Journal of Diabetes and Its Complications 39 (2025) 108972

Contents lists available at ScienceDirect

Journal of Diabetes and Its Complications

journal homepage: www.elsevier.com/locate/jdiacomp

Implementation of evidence-based foot screening in people with diabetes: A scoping review

Jemma M. Houghton [a,*], Matthew C. Hynes [b], Nia W. Roberts [c], Helene-Mari van der Westhuizen [a], Joel A. Dave [d], Andrew Farmer [a]

[a] Nuffield Department of Primary Care Health Sciences, University of Oxford, United Kingdom of Great Britain and Northern Ireland
[b] School of Medicine, Faculty of Health Sciences, Queen's University, Canada
[c] Bodleian Health Care Libraries, University of Oxford, United Kingdom of Great Britain and Northern Ireland
[d] Division of Endocrinology, Department of Medicine, University of Cape Town, South Africa

ARTICLE INFO

Keywords:
Diabetic foot
Foot ulcer
Amputation
Ischaemia
Risk assessment
Diabetic neuropathy
Prevention & control

ABSTRACT

Background: Recommendations to prevent diabetes ulceration and amputation include an annual foot check, primarily screening for sensation and circulation. Using these simple, evidence-based components is vital to identifying complications early, assessing risk, and managing care to prevent or delay amputations. However, routine implementation of these assessments is suboptimal and approaches to their integration remain poorly understood.

Aim: We aimed to identify and synthesize information on the factors affecting implementation of simple evidence-based diabetes foot screening.

Methods: We reviewed published and grey literature using a blinded two-stage process by two independent reviewers. Included studies were primary research that implemented or improved foot screening for adults with type 1 or 2 diabetes, assessing at least one of the following: 10-*g* monofilament sensitivity, pedal pulse palpation, or history of ulceration or amputation. A thematic synthesis approach was used.

Results: We screened 5133 titles and abstracts, reviewed 102 full-text articles, and included 26 studies in the final analysis. We identified four key themes: (1) Existing diabetes screening (i.e. retinal screening) or treatment interventions (i.e. medication collection) provide opportunities for synergistic integration; (2) Annual event-based foot screening (e.g. on World Diabetes Day) in lower resource settings provides community-focused preventative care; (3) Further opportunities to increase access to foot screening include self-administered screening and screening in complex residential settings; (4) Healthcare provider champions are essential for local foot screening implementation in primary and secondary care.

Conclusion: Further research should evaluate the issues identified in these four themes, in different contexts, and with support of implementation frameworks.

1. Introduction

Foot ulceration and amputation are complications of poorly controlled diabetes. The annual foot ulcer incidence rate in the global diabetes population is around 2 %,[1,2] meaning approximately 18.6 million people worldwide experience a diabetes foot ulcer each year.[3] Around 50 to 60 % of these foot ulcers become infected, and 20 % of which lead to an amputation.[3]

Recommendations to prevent diabetes foot ulceration and amputation include an annual foot check consisting of six to eleven components such a skin inspection, assessment for foot deformities, evaluation of protective sensation, a vascular assessment, and footwear evaluation.[4–6] Early detection, risk stratification, and management of foot problems is essential to preventing or delaying complications.[7,8] However, the implementation of foot screening into routine care is suboptimal and remains unclear,[9] particularly in settings where there are fiscal or human resource challenges. This scoping review aims to develop an understanding of the factors affecting the implementation of

* Corresponding author at: Radcliffe Primary Care Building, Radcliffe Observatory Quarter, Woodstock Rd, Oxford OX2 6GG, United Kingdom of Great Britain and Northern Ireland.
E-mail address: jemma.houghton@gtc.ox.ac.uk (J.M. Houghton).

https://doi.org/10.1016/j.jdiacomp.2025.108972
Received 20 November 2024; Received in revised form 27 January 2025; Accepted 11 February 2025
Available online 12 February 2025
1056-8727/© 2025 The Authors. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

preventative measures for diabetes-related foot ulceration and amputation to inform new and improve existing routine diabetes care.

One factor to suboptimal diabetes foot screening implementation may be the complexity and usefulness of foot screening tools. Previous research suggests that, because of their lack of reliability, using multiple prognostic factors for foot ulcer prevention may provide an unhelpful assessment of the foot at-risk.[10] Risk stratification using vague descriptive terms such as "low risk" instead of clear numerical risk estimates may also undermine the usefulness of foot checks.[10] The complexity of a single foot check with multiple components,[4] and confusion by the high number of proposed methods per assessment component,[5,11] may deter their widespread use in routine practice. There is a need for a simplified, more useful assessment of the foot at-risk,[12] alongside an understanding of how this may be implemented into routine care.

To simplify identifying high-risk feet, previous literature identified and validated a clinical prediction rule.[10] This clinical prediction rule, based on best evidence, focuses on the information obtained from three simple tests to estimate a patient's risk of developing a foot ulcer over a 2-year period: sensitivity to a 10-*g* monofilament, palpation of lower limb pulses, and history of ulceration or amputation.[10] The use of a simplified and evidence-based approach may be delivered consistently, with fewer resources, and may provide better reliability than other screening strategies currently in use. By focusing our review on studies that implemented the simple, evidence-based components of the proposed clinical prediction rule,[10] we aimed to provide additional data to inform future implementation or refinement of current clinical practice-areas which have not been the focus of previous reviews[13–17] or proposed work.[18,19]

Our scoping review aimed to identify and synthesize the available information regarding the facilitators and barriers affecting the implementation of specific evidence-based foot screening components in people with diabetes. Our secondary aim was to explore how implementation considerations vary across care settings, contexts, and by the users who conducted the foot screening.

2. Methods

This scoping review was conducted in accordance with the JBI Methodology for Scoping Reviews.[20] The Population Concept Context Framework was applied (Table 1). The protocol was prespecified and registered on Open Science Framework (Identifier: DOI 10.17605/OSF.IO/5TS7K).[21]

2.1. Data sources

A search strategy systematically identified published and unpublished literature. An initial limited search of Medline and CINAHL was done to identify articles on the topic. The text words contained in the titles and abstracts of relevant articles, and the index terms used to describe the articles were used to develop a full search strategy, in addition to expert contribution and collaboration with an information specialist (NR). The search strategy, including all identified keywords and index terms, was adapted for each included database and/or information source. Major electronic databases were searched, including Medline (Ovid), Embase (Ovid), The Cochrane Library, Global Health (Ovid), and CINAHL on 12 May 2023. The search strategy was rerun on the 04 June 2024 to update the review. See Table 2 for the Medline (Ovid) search strategy. No restrictions on language or time period were enforced. To identify grey literature and literature which did not undergo peer-review (i.e., theses and dissertations, research reports, practice guidelines, and working papers), a search was conducted using Google and in databases such as Trip and ProQuest. Forward and backward citation searching of included studies was also conducted.

Table 1
Population concept context framework.

Criteria	Determinants
Population	Adults (≥18 years old) diagnosed with type 1 or type 2 diabetes.
Context	Foot screening including a minimum of one of the following components: - 10-*g* monofilament sensitivity - palpation of pedal pulses - history of ulceration and/or lower limb amputation
Concept	Primary, secondary or tertiary care settings, community or at-home settings.

2.2. Study selection

Following the search, all identified citations were collated and uploaded into Rayyan, and duplicates removed. After a pilot test, titles and abstracts were screened by two independent reviewers (JMH and MCH) in a two-stage process. The first stage involved each reviewer independently screening all obtained records by title and abstract for eligibility (Table 1. Population Concept Context Framework). The second stage involved each reviewer independently assessing the full-text article of all eligible records for final inclusion. Titles, abstracts, and full-text article copies not in English were reviewed using automated translation software. Disagreements between reviewers were discussed and resolved. No disagreement needed to be resolved by a third reviewer (AF or JD). The study results are reported and presented in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses extension for scoping review (PRISMA-ScR).[22] Studies excluded after full-text review are listed in Appendix 1.

2.3. Inclusion and exclusion criteria

All primary research study designs implementing or improving diabetes foot screening in primary, secondary, tertiary care or community settings, and in adult populations diagnosed with diabetes (type 1 and type 2) were included. Drawing on previous work on the development of a clinical prediction rule,[10] our review focuses on the evidence-based components identified by this: 10-*g* monofilament sensitivity, pedal pulse palpation, and history of ulceration and/or amputation. This clinical prediction rule, validated in a community setting in the United Kingdom (UK) and requiring further assessment in other settings, highlights simple, statistically significant, and clinically relevant factors aligned with established guidelines.[4,6] For inclusion in our study, the screening conducted must have incorporated at least one of the clinical prediction rule components. The person conducting the screening (i.e., the screening user) could have included a physician (i.e., defined as medical doctors), a non-physician (i.e., defined as a clinically qualified health professional who is not a medical doctor), or non-clinician (i.e., defined as a provider who is not clinically qualified, for example patient-led). Studies primarily aimed at assessing and improving provider education and knowledge of diabetes foot screening were not included. Studies applying a diabetes foot screening tool for the main purpose of

Table 2
Medline (Ovid) search strategy.

Item	Search term
1	*Diabetic Neuropathies/
2	(diabet* adj (neuropath* or polyneuropath*)).ti,kf.
3	Diabetic Foot/
4	diabetic foot.ti,ab,kf.
5	1 or 2 or 3 or 4
6	Mass Screening/
7	Risk Assessment/
8	(screening and (risk? or algorith*)).ti,ab,kf.
9	monofilament.ti,ab,kf.
10	(foot adj3 (screen* or care or assess* or test*)).ti,ab,kf. and risk?.mp,kf.
11	6 or 7 or 8 or 9 or 10
12	5 and 11

prevalence estimation, tool validation, or diagnostic accuracy were also not included. Expert opinion or commentary pieces identified during the search are listed in Appendix 2 for reference.

2.4. Evidence synthesis

A thematic synthesis approach[23] was used to extract data from each source to address the research question. This synthesis was carried out using NVivo (Release 1.7.2) and allowed for the systematic analysis and integration of findings from multiple primary sources, and the identification of common themes and patterns across the included literature.

3. Results

The systematic search identified 5133 titles and abstracts. The number of titles and abstracts excluded at each stage of the review process are presented in Fig. 1. A total of 26 studies met the inclusion criteria, as outlined in Table 3 Appendix 3.

3.1. Study characteristics

Included studies were conducted across primary ($n = 17$), secondary ($n = 5$), tertiary care (n = 1) and community settings ($n = 3$) in the United States of America (USA) ($n = 12$), UK (n = 5), India ($n = 2$), South America ($n = 1$), Slovak Republic ($n = 1$), Jordan (n = 1), Kuwait (n = 1), Nigeria (n = 1), Canada (n = 1), and Indonesia (n = 1). Standardised diabetes foot screening tools included the Michigan Neuropathy Screening Instrument (MNSI)[24] ($n = 4$), Sibbald 60-Second Foot Screening Tool[25,26] ($n = 4$), Inlow's 60-Second Foot Screening Tool[27] ($n = 1$), and Miller's 3-minute diabetic foot exam[28] ($n = 1$). Fifteen studies met our review criteria by including at least one evidence-based component, and eleven studies met all three screening criteria. Some studies based their screening on American Diabetes Association (ADA) guidelines[29] (n = 4), Scotland Diabetes guidelines[30] (n = 1), International Working Group of the Diabetic Foot (IWGDF) guidelines[4](n = 1), and others did not report a specific tool or developed their own ($n = 10$) (Table 3 Appendix 3). The Plan Do Study Act (PDSA) model of quality improvement[31] was incorporated into eight studies ($n = 5$ theses and $n = 3$ journal articles). Other frameworks included the National Diabetes In-patient Audit methodology[32] (n = 1), Lippitt's change theory[33] (n = 1), and Kurt Lewin's change theory[34] (n = 1). Fifteen published studies did not report a theoretical framework or approach (Table 3 Appendix 3).

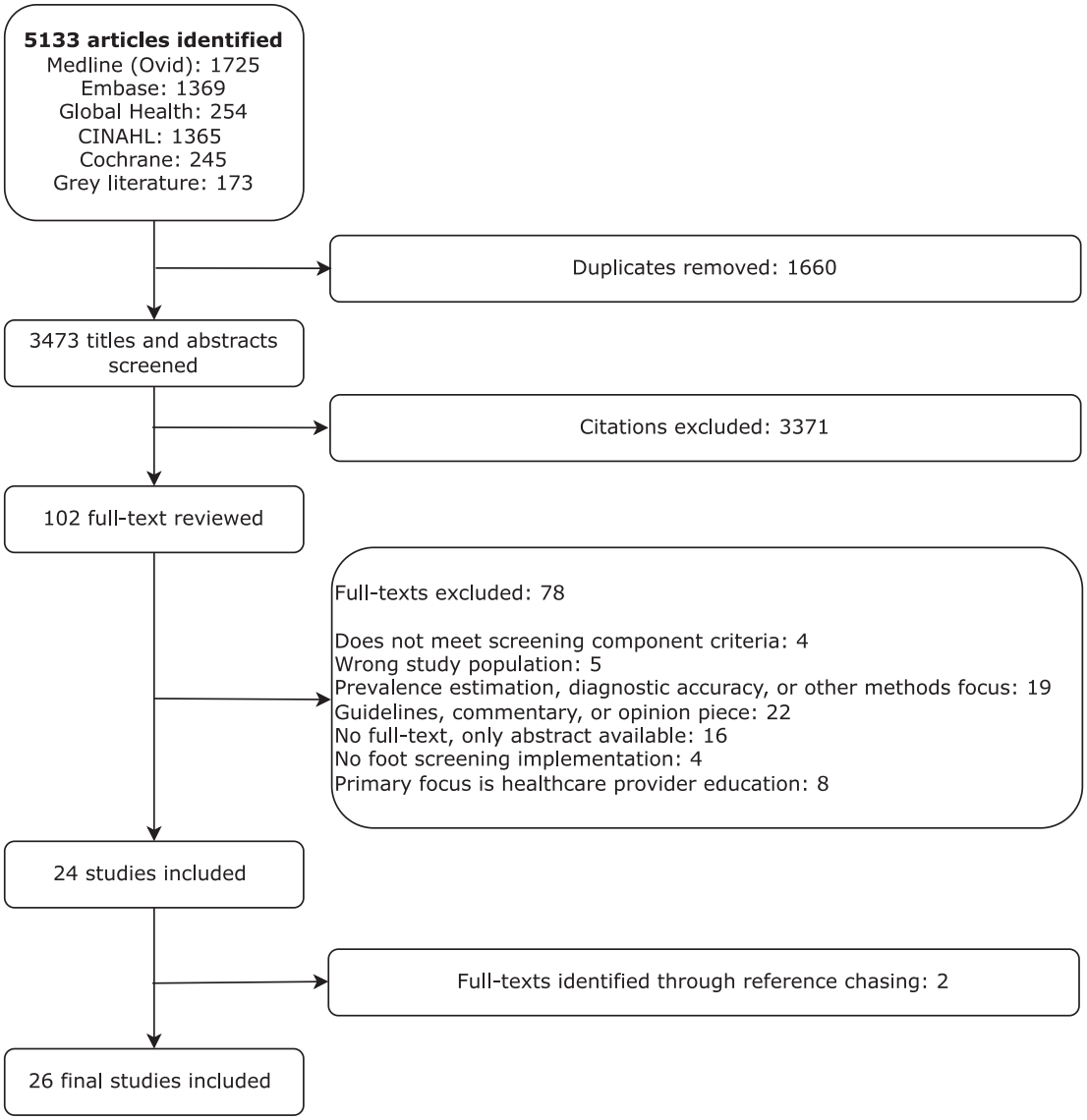

Fig. 1. PRISMA-ScR diagram for search strategy.

3.2. Key findings

Various facilitators and barriers affecting the implementation of foot screening in people with diabetes were found across different contexts, countries, and by users who conducted the screening. Findings have been categorised into 4 key themes (Fig. 2). We describe the facilitators and strengths of the screening approaches, and the barriers, limitations, and recommendations for their implementation for each theme.

3.2.1. Theme 1: existing diabetes screening and treatment interventions provides opportunities for synergistic integration of diabetes foot screening

Combining or integrating different diabetes care approaches creates an opportunity to include foot screening as part of routine care for people with diabetes. A parallel can be drawn between diabetes retinopathy screening programmes, set-up in high-income contexts such as in the UK,[35] and a diabetes foot screening programme. Two UK studies[36,37] demonstrated an integrated diabetes foot and retinopathy screening programme. During the retinal screening procedure,[36] people with diabetes underwent foot screening in the period between pupil dilation and retinal photography.

A combined service also offers the opportunity for people with diabetes to be empowered, by "*increasing their knowledge and awareness of the existence and importance of co-morbidities such as diabetes-related retinopathy, cardiovascular disease, diabetic neuropathy, and nephropathy.*[36,37]" Around 70 to 80 % of the patients participating in the combined screening programme were "*unaware of the impact that diabetes can have on the circulation of the lower limb and feet, and therefore, did not recognise the importance of regular foot checks.*[36]"

A synergistic intervention may reduce the number of outpatient consultations and streamline healthcare delivery. Such an approach can have potential for overburdened healthcare systems and settings where patients cannot afford multiple healthcare visits, however logistical and cost-related challenges would need to be addressed. The use of existing administrative frameworks, resources, and databases for current interventions drove these synergistic programmes.[36,37] A 2002 UK study[37] recommended, "*in districts with diabetes registers or mobile eye screening programmes, mobile foot screening would be simple to set-up and could prove a useful model for integration between primary and secondary care diabetes services.*"

The person conducting the foot screening as part of the synergistic intervention is important to consider, particularly regarding whether the role can be performed by a non-specialist provider (e.g., a nurse, diabetes educator, or community healthcare worker). While retinal screening programmes are designed to achieve high efficiency through tightly coordinating clinical space, time, and staff resources,[36,37] integrating foot screening during the interval between pupil dilation and retinal photography may disrupt efficiency as it assumes patient and staff availability during the interval, which may not align with operational workflows. Other factors to consider may include the increased pressure on existing referral pathways, more people with diabetes might be referred and require foot care due to the increased monitoring and screening efforts. Low patient attendance rates, indicating people are not attending their combined appointments or follow-ups, may also be a challenge and potentially result in worse health outcomes. One of the add-on retinal screening studies reported ~18 % of participants were not screened due to cancellation (n = 13) and non-attendance (n = 74).[36]

Incorporating diabetes foot screening in other clinical locations where routine diabetes care exists, such as pharmacies during medication collection, creates another synergistic opportunity for implementation of diabetes foot screening. Three studies demonstrated diabetes foot screening in community pharmacies,[38–40] with community pharmacists detecting peripheral neuropathy using part A of the MNSI.[38–40] One study[40] also incorporated a 10-g monofilament sensitivity assessment. A study conducted in Jordan[38] used the MNSI as it can be easily performed by a community pharmacist, acknowledging peripheral neuropathy detection using a neurothesiometer and electromyography required specialised services and training. The authors recommended "*future research should look into the total costs and feasibility of spreading similar programs to broader groups of people with*

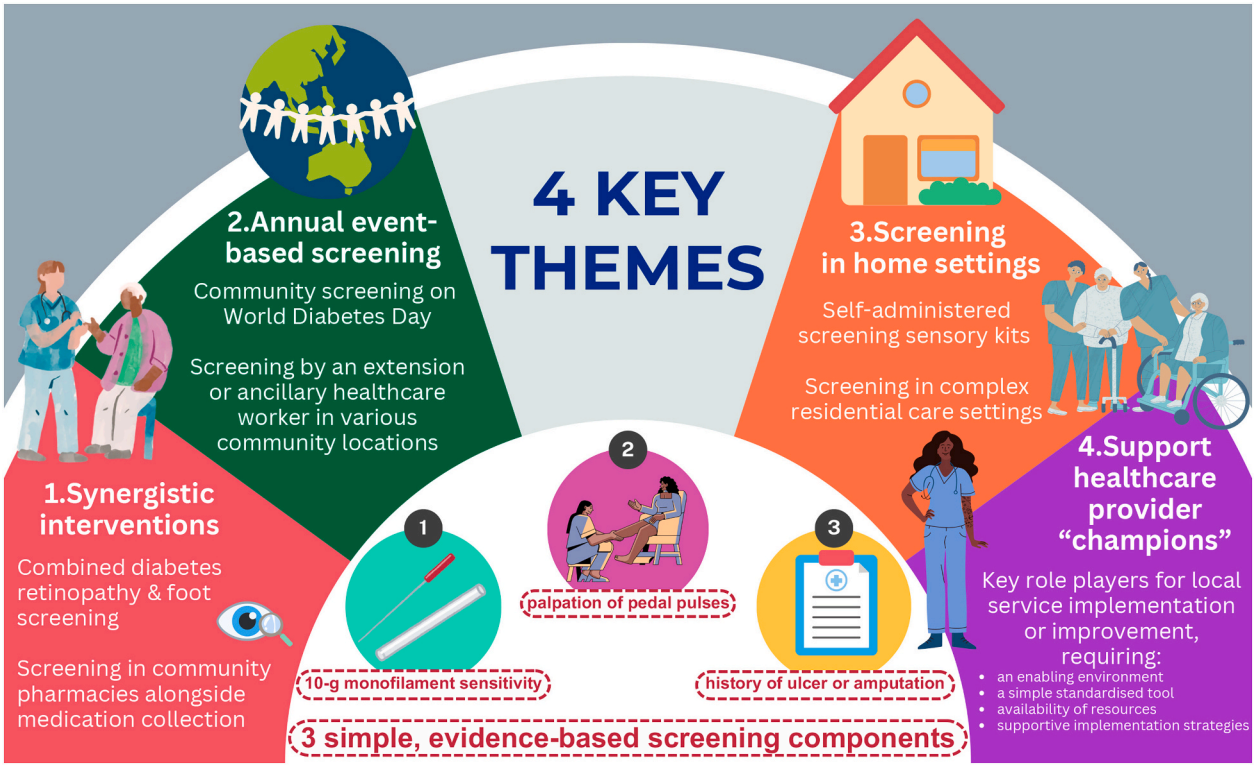

Fig. 2. Four key themes identifying implementation of diabetes foot screening.

diabetes." A limitation to a pharmacist screening approach may include missed opportunities to screen patients because family members or caregivers may collect medications on behalf of people with diabetes.[38]

No examples of synergistic screening approaches were described in low-income settings. With the limited capacity to provide specialised diabetes foot care services in many low-and middle-income countries, and the dearth of podiatry on the African continent,[41] it is essential for low-income contexts to progress developing a system similar to high-income settings. Preventative services should incorporate synergistic interventions at a primary care level, sites where foot protection management services are provided at a community level for simple problems, and where tertiary level multidisciplinary foot care services remain limited to handle complex foot problems.

3.2.2. Theme 2: in low-and middle-income contexts, annual event-based diabetes foot screening can provide community-focused preventative care

Holding annual event-based foot screening in lower resource settings can offer preventative health measures that benefit the entire community and align with current best practice guidelines. Adejumo et al[42] describe a community-based foot screening programme implemented in Nigeria on World Diabetes Day to combat a gap in diabetes foot care service provision. The authors acknowledged "*this [gap] is not necessarily because the skilled health personnel are not available, but because the few healthcare personnel are usually overwhelmed by the workload due to the relatively large turnout of patients with diabetes. This may lead to insufficient attention to the foot because of some other pressing needs of the patients with diabetes.*[42]"

An annual foot screening event on World Diabetes Day, supported by local community initiatives, may bridge the gap in similar low-and middle-income contexts. A major strength to event-based screening was "*the patients screened were those seen and managed regularly at different hospitals including both private and government owned who converged at the venue of the World Diabetes Day. This gave a much needed mix of participants rather than what would have been done only within one or two hospitals*[42] ."

A major challenge to an event-based community screening programme is the convergence of people with diabetes at one time. Due to the limited time and single-day nature, not all people with diabetes underwent the foot screening.[42] The authors stated, "*patients were in a hurry to go to the next station and were not patient enough to complete all the tests. Others could not provide responses to questions concerning previous history of foot lesions… Some patients were distracted and could not pull through the full screening process because it was an "open field screening," and the venue served as a spot for patients to socialise…that caused some level of distraction.*[42]" Some patients with diabetes missed the opportunity for screening due to "*not being able to make it to the venue, owing to the peculiar transportation system in a developing country like Nigeria, which may not be in favour of persons who have one or two disabilities.*[42]"

In multiple community locations in Indonesia,[43] community-based diabetes foot screening was performed by an *extension worker* (i.e., a community member trained to bring healthcare services directly to the community). The community settings were arranged with chairs in a circle, so the extension worker was visible to all participants. After the foot screening, the extension worker educated attendees on exercises and provided a lecture on diabetes management.[43]

An annual-event or community-based foot screening brings essential healthcare directly to people with diabetes, leveraging local resources, and trained community-members. Community-based interventions serve to fill a critical gap and potentially offer innovative and scalable solutions for diabetes care in resource-limited environments. No examples of community-driven screening were identified or described in high-income settings.

3.2.3. Theme 3: opportunities exist for bringing diabetes foot screening closer to the homes of patients at-risk or patients with limited access to healthcare services

In-home diabetes foot screening may benefit individuals perceived to be at higher risk of lower limb amputations and those with limited access to healthcare services. In a study conducted in 1998,[44] people with diabetes were sent self-administered sensory testing kits to identify diabetes-related peripheral neuropathy. Healthcare centres with established diabetes prevention programmes and trained personnel were the foundation of this screening approach. Existing data registers were used to identify follow-up appointments and facilitated implementation.[44] Self-screening kits were mailed to patients and included a 10-*g* monofilament and easy-to-read and illustrated instructions (in English and Spanish) describing how to hold the instrument, how to apply it to the skin, and where to apply it to the foot.[44] The authors showed that patients with diabetes can test their feet without assistance from another person, and sensory loss was newly identified in 23 people. The authors stated, "*this detection of unidentified sensory loss underscores the value of patients becoming empowered to share in the evaluation of their feet. If patients are able to use a sensory testing tool and share in the evaluation of their feet, providers must be knowledgeable about sensory testing and the appropriateness and availability of preventative foot care services.*"

Strong patient motivation is required to facilitate in-home screening. Of the 196 self-screening forms mailed, 74 % ($n = 145$) were returned and completed, the authors stated this result indicated a "*patient interest in sharing in the evaluation of their feet as well as the usability of the testing instrument by the patients.*" Participant age is important to consider, as older people with diabetes may have difficulty conducting the self-screening, leading to the risk of a false negative screening result and patients thereby not obtaining preventative care.[44] At-home self-administered screening was not recommended to replace routine evaluation by a provider, but this approach may provide an opportunity for patients to share in the responsibility for preventing complications.[44]

Complex residential care is another in-home screening opportunity. A Canadian study[45] showed diabetes foot screening can be conducted using a standardised screening tool. However, the complexity of the screening tool and complexity of the patient population was acknowledged. The screening users (i.e., advanced practitioner nurses), noted patient comorbidity was a significant barrier to effective implementation.[45] The tool required modification to suit the patient population, and the variability in the nurse's different responses and approaches to screening influenced the risk stratification and thereby the subsequent plans for ongoing patient care.[45]

These two examples highlight the potential for bringing foot screening to the homes of diabetes patients, particularly in high-income settings. No examples of in-the-home screening were identified or described in low-income settings. Exploring these approaches in low-and middle-income contexts may be limited by postal or healthcare infrastructure. However, resource-constrained environments may benefit from exploring mobile and telemedicine technology for diabetes foot screening. Exploring the role of the patient as an active participant in the screening process, tailoring interventions to their context through co-design methods,[46] and leveraging technologies could address outcomes across these diverse in-the-home settings.

3.2.4. Theme 4: healthcare provider champions are key role players for local service improvements in diabetes foot screening in primary, secondary or tertiary care

Identifying a healthcare provider who can champion the implementation of diabetes foot screening in primary and secondary care settings is a key step. Eight of the included studies were doctoral nursing qualification projects, where a nurse practitioner identified a lack of diabetes foot screening in their setting and 'championed' to improve an existing service or implement a new care pathway. Nine other included studies consisted of existing staff members (i.e., a nurse or a podiatrist) conducting quality improvement projects. In one case, the healthcare

provider champions were motivated by diabetes-associated lower limb outcomes of national audits such as the National Diabetes In-patient Audit.[47]

These champions required an enabling environment including funding[48–51] (e.g., from ministries of health,[52] partnerships,[51] or out-of-pocket payments), clinical guideline adaptation,[52] organisational workflow modification,[49,53–55] integration into existing registries,[49,51] healthcare provider buy-in,[48,50,51,53–58] stakeholder involvement,[48,50–52,54–56,59] screening user education and training,[45,47–60] continued mentorship of the screening user,[52,53,56] and the availability of foot screening resources.[49,51,54–56]

A major barrier to foot screening implementation in primary care was the lack of availability of a standardised screening tool and a healthcare provider's limited consultation time.[45,48,53,55,56] However, current standardised tools such as the Sibbald 60-Second Foot Screening Tool[25,26] or Inlow's 60-Second Foot Screening Tool[27] were found to be lacking in efficiency. The advanced nurse practitioners in the Canadian study[45] reported the Inlow's 60-second Diabetic Foot Screen tool[25,26] assessment took an average of 6 to 7 min and that several revisions were required to improve the validity and reliability of the tool in their setting and patient population.[45] Another doctoral nursing study conducted in primary care[48] mentioned, *"Providers typically have an average of 15 minutes to see a patient for a follow-up visit and 30 minutes to establish care for a new patient at the clinic. This short period of time does not allow providers to address every aspect of diabetes care."* Here, the author relied on the integration of a diabetes self-management foot log to assist in monitoring foot and lower limb complications alongside using Sibbald's 60-second screening tool.[48]

Strategies to support the implementation of diabetes foot screening in primary and secondary care included reminder mechanisms (i.e., placing foot screening tools on the reverse of patient glucose monitoring chart,[59] or in examination rooms,[47,49] the use of patient management flow sheets,[54] information posters,[55,57] laminated cards,[47,50,60] and mention of foot screening in staff newsletters[47]); integration into electronic healthcare records[56,57]; task shifting[53] and consensus on healthcare provider roles and responsibilities; the use of interpreters[51]; and tool translation[45] and patient handouts provided in local languages.[48,53,56]

4. Discussion

We identified themes around aspects of care delivery that could inform the implementation of a simple evidence-based diabetes foot screening across various care settings, contexts, and by different screening users. Four themes were identified: (1) using synergistic screening interventions, (2) annual event-based screening, (3) screening in home or complex residential care settings, and (4) supporting healthcare provider champions for intervention implementation.

None of the studies included in this review restricted their screening approach to the three simple, evidence-based criteria identified previously,[10] and which are based on best practice and supported by guidelines.[4] To our knowledge, these criteria and the use of a quantitative risk stratification,[10] have not yet been implemented as a standardised package in routine care. We noted the use of complex diabetes foot screening tools, with variety in their included components and type of risk stratification (i.e. descriptive versus a composite quantitative risk estimate or score). We think a simplified screening approach of the three-evidence-based components is an important consideration for future implementation or improvement of current foot service provision. The reduction in screening components and the use of a quantitative risk stratification may facilitate normalisation into routine care.

Our review highlights factors characteristic of foot screening implementation that may be valuable in lower resource or overburdened healthcare settings, where due to numerous competing healthcare demands, foot screening does not receive the attention needed to mitigate complications. An event-based foot screening programme (e.g., on World Diabetes Day), community screening in various public locations (e.g., a community centre, town hall, or pharmacy), or self-administered screening may contribute to improved access, surveillance for risk factors, and prevention of lower limb complications. To improve care in low-and middle-income settings, foot screening should not be seen as being based on a single level of the healthcare system (i.e. primary) and efforts should be focused on developing community-based care initiatives and a three-tiered approach similar to that of high-income settings.

A diabetes foot screening encompassing the three simple, evidence-based components[10] could offer increased accessibility of a foot screening intervention, particularly around the screening user or provider who conducts the screening. We think a proposed intervention of the three components requires no specialised training and may suit the factors we put forward in this review.

The lack of podiatry in many settings worldwide,[41,61] irrespective of context (i.e. Gross National Income classification), further emphasise a need for a multi-disciplinary approach and incorporation of task-shifting or a non-specialised screening user. Both examples of the combined foot and retinal screening programmes involved a podiatrist.[36,37] In settings where podiatry is limited or not available, but diabetes retinopathy programmes are in place, other ancillary healthcare workers may be able to perform foot screening, such as the described studies employing community pharmacists[38–40] and trained community members.[43] Related literature,[62] which did not meet our inclusion criteria, identified the potential for an ancillary healthcare worker role, such as an accredited social health activists. Implementing a synergistic model with additional dedicated staff or the availability of appropriate clinical space potentially increases costs and operational complexity. Future research should examine the feasibility and cost-effectiveness of the synergistic models put forward in this review in real-world settings.

In contrast to a previous review[16] and a proposed review,[19] our review has no restrictions on time or language, nor on healthcare settings or users who conducted the foot screening. Our review builds on the development of a clinical prediction rule,[10] and is grounded in two previous reviews which provided the foundation for the clinical prediction rule research.[13,63] Our review approach adopts a simpler approach to screening and is more comprehensive as it focuses on what foot screening components are being conducted, who is performing the screening, how this is being done in the local context, and what facilitates or inhibits the process of normalisation into routine clinical practice.

A limitation of our study is the framework used to define our inclusion criteria potentially limiting the inclusion of healthcare provider qualitative studies. We noted citations in our search strategy which did not meet our review eligibility criteria because their study populations were predominantly healthcare providers.[64–66] Our inclusion criteria defined a study population of adults ≥18 years old with a diagnosis of type 1 or 2 diabetes. We believe our review approach and aim remains relevant, comprehensive and rigorous. Many of these papers[64–66] incorporate healthcare provider education as the main intervention for improving foot screening, yet there is a gap in the understanding of the optimal strategy for establishing a screening pathway, which is the focus of our review. Furthermore, of the 26 included studies, only four studies were from low-and middle-income contexts[40,42,43,53] and only one from the African continent.[42]

Recommendations for future research and implementation are to consider the use of a more simplified screening approach, and which incorporates quantitative risk stratification. The three components focused on in our review offer an easy, quick, and more useful foot screening involving quantitative risk stratification than current approaches.[4] Our review findings also highlight consideration for future research in this field in Africa and Asia, especially given the greatest increase in diabetes prevalence is expected in Africa in the next two decades.[67]

We identified minimal use of supportive theoretical implementation frameworks underpinning the process of screening implementation. We

recommend future research to incorporate a framework, or a selected combination of frameworks, such as the Practical Robust Implementation and Sustainability Model (PRISM),[68,69] the Reach, Effectiveness, Adoption, Implementation, Maintenance (RE-AIM) framework,[70,71] Normalisation Process Theory (NPT),[72] Consolidated Framework for Implementation Research (CFIR),[73] or the UK's Medical Research Council guidance[74] to support integration into routine care. Frameworks such as these provide the theoretical foundation needed to navigate the intricacies of complex intervention implementation, focusing on how interventions become normalised into routine care, emphasising collective and social processes, and ultimately leading to effective and sustainable outcomes.

5. Conclusion

If inadequate primary preventative measures continue, or remain absent, the incidence of diabetes foot ulceration is expected to increase alongside diabetes prevalence. Our review outlines factors that may be characteristic of a successful foot screening programme and could be used to support the implementation of a simple evidence-based diabetes foot screening intervention across various care settings, contexts, and by different screening users. We recommend future work to investigate the feasibility of the three-component evidence-based approach with quantitative risk stratification, especially in low-and middle-income contexts, where majority of people with diabetes reside. Guided by implementation science frameworks, future research should also integrate qualitative research to explore the perspectives of patients and healthcare providers on the practicality, acceptability, and barriers to implementation, and to provide valuable insights for intervention co-design.

CRediT authorship contribution statement

Jemma M. Houghton: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Matthew C. Hynes:** Writing – review & editing, Investigation. **Nia W. Roberts:** Writing – review & editing, Resources, Methodology. **Helene-Mari van der Westhuizen:** Writing – review & editing, Supervision. **Joel A. Dave:** Writing – review & editing, Supervision. **Andrew Farmer:** Writing – review & editing, Supervision.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The doctoral researcher (JMH) is a recipient of a Rhodes Scholarship, supported by the Rhodes Trust. HvdW is funded by a Wellcome Trust Grant 226447/Z/22/Z. AF is supported by National Institute for Health Research (NIHR) Oxford Biomedical Research Centre (BRC). The views expressed are those of the author(s) and not necessarily those of the NIHR BRC or Rhodes Trust.

Declaration of competing interest

The authors declare that they have no competing interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jdiacomp.2025.108972.

References

1. Zhang Y, Lazzarini PA, McPhail SM, van Netten JJ, Armstrong DG, Pacella RE. Global disability burdens of diabetes-related lower-extremity complications in 1990 and 2016. *Diabetes Care*. 2020;43:964–974.
2. Lazzarini PA, Pacella RE, Armstrong DG, van Netten JJ. Diabetes-related lower-extremity complications are a leading cause of the global burden of disability. *Diabet Med*. 2018;35:1297–1299.
3. Armstrong DG, Tan TW, Boulton AJM, Bus SA. Diabetic foot ulcers: a review. *JAMA*. 2023;330:62–75 [Jul 3].
4. Schaper NC, van Netten JJ, Apelqvist J, Bus SA, Hinchliffe RJ, Lipsky BA. Practical guidelines on the prevention and management of diabetic foot disease (IWGDF 2019 update). IWGDF Editorial Board, editor. *Diabetes Metab Res Rev*. 2020;36 Suppl 1 (dcy, 100883450):e3266.
5. Boulton AJM, Armstrong DG, Albert SF, Frykberg RG, Hellman R, Kirkman MS, et al. Comprehensive foot examination and risk assessment: a report of the Task Force of the Foot Care Interest Group of the American Diabetes Association, with endorsement by the American Association of Clinical Endocrinologists. *Diabetes Care*. 2008;31:1679–1685 [Aug 1].
6. NICE guideline. Diabetic foot problems: prevention and management [internet]. In: *National Institute for Health and Care Excellence*; 2019:8–11. Available from: www.nice.org.uk/guidance/ng19.
7. Belch JJF, Topol EJ, Agnelli G, Bertrand M, Califf RM, Clement DL, et al. Critical issues in peripheral arterial disease detection and management: a call to action. Arch Intern Med 1960. 2003;163(8):884–92.
8. Allen LL, Khakharia A, Phillips LS, Johnson TM, Uphold CR, Perkins MM, et al. Annual foot exams are associated with reduced incident amputation among older veterans with diabetes. *J Appl Gerontol*. 2023;42:205–212 [Feb 1].
9. Bus SA, Van Netten JJ. Podcast on the IWGDF 2023 Guidelines on the Prevention of Foot Ulcers in Persons with Diabetes. *Diabetes Ther.*. 2024 https://doi.org/10.1007/s13300-024-01578-7. Epub ahead of print. PMID: 38668997.
10. Chappell FM, Crawford F, Horne M, Leese GP, Martin A, Weller D, et al. Development and validation of a clinical prediction rule for development of diabetic foot ulceration: an analysis of data from five cohort studies. *BMJ Open Diabetes Res Amp Care*. 2021;9, e002150 [May 1].
11. Formosa C, Gatt A, Chockalingam N. A critical evaluation of existing diabetic foot screening guidelines. *Rev Diabet Stud*. 2016;13:158–186.
12. Formosa C, Chockalingam N, Papanas N, Gatt A. Diabetic Foot Screening Guidelines and the Role of Artificial Intelligence: Time to Turn the Tide!. *The International Journal of Lower Extremity Wounds*. 2024. https://doi.org/10.1177/15347346241234421.
13. Crawford F, Nicolson DJ, Amanna AE, Smith M. Reliability of the evidence to guide decision-making in foot ulcer prevention in diabetes: an overview of systematic reviews. *BMC Med Res Methodol*. 2022;22:274 [Oct 20].
14. Netten JJ, Raspovic A, Lavery LA, Monteiro-Soares M, Paton J, Rasmussen A, et al. Prevention of foot ulcers in persons with diabetes at risk of ulceration: a systematic review and meta-analysis. *Diabetes Metab Res Rev*. 2024;40(3):e3652-n/a.
15. Monteiro-Soares M, Vale-Lima J, Martiniano J, Pinheiro-Torres S, Dias V, Boyko EJ. A systematic review with meta-analysis of the impact of access and quality of diabetic foot care delivery in preventing lower extremity amputation. *J Diabetes Complications*. 2021;35, 107837.
16. Mullan L, Driscoll A, Wynter K, Rasmussen B. Barriers and enablers to delivering preventative and early intervention footcare to people with diabetes: a scoping review of healthcare professionals' perceptions. *Aust J Prim Health*. 2019;25:517.
17.. Patel J, Zamzam A, Syed M, Blanchette V, Cross K, Albalawi Z, et al. A Scoping Review of Foot Screening in People With Diabetes Mellitus Across Canada... Diabetes Canada/Canadian Society of Endocrinology and Metabolism (CSEM) Professional Conference (Virtual), November 23–26, 2021. Can J Diabetes 2021;45(7):S4–S4.
18. McIntosh A, Peters J, Young R, Hutchinson A, Chiverton R, Clarkson S. *Prevention and Management of Foot Problems in Type 2 Diabetes: Clinical Guidelines and Evidence*. Sheffield: University of Sheffield; 2003.
19.. Naughten E, Giltenane M, O'Brien T, Ivory J, Gethin G. A scoping review protocol to identify strategies to implement evidence-based diabetic foot disease guidelines for healthcare professionals in primary care [version 1; peer review: awaiting peer review]. HRB Open Res [Internet] 2023;6(20). Available from: https://hrbopenresearch.org/articles/6-20/v1.
20.. Peters M, Godfrey C, McInerney P, Munn Z, Tricco A, Khalil H. Chapter 11: Scoping reviews. In: Aromataris E, Munn Z, editors. JBI Manual for Evidence Synthesis [Internet]. JBI; 2020. Available from: https://synthesismanual.jbi.global https://doi.org/10.46658/JBIMES-20-12.
21. Houghton JM, Hynes M, Roberts NW, van der Westhuizen H, Dave JD, Farmer A. *Factors Affecting the Implementation of Foot Screening in People with Diabetes: A Scoping Review Protocol [Internet]*. 2023. https://doi.org/10.17605/OSF.IO/P8KNQ.
22. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med*. 2018;169:467–473.
23. Thomas J, Harden A. Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Med Res Methodol*. 2008;8:45.
24. Feldman EL, Stevens MJ, Thomas PK, Brown MB, Canal N, Greene DA. A practical two-step quantitative clinical and electrophysiological assessment for the diagnosis and staging of diabetic neuropathy. *Diabetes Care*. 1994;17:1281–1289.
25. Sibbald RG, Ayello EA, Alavi A, Ostrow B, Lowe J, Botros M, et al. Screening for the high-risk diabetic foot: a 60-second tool (2012). *Adv Skin Wound Care*. 2012;25:465–476.

26.. Sibbald R, Woo K, Ostrow B. Preventing amputations: the need for screening, diagnosis and treatment of diabetic foot complications in Guyana, South America. J World Counc Enteros Ther 228 234–6 2008. 2008 Jan 1;.
27. Inlow S. The 60-second foot exam for people with diabetes. *Wound Care Can*. 2004; 2:10–11.
28. Miller JD, Carter E, Shih J, Giovinco NA, Boulton AJM, Mills JL, et al. How to do a 3-minute diabetic foot exam. *J Fam Pract*. 2014;63:646–656.
29.. American Diabetes Association professional practice committee. 12. Retinopathy, neuropathy, and foot care: standards of Care in Diabetes—2024. *Diabetes Care*. 2024;47(Supplement_1):S231–43.
30.. SCI-Diabetes [Internet]. [cited 2024 Aug 14]. Available from: https://www.sci-diabetes.scot.nhs.uk/.
31. Taylor MJ, McNicholas C, Nicolay C, Darzi A, Bell D, Reed JE. Systematic review of the application of the plan–do–study–act method to improve quality in healthcare. *BMJ Qual Saf*. 2014;23:290–298 [Apr 1].
32.. NHS England Digital [Internet]. [cited 2024 Aug 14]. National Diabetes Inpatient Audit (NaDIA) - 2016. Available from: https://digital.nhs.uk/data-and-information/publications/statistical/national-diabetes-inpatient-audit/national-diabetes-inpatient-audit-nadia-2016.
33. Lippitt R. *The Dynamics of Planned Change; a Comparative Study of Principles and Techniques / [by] Ronald Lippitt, Jeanne Watson [and] Bruce Westley. Under the General Editorship of Willard B. Spalding*. New York: Harcourt, Brace; 1958 [312 pp.].
34.. Lewin K. Field Theory in Social Science: Selected Theoretical Papers Edited by Dowin Cartwright [Internet]. New York: Harper & Brothers; 1951. Available from: https://ia802905.us.archive.org/4/items/in.ernet.dli.2015.138989/2015.138989.Field-Theory-In-Social-Science-Selected-Theoretical-Oaoers.pdf.
35. Liew G, Michaelides M, Bunce C. A comparison of the causes of blindness certifications in England and Wales in working age adults (16–64 years), 1999–2000 with 2009–2010. *BMJ Open*. 2014;4, e004015 [Feb 1].
36.. Lewis J.E.A., Morris K., Powell T., Thomas R.L., Owens D.R. AO - Lewis JEO https://orcid.org/0000-0002-9837-6131. Combining diabetic foot and retinopathy screening: A step in the right direction? - a feasibility study. SAGE Open Med [Internet]. 2020;8. Available from: https://journals.sagepub.com/home/SMO.
37. Sampson MJ, Shepstone L, Greenwood RH, Harvey I, Humphries J, Heyburn PJ, et al. An integrated mobile foot and retinal screening programme for people with type 2 diabetes managed in primary care. *Diabet Med*. 2002;19:74–76.
38. Matalqah LM, Yehya A, Radaideh KM. Pharmacist-lead screening for diabetic peripheral neuropathy using Michigan Neuropathy Screening Instrument (MNSI). *Int J Neurosci*. 2024;134(8):882–888. https://doi.org/10.1080/00207454.2022.2154671. Epub 2022 Dec 19. PMID: 36458560.
39. Pagáčová Z, Grofik M, Fazekaš T, Žufková V, Mináriková D. Screening for diabetic peripheral neuropathy at community pharmacies in Slovakia. *Croat Med J*. 2024;65: 85–92 [Apr].
40. Porselvi A, Jeevitha M, Shankar MSU. A cross-sectional study on the extended role of clinical pharmacist in assessing the risk factors for developing diabetic foot ulcers among the diabetic patients. *Asian J Pharm*. 2022;16:79–86.
41. Daily MT, Maverick. *Cited 2024 Oct 28*. SA needs more public health podiatrists to stem diabetes-related amputations; 2022. Available from: https://www.dailymaverick.co.za/article/2022-03-21-sa-needs-more-public-health-podiatrists-to-stem-diabetes-related-amputations/.
42. Adejumo PO, Adeniyi AF, Fasanmade AA. Results of a 60 second foot screening for patients with diabetes conducted on the 2011 world diabetes day. *J Nurs Educ Pract [Internet]*. 2013;3 [Jan 8]. Available from: http://www.diabeticfootcareindia.com/files/DFCI-MF-Nigeria.pdf.
43. Setiawan H, Suhanda S, Rosalianti E, Firmansyah A, Fitriani A, Hamdani D, et al. Health education, screening and diabetic foot Excercise in Cimanggu District. *Bogor ABDIMAS J Pengabdi Masy*. 2022;5:2410–2415.
44. Birke JA, Rolfsen RJ. Evaluation of a self-administered sensory testing tool to identify patients at risk of diabetes-related foot problems. *Diabetes Care*. 1998;21: 23–25.
45. Carreau L, Niezgoda H, Leblond S, Trainor A, Orsted H, Woodbury MG. A prospective, descriptive study to assess the reliability and usability of a rapid foot screen for patients with diabetes mellitus in a complex continuing care setting. *Ostomy Wound Manag*. 2013;59:28–34.
46. Bate P, Robert G. Experience-based design: from redesigning the system around the patient to co-designing services with the patient. *Qual Saf Health Care*. 2006;15: 307–310.
47. Goulding V, Bale S. Diabetic foot assessment: a service improvement project aimed at enhancing compliance. *Wounds UK*. 2019;15:44–53.
48.. Bakhshi M. Implementing Foot Care Program in a Rural Clinic [Internet]. [California, United States of America]: University of San Francisco; 2019. Available from: https://repository.usfca.edu/cgi/viewcontent.cgi?params=/context/dnp/article/1193/&path_info=auto_convert.pdf.
49. Holland CA. *Improving Diabetic Foot Evaluations and Podiatry Referrals in Primary Care [Internet]*. Montana State University; 2023 [cited 2024 Jun 5]. Available from: https://scholarworks.montana.edu/handle/1/18035.
50.. George R. Implementing A Routine Diabetic Foot Screening in a Primary Care Clinic (DPN Scholarly Project, East Carolina University) [Internet]. East Carolina University; 2022 [cited 4AD Jan 1]. Available from: https://thescholarship.ecu.edu/bitstream/handle/10342/10565/George.Regimol.FINAL%20DNP%20Paper.4-19-22.pdf?sequence=1&isAllowed=y.
51.. Bonsu MA. Development and Evaluation of a Nurse Practitioner-Directed Podiatry Referral Process Among Type 2 Diabetic Patients in a Primary Care Setting [Internet]. [Delaware]: Wilmington University, ProQuest Dissertations & Theses; 2023 [cited 2024 Oct 23]. Available from: https://www.proquest.com/docview/2846746019.
52. Lowe J, Sibbald RG, Taha NY, Lebovic G, Rambaran M, Martin C, et al. The Guyana diabetes and foot care project: improved diabetic foot evaluation reduces amputation rates by two-thirds in a lower middle income country. *Int J Endocrinol*. 2015;2015, 920124.
53. Mehndiratta A, Mishra SC, Bhandarkar P, Chhatbar K, Cluzeau F, PrimaryCareDoctors T. Increasing identification of foot at risk of complications in patients with diabetes: a quality improvement project in an urban primary health centre in India. *BMJ Open Qual*. 2020;9.
54.. Wilson KM. Improving the rate of diabetes preventative care practices in a nurse practitioner owned family clinic: a quality improvement project [internet]. ProQuest Dissertations & Theses; 2016 [cited 2024 Jul 24]. Available from: https://www.proquest.com/docview/1794656129/abstract/?pq-origsite=primo.
55.. Sylvain P. *Implementation of a Comprehensive Diabetic Foot Care Program in Primary Care [Internet]*. Massachusetts, United States: University of Massachusetts Boston; 2023 [cited 2024 Jun 5]. Available from: https://scholarworks.umb.edu/nursing_dnp_capstone/28.
56. Ademola-Ojo M. *Implementation of Comprehensive Footcare Program within Primary Care [Internet]*. University of the Incarnate Ward; 2021. Available from: https://athenaeum.uiw.edu/uiw_dnp/100?utm_source=athenaeum.uiw.edu%2Fuiw_dnp%2F100&utm_medium=PDF&utm_campaign=PDFCoverPages.
57. Gallman EC, Conner RS, Johnson E. Improving the detection of foot abnormalities in patients with diabetes. *Clin Diabetes*. 2017;35:55–59 [Jan 1].
58.. Rankin T. Nurse-Driven Diabetic Foot Assessment in a Clinic Setting [Internet] [D.N.P.]. ProQuest Dissertations and Theses. [Arizone, United States]: Grand Canyon University; 2023. Available from: https://www.proquest.com/dissertations-theses/nurse-driven-diabetic-foot-assessment-clinic/docview/2802242219/se-2?accountid=13042.
59. Charlton R, Murchison R, Gooday C, Dhatariya K. Implementation of a new foot assessment tool for people with diabetes in hospital. *Diabet Foot J*. 2017;20:24–28.
60. Guttormsen K, Tilbury J, Khurana R, Huyton D. Application of simplified diabetic foot assessment in an acute medical unit. *Diabet Foot J*. 2020;23:40–46.
61. Couch A, Menz HB, O'Sullivan B, Haines T, Williams CM. Describing the factors related to rural podiatry work and retention in the podiatry workforce: a national survey. *J Foot Ankle Res*. 2023;16:4 [Feb 7].
62. Maiya AG, Gundmi S, Matpady P, Jadhav R, Lingadakai R, Hande M, et al. Prevalence of foot complications in people with type 2 diabetes mellitus: a community-based survey in rural Udupi. *Int J Low Extrem Wounds*. 2018;17: 169–175.
63. Crawford F, Cezard G, Chappell FM, Murray GD, Price JF, Sheikh A, et al. A systematic review and individual patient data meta-analysis of prognostic factors for foot ulceration in people with diabetes: the international research collaboration for the prediction of diabetic foot ulcerations (PODUS). *Health Technol Assess*. 2015; 19:1–210.
64. Allen A. Improving healthcare providers' adherence to foot exams for type-II diabetic patients in a primary care clinic. *J Med Sci Health*. 2023;9:177–181 [Sep 13].
65.. Kosgei TB. Pathway to Increase Type 2 Diabetic Foot Exams [Internet] [D.N.P.]. ProQuest Dissertations and Theses. [United States – Oklahoma]: Oklahoma City University; 2019. Available from: https://www.proquest.com/dissertations-theses/pathway-increase-type-2-diabetic-foot-exams/docview/2328746454/se-2?accountid=13042.
66. Murphy Buschkoetter KL, Powell W, Mazour L. Implementation of a comprehensive diabetic foot exam protocol in rural primary care. *Online J Rural Nurs Health Care*. 2019;19:43–63.
67.. *International Diabetes Federation. IDF Diabetes Atlas*. 10th edn. [Internet]; 2021. Brussels, Belgium; Available from: www.diabetesatlas.org.
68. Jolles MP, Fort MP, Glasgow RE. Aligning the planning, development, and implementation of complex interventions to local contexts with an equity focus: application of the PRISM/RE-AIM framework. *Int J Equity Health*. 2024;23:41.
69. Feldstein AC, Glasgow RE. A practical, robust implementation and sustainability model (PRISM) for integrating research findings into practice. *Jt Comm J Qual Patient Saf*. 2008;34:228–243 [Apr].
70. Kessler RS, Purcell EP, Glasgow RE, Klesges LM, Benkeser RM, Peek CJ. What does it mean to "employ" the RE-AIM model? *Eval Health Prof*. 2013;36:44–66 [Mar 1].
71.. Re G, Tm V, Sm B. Evaluating the public health impact of health promotion interventions: the RE-AIM framework. Am J Public Health [Internet] 1999 Sep [cited 2024 Oct 15];89(9). Available from: https://pubmed.ncbi.nlm.nih.gov/10474547/?from_term=Evaluating+the+public+health+impact+of+health+promotion+interventions%3A+the+RE-AIM+framework&from_pos=1.
72. Murray E, Treweek S, Pope C, MacFarlane A, Ballini L, Dowrick C, et al. Normalisation process theory: a framework for developing, evaluating and implementing complex interventions. *BMC Med*. 2010;8:63 [Oct 20].
73. Damschroder LJ, Reardon CM, Opra Widerquist MA, Lowery J. Conceptualizing outcomes for use with the Consolidated Framework for Implementation Research (CFIR): the CFIR Outcomes Addendum. *Implement Sci*. 2022;17:7 [Jan 22].
74. Skivington K, Matthews L, Simpson SA, Craig P, Baird J, Blazeby JM, et al. A new framework for developing and evaluating complex interventions: update of Medical Research Council guidance. *BMJ*. 2021;374, n2061 [Sep 30].