrin receptor indices, and markedly increased hepcidin levels in multibacillary patients, indicating a pattern compatible with inflammation-related iron sequestration rather than isolated iron deficiency. Hepcidin expression was higher in lepromatous lesions than in tuberculoid lesions, whereas ferroportin expression showed the opposite pattern, supporting a model in which altered iron handling within macrophages contributes to the microenvironment associated with multibacillary disease. Together, the included studies provide complementary evidence that both BMI and iron-related parameters are variably disturbed across the clinical spectrum of leprosy, and suggest that deviations in nutritional and iron status may be linked to more severe disease forms, disability, or functional limitation.

DISCUSSION

This review supports a differentiated view of nutritional and metabolic markers in leprosy: BMI appears to be an imprecise correlate of clinical status, whereas iron-related and other metabolic indicators show a closer relationship to bacillary burden and systemic impact. Across several cohorts, BMI categories did not consistently predict reactional episodes, deformities, operational classification or plantar ulcers, suggesting that total body mass alone does not adequately capture the complex interaction between neuropathy, disability, socioeconomic context and disease expression (7–9). At the same time, population and clinic studies describe a “double burden” pattern in which overweight and obesity coexist with food insecurity, functional limitation and suboptimal diet, indicating that both excess and deficit of body mass may be present in people affected by leprosy (6,11,12).

The newer evidence broadens this picture by linking nutritional status, oxidative stress and cardiometabolic risk. Nigerian multibacillary patients on multidrug therapy and those released from treatment showed lower BMI and total cholesterol, but also higher indices of oxidative stress and, in the released-from-treatment group, a more atherogenic lipid profile and waist–hip ratio, suggesting persistent cardiovascular vulnerability despite bacteriological cure (12). Ethiopian case–control data demonstrated that underweight (BMI <18.5 kg/m²) was strongly associated with leprosy (adjusted OR 9.25), and food insecurity indicators such as skipping meals and lack

of money for food were also linked to disease, reinforcing the role of chronic undernutrition as a susceptibility factor (13). In Bali, plasma IGF-1, a more sensitive marker of nutritional and anabolic status, showed a strong inverse correlation with bacterial index, indicating that poorer nutritional–endocrine profiles track with higher bacillary loads even where BMI is often normal (14). Taken together, these findings help explain why BMI alone shows weak and inconsistent associations in our synthesis: it is a crude anthropometric proxy that fails to distinguish between undernourished, sarcopenic and metabolically unhealthy phenotypes that are better captured by functional, biochemical or endocrine markers.

By contrast, the iron axis appears more mechanistically "wired" into leprosy pathogenesis. Experimental work has shown that *M. leprae* subverts host cell metabolism, including lipid and iron pathways, to support bacterial persistence and disease tolerance (15). Clinical studies further demonstrate a profile compatible with mixed anaemia of inflammation and iron deficiency in multibacillary disease, with elevated hepcidin correlated to bacilloscopic index, supporting inflammation-driven iron sequestration as part of the lesional micro-environment (10). Low serum iron has been significantly associated with multibacillary classification, even when BMI does not discriminate across clinical categories (9). Within this framework, iron parameters are not merely nutritional markers but also indicators of host–pathogen interaction and inflammatory load, which may explain the more consistent association signal observed in this review.

The broader social and epidemiological context also modifies how BMI and iron status relate to clinical outcomes. Large-scale Brazilian data show that conditional cash-transfer coverage can reduce leprosy incidence in high-burden municipalities, particularly for paucibacillary and disability-associated cases, underlining the contribution of poverty alleviation, food security and healthcare access to disease control (16). Household-level transmission studies in Bangladesh highlight that highly smear-positive index cases are the dominant risk factor for leprosy development among contacts, emphasizing that exposure intensity and delayed diagnosis interact with host susceptibility rather than BMI alone determining risk (17,18). The Ethiopian case–control work further aligns with this by linking food insecurity and undernutrition to leprosy, suggesting that structural deprivation and dietary compromise modulate immune competence and thereby alter the clinical expression of infection (13).

Evidence from outside leprosy strengthens the interpretation that BMI behaves as a context-dependent risk marker in populations with disability and chronic disease. Longitudinal Korean cohort data show that people with physical disabilities accumulate higher BMI over time and are more likely to follow high-BMI trajectories if they are women, live alone or are economically inactive (19). Similarly, in a Japanese sample, higher BMI, living alone, greater alcohol intake and short sleep were jointly associated with reduced gray-matter volume, suggesting that overlapping lifestyle risks, rather than BMI in isolation, drive neurobiological consequences (20). These findings parallel the situation of many leprosy-affected individuals who live with chronic disability, stigma and social isolation, and they support interpreting BMI within a multidimensional matrix of functional capacity, mental health and lifestyle rather than as a simple linear predictor of leprosy severity.

Overall, the integrated evidence suggests that while BMI remains a useful, low-cost screening tool, its standalone value as a marker of leprosy clinical status is limited and should be complemented by indicators of undernutrition, food insecurity, functional limitation and metabolic stress, such as IGF-1 or lipid profiles (12–14). In contrast, serum iron parameters, interpreted within an inflammation-aware framework and supported by mechanistic data on host iron metabolism, emerge as more robust correlates of multibacillary disease and bacillary load (10,15). Future observational and interventional studies should therefore standardize clinical status endpoints, incorporate comprehensive nutritional and metabolic profiling, and explicitly address social determinants such as poverty and food insecurity, to clarify how BMI, iron and related markers can be integrated into practical risk-stratification and management algorithms for leprosy.

CONCLUSIONCurrent evidence suggests that BMI alone has limited value as an indicator of clinical status in patients with leprosy, as no consistent associations were observed with reactional states, operational classification, deformities, plantar ulcers, or functional impairment across the included studies. Although abnormalities in nutritional status are common among individuals affected by leprosy, BMI appears to be an insufficient surrogate for the complex interplay between nutritional status, inflammation, disability, and disease severity. In contrast, iron-related biomarkers, particularly low serum iron and elevated hepcidin expression, demonstrated more consistent associations with multibacillary disease and bacillary burden, highlighting the role of inflammation-mediated iron dysregulation in leprosy pathogenesis. These findings suggest that iron metabolism markers may provide greater clinical utility than BMI for assessing disease severity and monitoring patients with advanced leprosy. Nevertheless, the available evidence is limited by the observational nature of the included studies and their overall moderate-to-serious risk of bias. Future well-designed prospective studies incorporating standardized nutritional, inflammatory, and iron metabolism assessments are needed to establish clinically applicable biomarkers for disease stratification and prognosis in leprosy.

DECLARATIONS

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

HS conceptualized the study, conducted the literature search, screened the studies, extracted and analyzed the data, and drafted the manuscript. AA, FT, DK, AN, and NRF contributed to study design, data interpretation, critical revision of the manuscript, and supervision of the review process. All authors read and approved the final manuscript.

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