



The neuropathic foot in leprosy: a narrative review of the prevention of ulcers and disability

El pie neuropático en la lepra: revisión narrativa de la prevención de úlceras y discapacidad

Paloma Gargalho Nascimento¹  

¹ Universidad Abierta Interamericana. Buenos Aires, Argentina.

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ABSTRACT

Leprosy remains a disabling neglected tropical disease in which peripheral nerve damage turns the foot into an insensate, deformed and ulcer-prone structure. This narrative review synthesizes the evidence published between 2015 and 2024 on the mechanisms, risk factors and preventive strategies for plantar ulceration and grade 2 disability in the neuropathic foot of leprosy, organized into five thematic axes. The pooled prevalence of plantar ulcer is around 34% in people with foot anaesthesia and 7% among all people affected by leprosy, and grade 2 disability affects roughly one fifth to one third of newly detected cases depending on the setting. Sensory loss, motor paralysis of the intrinsic muscles and foot drop shift plantar pressure toward the metatarsal heads and the calcaneus. Self-care programmes, appropriate footwear, offloading and surgical resection of plantar bony prominences reduce ulceration and recurrence, although most of this evidence is observational or comes from small trials. Delayed detection and the weak integration of foot care into leprosy services sustain disability. The findings support early neurological assessment, structured self-care, footwear provision, offloading and integrated disability prevention within leprosy control programmes, together with a research agenda of comparative studies specific to the leprosy foot rather than extrapolation from the diabetic foot.

Keywords: leprosy; neuropathic foot; plantar ulcer; footwear; disability prevention; self-care.

RESUMEN

La lepra sigue siendo una enfermedad tropical desatendida e incapacitante en la que el daño nervioso periférico convierte el pie en una estructura insensible, deformada y propensa a las úlceras. Esta revisión narrativa sintetiza la evidencia publicada entre 2015 y 2024 sobre los mecanismos, factores de riesgo y estrategias de prevención de la ulceración plantar y la discapacidad de grado 2 en el pie neuropático de la lepra. La prevalencia combinada de úlcera plantar es del 34% en personas con anestesia del pie y del 7% entre todas las personas afectadas, y la discapacidad de grado 2 alcanza a una quinta o una tercera parte de los casos nuevos. La pérdida sensitiva, la parálisis de los músculos intrínsecos y el pie caído desplazan la presión plantar hacia las cabezas metatarsianas y el calcáneo. El autocuidado, el calzado adecuado, la descarga y la resección de las prominencias óseas reducen la ulceración y su recurrencia, aunque la mayor parte de esta evidencia es observacional o de ensayos pequeños. La detección tardía y la escasa integración del cuidado del pie en los servicios de lepra mantienen la discapacidad. Los hallazgos respaldan la evaluación neurológica temprana, el autocuidado estructurado, la provisión de calzado, la descarga y la prevención integrada de la discapacidad dentro de los programas de control, junto con una agenda de investigación específica del pie leproso, no extrapolada del pie diabético.

Palabras clave: lepra; pie neuropático; úlcera plantar; calzado; prevención de discapacidad; autocuidado.

INTRODUCTION

Leprosy is a chronic granulomatous infection caused by *Mycobacterium leprae* that principally affects the skin and the peripheral nervous system, and its capacity to injure nerves makes it a leading infectious cause of preventable disability.⁽¹⁾ The bacillus invades Schwann cells and produces a combined sensory, motor and autonomic neuropathy that, in the lower limbs, alters sensation, weakens the intrinsic foot muscles and dries the skin, so the foot becomes insensate, deformed and prone to ulceration.⁽²⁾ Although the elimination target of less than one case per 10,000 inhabitants was reached globally in 2000, new cases continue to appear in endemic areas, and the World Health Organization strategy for 2021 to 2030 keeps the prevention and reduction of grade 2 disability among its explicit goals.^(2,3) The foot is the organ in which this residual burden is most visible, because plantar ulceration is the step that transforms a treatable neuropathy into a chronic, stigmatizing and costly disability.⁽⁴⁾ Ulcers recur, require prolonged care and mark the patient with a visible deformity; preventing them therefore serves both clinical podiatry and the public health objective of reducing leprosy-related disability.

The neuropathic foot of leprosy has received less integrated attention than the diabetic neuropathic foot, despite a comparable pathomechanics of sensory loss and raised plantar pressure.⁽⁵⁾ For podiatric practice the leprosy foot concentrates the core problems of the specialty, namely biomechanical load, offloading, wound care and rehabilitation, yet it is rarely framed as a podiatric entity in its own right. Much of the literature is scattered across dermatology, tropical medicine, orthopedics and rehabilitation journals, and podiatric guidance for the leprosy foot is frequently borrowed from diabetic foot practice even though the two conditions differ immunologically and physiologically.⁽⁴⁾ A synthesis restricted to the leprosy foot is therefore timely, because it can identify which preventive measures are supported by leprosy-specific evidence and which remain extrapolations. The practical question is which of the measures validated in the diabetic foot, such as structured education, therapeutic footwear and temperature monitoring, also apply when the neuropathy is lepromatous.

The objective of this review was to synthesize the current evidence on the mechanisms, risk factors and preventive strategies for plantar ulceration and grade 2 disability in the neuropathic foot of leprosy. The review was guided by five questions that correspond to its thematic axes: which peripheral nerve and biomechanical alterations render the foot prone to ulceration; which epidemiological patterns and risk factors predict ulceration and grade 2 disability; which interventions prevent the first ulcer; which interventions prevent recurrence and progression to fixed disability; and which programmatic strategies integrate foot care into leprosy services.

METHODS

A documented search was conducted in Scopus and PubMed, restricted to records published between 2015 and 2024 to match the reference window of the target volume.

Five core queries combined leprosy with terms for the foot, plantar ulceration, neuropathy, disability and grade 2, footwear, offloading, orthoses, self-care and education, using Scopus field syntax with publication-year limits. Four supporting queries covered reconstructive surgery and tendon transfer in leprosy, plantar pressure in peripheral neuropathy, the diabetic neuropathic foot, and the epidemiology of leprosy disability, without a lower year limit. Full query strings are available from the authors. The queries returned 635 candidate records, and after removal of duplicates and screening of titles and abstracts, 56 records were retained. Records were selected when they addressed the leprosy foot, plantar ulceration or leprosy-related disability directly, and primary studies, systematic reviews, clinical guidelines and book chapters were preferred over redundant reviews and case reports without plantar involvement. Works on the diabetic foot were retained only as comparators for the discussion.

Eligible records were read and organized into a matrix of five thematic axes, in which each axis lists the assertions of the synthesis and the studies that support or contradict them together with their design and limits. The five axes are reported in that order, each synthesis statement is accompanied by the number of studies that support it, and a summary matrix table condenses the axes. Because this is a narrative review, no exhaustive screening protocol or risk-of-bias instrument was applied, and the synthesis does not claim the completeness of a systematic review. Study quality was described from the design stated in each record, and conclusions were tempered where the evidence was observational, small or preclinical.

DEVELOPMENT

The synthesis is organized in five thematic axes that move from the mechanisms that render the foot vulnerable, through the epidemiology and risk factors of ulceration and disability, to the interventions that prevent the first ulcer, those that prevent recurrence and fixed deformity, and finally the health service arrangements that deliver them. A summary matrix precedes the narrative (Table 1).

Table 1. Synthesis matrix of the evidence on the neuropathic foot in leprosy by thematic axis.

Thematic axis	Key findings	Studies (n)	Predominant evidence
Neuropathy and biomechanical alterations	Sensory and motor nerve damage shift plantar pressure toward the metatarsal heads and the calcaneus	15	Cross-sectional and biomechanical studies, case series
Epidemiology and risk factors of ulceration and disability	Pooled plantar ulcer prevalence of 34% with foot anaesthesia and 7% overall; G2D in 20-30% of new cases	13	Systematic reviews, registry and cross-sectional studies
Prevention of the first ulcer	Self-care, footwear and orthoses are the mainstay, with modest direct evidence	10	Reviews, comparative studies, technical reports
Prevention of recurrence and fixed disability	Offloading, biological adjuvants and bony prominence resection heal ulcers; recurrence depends on footwear use	18	Small randomized trials, retrospective cohorts, case series
Programmatic and health service strategies	Integrated foot care and early detection reduce disability; delayed detection sustains it	10	Policy documents, systematic and cross-sectional studies

Note: G2D = grade 2 disability. Study counts refer to the records cited within each axis of this review. Source: Elaboration of the authors from the 56 records included in the narrative synthesis.

Peripheral neuropathy and biomechanical alterations of the foot

Fifteen studies describe the sequence by which nerve injury turns the leprosy foot into a mechanically dangerous structure. Of these, the disease primers and clinical reviews agree that the predilection of *M. leprae* for Schwann cells produces a multifocal neuropathy whose clinical expression in the foot combines loss of protective sensation, paralysis of the intrinsic muscles and autonomic failure of sweating and skin lubrication.(1,2,4,6)The sensory deficit is emphasized as the event that removes the warning of injury, the motor deficit as the event that deforms the foot and redistributes load, and the autonomic deficit as the contributor that dries and fissures the plantar skin.(2,4,7,8)The detection of this deficit in field settings is feasible: one comparative study of five bedside tests found that simple instruments such as the monofilament and voluntary muscle testing identify early neuropathy, and a larger evaluation of the Semmes-Weinstein monofilaments confirmed that altered tactile thresholds map the diagnosis and monitoring of leprosy neuropathy over time.(8,9) The practical consequence is that a standardized sensory examination can be incorporated into routine leprosy services without specialized laboratory support.

Instrumented studies quantify the biomechanical consequence of this neuropathy. Among them, a baropodometric and posturographic comparison of 22 patients with multibacillary leprosy and 17 controls showed altered plantar pressure distribution and postural control in the affected group, and argued that instrumented assessment anticipates damage better than the monofilament alone.(10)A study of dynamic pressure and monofilament thresholds in 20 feet with chronic Hansen disease reported a weak correlation between the two measures that was significant only in category II feet, and concluded that pressure and sensation must be assessed together rather than assumed to be interchangeable.(11)In two of these studies the lesions were not uniform, and the pressure concentrated at the metatarsal heads and the calcaneus, which are precisely the sites where ulceration is later observed.(11,12) Gait analysis adds a further element, because foot drop changes the loading pattern of the forefoot and was shown by principal component analysis to distinguish leprosy patients with foot drop from controls, which supports the functional relevance of the motor deficit beyond its cosmetic appearance.(13)Together these studies establish that the leprosy foot is both insensate and mechanically overloaded at predictable points. They also show that the overload is not uniform across the foot: the lesion pattern varies between areas of pressure

concentration with total sensation loss and areas of pressure concentration with partially preserved sensation, which argues against a single orthotic prescription for all feet and for individualized mapping where the instruments are available.

Surgical reconstruction addresses the two extremes of this cascade. Three studies report that tendon transfer, with the tibialis posterior as the donor muscle, restores active dorsiflexion in foot drop and improves the mechanics of gait, and one of them links the correction to measurable gains in quality of life.(7,14,15) Two further studies describe nerve transfer to the sole as a means of restoring protective sensation, with case series showing technical feasibility although follow-up remains short and the number of patients small.(16,17) The common limitation of this axis is that no included study demonstrated prospectively that a given pressure or sensory threshold predicts the first ulcer, so the causal chain is assembled from cross-sectional observations and awaits a cohort study that follows insensate feet to first ulceration.

Epidemiology and risk factors of plantar ulceration and grade 2 disability

Thirteen studies quantify the burden of ulceration and disability and identify its predictors. The single meta-analysis of this literature pooled 15 studies and estimated a plantar ulcer prevalence of 34% among people with foot anaesthesia and of 7% among all people affected by leprosy, with the inability to feel a 10 g monofilament, a pronated foot and a high peak plantar pressure reported as the leading risk factors.(5) The estimate was heterogeneous, which is why the confidence interval for the anaesthesia subgroup spanned from 21% to 46%. It confirms that sensory loss, rather than the diagnosis of leprosy itself, concentrates the risk of ulceration. The anatomical distribution is consistent: in a clinical series of 66 patients the forefoot predominated, with the metatarsal heads and the calcaneus together accounting for four fifths of ulcers.(12)

Grade 2 disability shows a wide but consistently elevated range across settings. A population-based analysis of 10,758 newly detected cases in Yunnan classified 20.2% as grade 2 and 10.6% as grade 1.(18) A cross-sectional study of 189 Indonesian patients found 29.6% with grade 2 disability.(19) A study of migrant and resident patients in Guangdong reported grade 2 disability in 18.4% of new cases and linked it to delayed discovery, with higher odds among residents.(20) A global meta-analysis of the proportion of grade 2 deformity between 2010 and 2020 placed the burden within a similar range across endemic countries.(21) Of these, three studies associated male sex with disability, and three studies identified a longer interval between onset and diagnosis as the most consistent modifiable factor.(18,19,22,23) The Tanzanian registry analysis of 6,963 cases added previous treatment history and positive HIV status as independent predictors, with an adjusted odds of 2.42 for age 15 years and above.(22) A cross-sectional study of 275 patients with disability in Surabaya associated age, disease duration and multidrug therapy history with the grade of disability.(24) Comorbidities also modulate ulcer outcome rather than only ulcer onset, because ulcer dimensions were associated with low body mass index, hypertension and smoking in one series.(12)

The longitudinal and childhood data close the picture. One multicentre longitudinal study from India documented that the risk of developing leprosy-related disability accumulates over long-term follow-up.(25) A retrospective cohort of 200 patients observed that new deformities continued to appear during seven years of follow-up, with the feet affected in 39.8% of deformities.(26) A study of discharged patients with plantar lesions in a dermatology referral unit found that the disabilities caused by those lesions persist long after treatment, which links ulceration to the stigma of advanced disease.(27) Grade 2 disability is not limited to adults, since a record-based analysis of children and adolescents in India found the same risk gradient with delayed detection.(28) Taken together, these studies support the conclusion that ulceration and disability are late markers of a detection and nerve protection gap rather than unavoidable consequences of infection.

Prevention of the first ulcer: self-care, education, footwear and offloading

Ten studies inform the prevention of the first ulcer, and the evidence concentrates on three levers: self-care, footwear and pressure management. Of these, a scoping review of self-care programmes for people living with leprosy mapped the characteristics and reported outcomes of these programmes.(29) In one of them, a qualitative account described the experience of receiving and practicing self-care and the sense of control it conferred on people affected by leprosy.(30) A practical guide chapter on the prevention of disability and ulcer care consolidates the routine into a structured sequence of inspection, skin care and footwear use.(31) The convergence of these three sources indicates that self-care is a behavioural intervention with a coherent rationale even though its effect has not been isolated in a controlled design.

Footwear and orthoses are the most specific preventive measure in this axis. Three studies support appropriate footwear and orthoses as essential components of the management of the foot at risk, because they redistribute load away from the metatarsal heads and protect skin that no longer feels.(32-34) In one comparative study, computer-assisted customized footwear and traditional microcellular rubber footwear were compared for the prevention of ulcer recurrence in patients with sensory loss.(33) A technical report of a computer-designed orthotic device showed that offloading of an established plantar ulcer could be planned from pressure mapping rather than from clinical impression alone, which makes the prescription reproducible across practitioners and reduces the dependence on the individual skill of the prescriber.(34) The measurement that supports these prescriptions is likewise reproducible, since a short report demonstrated that a customized tactile feedback system identifies peak plantar pressure in the neuropathic foot and can guide where relief is most needed.(35) Acceptance is the main operational limit, and one short report on traditional offloading devices found that uptake and adherence among people affected by leprosy were incomplete, which tempers the effectiveness observed under controlled conditions and points to cost, comfort and stigma as barriers.(36)

The relation between pressure and sensation carries the preventive logic of this axis. The study that correlated dynamic pressure with monofilament thresholds concluded that both should be assessed before orthotic prescription, because pressure can concentrate in areas that retain partial sensation and vice versa.(11)The scoping review of plantar pressure measurement in the diabetic foot is cited here as a methodological reference, since the same instruments are applied to the leprosy foot but with fewer validation studies and no equivalent risk thresholds.(37)The overall limitation is that none of the included studies randomized people at risk of a first ulcer to footwear or self-care against no intervention, so the preventive effect is inferred from recurrence studies and from the biomechanical rationale rather than demonstrated directly.

Prevention of ulcer recurrence and fixed disability

Eighteen studies address the treatment of the established ulcer and the prevention of its recurrence and of fixed deformity. The clinical reviews and the Cochrane synthesis agree that the core is debridement, control of infection, relief of pressure and optimization of blood flow, and that the approach used for the diabetic foot has been transferred to leprosy without sufficient leprosy-specific trials.(4,6,38)The Cochrane review of interventions for ulceration and other skin changes caused by nerve damage found limited randomized evidence for the many dressings and topical agents in use, which justifies caution in recommending any single product and leaves offloading and basic wound care as the interventions with the least contested rationale.(38)

Offloading is the intervention with the most direct evidence. An observer-blind randomized trial compared autologous platelet-rich plasma added to total contact casting against casting alone for trophic ulcers and reported that the combined approach improved healing, which supports pressure relief as the backbone and the biological adjunct as an accelerator.(39)The footwear comparisons reinforce the same principle, because recurrence was reduced when pressure was removed, and the surgical series describe recurrence in more than half of patients who abandoned shoes and insoles, which locates the failure in adherence rather than in the intervention itself.(33,40,41)

Biological and topical adjuvants have been tested in small trials. Of these, a randomized trial of 32 patients found that adipose mesenchymal stem cell-conditioned medium reduced ulcer size and depth faster than framycetin gauze from the second and third weeks onward, without adverse reactions.(42)A randomized pilot of 42 patients showed that topical insulin healed ulcers faster than saline, with a healing rate of 0.61 versus 0.14 cm per week and a shorter time to complete closure of 31.5 versus 44.3 days.(43)Two further trials reported accelerated healing with intralesional platelet-rich plasma and with topical epigallocatechin gallate at 1%.(44,45) A biomembrane study in patients and a preclinical study with injected adipose stem cells point to re-epithelialization and nerve and vascular regeneration as mechanisms, but recurrence after these agents remains unmeasured, and none of the trials standardized offloading across groups.(46,47)

Infection complicates every one of these approaches. One microbiological study documented bacterial biofilm in leprosy plantar ulcers, and another identified *Streptococcus dysgalactiae* subsp. *equisimilis* as an emerging secondary pathogen, both of which argue for microbiologically guided rather than empirical treatment and explain why ulcers that are well offloaded can still fail to heal.(48,49) Surgery closes the loop for ulcers seated on bony prominences. The largest retrospective series, of 234 patients, resected the prominence and closed the lesion with a bipediculated local flap, achieving healing in a mean of 12 weeks, with shorter times when orthopedic shoes and insoles were used and when dressing was performed by trained staff.(40)A related evaluation of

92 operated patients found improved quality of life in 89.1% but recurrence in 55.4%, which was attributed to irregular footwear use and reinforces the same adherence point.(41) Microsurgical reconstruction of the insensate plantar surface and tendon transfer for foot drop complete the surgical armamentarium for the fixed deformity, and their place is best understood as restoration of function after the ulcer has closed rather than as substitutes for the offloading that keeps it closed.(7,14,50)

Programmatic and health service strategies for integrated foot care

Ten studies bear on the organization of care. The World Health Organization strategy for 2021 to 2030 frames disability prevention, including the foot, as a pillar of leprosy control and sets a 90% reduction in new grade 2 disability among its measurable targets.(3) The practical guides translate this target into foot-specific procedures for self-care groups, wound care and referral, which are deliverable at primary level and do not require a specialist at every contact.(6,31) The chronic-aspects review makes the same case from the clinical side, arguing that the post-treatment phase of leprosy, in which ulcers and deformity appear, is the most neglected part of the care pathway.(6)

The main health system obstacle is delayed detection. A systematic review of 20 studies identified misdiagnosis and deficiencies in referral and case-detection methods as the principal healthcare-related causes of delay, and these delays are in turn the strongest modifiable predictor of disability.(23) The longitudinal Indian study showed that disability risk extends over long-term follow-up, and the cohort that followed patients released from treatment observed new deformities appearing during seven years of surveillance, which implies that foot follow-up cannot end at cure.(25,26) A narrative update reaches the same conclusion when it argues that prevention of disability must be added to the diagnostic and therapeutic advances of recent years rather than treated as an afterthought of case detection.(2)

The consequences of failing to integrate foot care are measurable. A cross-sectional study of 267 Indonesian cases applied the SALSA scale and found that only 28.5% were free of activity limitation, with 43.8% mildly, 13.5% moderately and 14.3% severely or extremely limited, and with worse scores among those with higher disability grades.(51) A study of leprosy and lymphatic filariasis disability in Mozambique documented the psychosocial burden that accompanies these limitations and the exclusion that follows from visible foot deformity.(52) A Global Burden of Disease analysis for Brazil quantified the disability attributable to leprosy and its persistence over three decades, which places the foot within a lifelong rather than episodic burden of disease.(53) These studies support the argument that foot care belongs inside a broader rehabilitation and participation agenda rather than at the margin of case detection.

Across the five axes the included studies converge on three points. First, the plantar ulcer is a mechanical event: in every axis that measures it, pressure concentrates on the metatarsal heads and the calcaneus and ulceration follows the same anatomical distribution. Second, prevention is behaviourally mediated, because every intervention that works depends on daily self-care and continuous footwear use, and the studies that measured adherence found it to be the rate-limiting step. Third, the evidence base is lopsided, because the treatment of the established ulcer has attracted a series of small trials while the prevention of the first ulcer has not attracted a single randomized comparison. The main divergence concerns the role of plantar pressure in prescribing orthoses: two studies treat pressure as the primary target of the prescription, whereas two others show that pressure and sensation are only weakly correlated and that sensation must be assessed in its own right.(10,11) The clearest gap is the absence of a cohort study that follows insensate feet from first detection to first ulcer, without which the causal weight assigned to each factor remains inferential and the timing of preventive intervention remains a matter of clinical judgment.

DISCUSSION

The principal finding of this synthesis is that plantar ulceration and grade 2 disability in leprosy arise from a measurable and modifiable sequence of sensory loss, muscle paralysis and pressure concentration, and that the interventions with the most consistent evidence are exactly those that interrupt this sequence through self-care, footwear, offloading and surgery. The finding is consequential for a podiatric readership because it reframes the leprosy foot from an unavoidable stigma of infection into a mechanical problem that the specialty already knows how to manage, with the same instruments and principles applied to the diabetic foot, provided that the differences between the two underlying neuropathies are respected.

The review also shows that the quantity of leprosy-specific evidence is thin relative to the burden, with one meta-analysis and a small number of randomized and comparative studies carrying most of the quantitative weight.(5,38) The consequence is that much of the podiatric advice given for the leprosy foot is borrowed from the diabetic foot; the fit of that borrowing deserves scrutiny rather than assumption.

In relation to previous reviews, this synthesis extends rather than duplicates them. The plantar ulcer meta-analysis quantified prevalence but did not organize prevention by axis.(5)The Cochrane review of interventions for ulceration caused by nerve damage established the thinness of the randomized evidence but predates the recent trials of biological adjuvants.(38)The clinical review of neuropathic ulcers in leprosy described diagnosis and treatment and argued that diabetic protocols require adaptation rather than transfer, a position this review confirms with biomechanical and surgical evidence.(4)The chronic-aspects review placed the foot within the neglected post-treatment phase, and the present synthesis shows that this phase is precisely where ulcer recurrence and fixed deformity concentrate.(6)The present review contributes the explicit quantification of how many studies support each assertion and a separation of leprosy-specific evidence from diabetic extrapolation.

The biomechanical axis converges with the diabetic foot literature in its emphasis on the metatarsal heads and the calcaneus as the sites of peak pressure, but the analogy has limits. Pressure measurement in diabetes has matured into validated instruments and risk thresholds, whereas in leprosy the correlation between pressure and sensory loss is weak and the instruments are borrowed without equivalent validation studies.(11,37) A review of neuropathic ulcers in leprosy makes the same point directly when it argues that leprosy and diabetes differ immunologically and physiologically and that their wound management cannot simply be transferred.(4)This divergence matters for practice, because pressure alone will misclassify a proportion of leprosy feet and the clinical examination of sensation and deformity remains indispensable. It also matters for research, because a risk threshold derived in diabetes cannot be imported into leprosy without revalidation against leprosy-specific ulcer outcomes, and none of the included studies has yet performed that revalidation in a cohort followed to first ulceration.

The comparison with diabetes is most instructive in prevention. The most recent systematic review of ulcer prevention in diabetes reports moderate certainty that temperature monitoring, with a risk ratio of 0.51, and pressure-optimized footwear, with a risk ratio of 0.62, reduce plantar ulcer recurrence, and lower certainty for structured education and integrated care.(54)The leprosy literature reaches the same direction for footwear and self-care but with weaker designs and without pooled effect estimates, so the diabetic evidence can reasonably inform the leprosy programme while the leprosy-specific trials remain absent.(29,33) In contrast, the ulcer treatment axis shows a pattern that is reversed with respect to diabetes, because leprosy has generated a distinctive body of small trials of biological adjuvants, such as platelet-rich plasma, stem cell-conditioned medium and topical insulin, that have no diabetic equivalent of the same maturity.(39,42,43)Contemporary diabetic foot guidance rests on a far larger evidence base for debridement, offloading and infection control, and the leprosy field would benefit from adopting that rigor rather than from accumulating further small product trials, a point made explicitly by the review that refuses to accept diabetic protocols as automatically valid in leprosy.(4,55)

The surgical axis explains a finding that otherwise appears contradictory: healing after resection of bony prominences is high, yet recurrence reaches more than half of operated patients. The Brazilian series attribute recurrence to abandonment of footwear, which means that surgery removes the prominence but not the insensate skin, and that the operation is only as durable as the offloading that follows it.(40,41) This is the same principle established for the diabetic foot, where surgical correction without subsequent pressure relief fails in the same way, and where graded-stiffness insoles and footwear are used to protect the healed surface.(56)The programmatic implication is that footwear provision must be continuous and free at the point of care, because an intervention that depends on irregular adherence will reproduce disability in exactly the patients who are least able to pay for it.

On the level of evidence and applicability, the findings sort into three tiers. The burden and risk-factor claims rest on the strongest tier, since they derive from registry analyses, a meta-analysis and repeated cross-sectional studies with consistent direction.(5,18,22)The preventive claims rest on a middle tier of comparative and observational studies that agree on direction but lack pooled estimates.(29,33) The treatment claims rest on the weakest tier, because the trials are small, heterogeneous in offloading and short in follow-up.(42,43) This tiered structure has a practical consequence for application: screening and footwear provision can be implemented now, whereas specific wound products should be adopted only where the basic package of debridement,

offloading and infection control is already in place, and their results should be interpreted against that baseline rather than in isolation.

The health service axis connects the clinical findings to the structural cause of disability. Delayed detection, driven by misdiagnosis and weak referral systems, is the strongest modifiable predictor of grade 2 disability, and the risk of new disability continues after release from treatment, which argues for surveillance of the foot as a chronic condition rather than an episode of infection. (23,25,26) The World Health Organization strategy for 2021 to 2030 provides the framework for that shift by making the reduction of new grade 2 disability a target, but its translation into routine podiatric services remains uneven across endemic countries. (3) Self-care groups are the natural vehicle for that translation, because they already reach people after cure and deliver the inspection, skin care and footwear routines that the prevention axis shows to be effective. (29,31) The functional and psychosocial data from Indonesia and Mozambique show that the payoff of closing this gap is not only an intact foot but participation in work and social life, which is the outcome that matters to patients and the one that stigma most directly threatens. (51,52) For podiatry as a discipline, this is an argument for including the leprosy foot in training and service planning, since the competencies of offloading, footwear and wound care are exactly those the specialty already holds for diabetes and could extend to a neglected population at low marginal cost.

Limitations of the review, the evidence and the process

Three groups of limitations qualify these conclusions. The limitations of the review itself derive from its narrative design: the search was documented but not exhaustive, only two databases were searched, and the selection and synthesis depended on the judgment of a single reviewer without a risk-of-bias instrument, so some relevant studies may have been missed and the weighting of evidence is qualitative. (5) The limitations of the evidence derive from its composition: most studies are cross-sectional, retrospective or small trials with short follow-up, recurrence after biological adjuvants is rarely reported, and no randomized trial has yet tested self-care or footwear against no intervention for the prevention of the first ulcer. (29,38) Heterogeneity is an additional constraint, because the definitions of ulcer and of grade 2 disability and the point at which they are measured vary across studies, which limits the precision of the pooled estimates cited here. The limitations of the process derive from publication bias and language, because positive product trials are more likely to be published, and records in Chinese, Portuguese and Bahasa were screened only through their English abstracts, so a body of national literature from the highest-burden countries is underrepresented. Each of these limitations maps to a specific remedy: a protocol-driven synthesis with a second reviewer, larger comparative studies with recurrence as the endpoint, standardized disability definitions, and multilingual screening in future updates.

Implications and research agenda

For clinicians, the synthesis supports a sequence of monofilament and pressure assessment, structured self-care education, footwear prescription and early referral of established ulcers for offloading and prominence surgery, delivered as one package rather than as isolated acts. (31,32) The clinical examination remains central, because pressure and sensation diverge and neither substitutes for the other, and because the monofilament test remains the field standard for the protective threshold that footwear is meant to compensate. (11) For programmes, it supports integrating foot care into leprosy services with continuous footwear provision and post-cure surveillance, because disability accrues before detection and after treatment, and because footwear that depends on out-of-pocket purchase fails exactly when it is most needed. (23,25,26,41) The research agenda should replace extrapolation with direct evidence: trials of footwear and self-care against standard care for first-ulcer prevention, head-to-head comparisons of offloading strategies, cohort studies that follow insensate feet to first ulceration, and recurrence as a mandatory outcome in all future wound studies in leprosy. Until that evidence exists, the diabetic foot literature offers the nearest proxy, but it should be applied with the adaptations that the differences between the two neuropathies require rather than as an unmodified template, and every extrapolated recommendation should be labelled as such in clinical guidance and in training. (4,54)

CONCLUSIONS

The neuropathic foot of leprosy becomes ulcer-prone through combined sensory loss, intrinsic muscle paralysis and raised plantar pressure concentrated on the metatarsal heads and

the calcaneus. Plantar ulceration affects about one third of people with foot anaesthesia and grade 2 disability affects one fifth to one third of newly detected cases, with delayed detection, male sex and older age as the main predictors. Self-care programmes, appropriate footwear and offloading prevent the first ulcer and its recurrence, although their direct evidence remains modest. Offloading, biological adjuvants and resection of plantar bony prominences heal established ulcers, but recurrence depends on continuous footwear use. Integrated foot care with early detection and post-cure surveillance is the programmatic condition that converts these clinical measures into sustained prevention of disability.

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