Challenges in Diabetic Foot Management: A Glimpse at the Pathology its Burden, Innovations, and the Way Forward

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Abstract

Objectives: Type 2 diabetes mellitus is a global public health crisis. In Oman, prevalence ranges from 10.4% to 21.1%, with impaired fasting glucose affecting 35.1% of males. Projections show a rise from 15.2% in 2020 to 23.8% by 2050, with case numbers increasing from 190,489 to 570,227. Incidence rates are expected to grow from 8.3 to 12.1 per 1,000 person-years, while diabetes-related health expenditures are projected to climb by 36%, from 21.2% in 2020 to 28.8% in 2050. As the burden grows, diabetic foot ulcers alone will place added strain on healthcare systems. This review aims to outline the pathophysiology of diabetic foot ulcers, highlight care barriers, present treatment advances, and suggest strategies to improve outcomes in Oman.

Methods: This narrative review integrates published evidence with clinical and regional perspectives on diabetic foot disease care in Oman and the Gulf. Literature from 2000 to 2024 was searched in MEDLINE/PubMed, Scopus, LILACS, SCIELO, and Google Scholar using terms including "type 2 diabetes mellitus," "diabetic foot," "diabetic foot ulcer," "amputation," "peripheral vascular disease," "Oman," "Gulf region," "multidisciplinary care," and "podiatry." Grey literature—national reports, Ministry of Health publications, regional guidelines, and outputs from the Gulf Diabetic Foot Working Group—was also reviewed. The review incorporates the senior authors' direct experience in diabetic foot care and service development in Muscat.

Results and Conclusion: Major gaps include delayed diagnosis, limited awareness, weak screening, and insufficient multidisciplinary coordination. Innovations such as integrated foot care teams, advanced wound care, and telehealth show strong potential. Structured pathways and early detection reduce complications, amputations, and long-term disability. Diabetic foot ulcer care in Oman requires urgent, system-wide reform.

Keywords: Diabetic Foot; Diabetic Foot Attack; Diabetes Mellitus; Peripheral Vascular Disease; Dm Foot.

Introduction

Oman has seen a significant rise in chronic non-communicable diseases, largely due to rapid economic growth and lifestyle changes. Among these, diabetes has emerged as a major public health challenge, with obesity identified as the primary risk factor. This epidemic is expected to worsen in the coming decades.[1,2]

One of the most severe complications of diabetes is diabetic foot disease (DFD), which includes foot ulcers, infections, and amputations. Studies show that 19% to 34% of diabetic patients will develop a diabetic foot ulcer (DFU) in their lifetime, and 85% of all diabetes-related amputations are preceded by a DFU.[3] Approximately 20% of these ulcers progress to lower-extremity amputations, and 10% of patients die within one year of their first DFU diagnosis. Individuals with diabetes face a 15- to 40-fold increased risk of non-traumatic lower-extremity amputations compared to non-diabetic individuals.[3,4] However, up to 85% of these amputations are preventable with early detection and proper management. A recent, evidence-based prevalence of diabetes, diabetic foot ulcers, peripheral arterial disease (PAD), and diabetic polyneuropathy in Middle East and North Africa (MENA) countries is provided in Table 1.[5–19] These alarming statistics highlight the urgent need for proactive foot care, regular screenings, and comprehensive patient education to reduce the burden of diabetic foot complications. As diabetes rates rise, DFD has become one of the most debilitating and costly

complications, affecting up to 25% of diabetic patients. In Oman, diabetes accounts for nearly half of all lower-limb amputations, making it a critical public health issue.[20] The Ministry of Health has prioritized care of diabetes and its complications by establishing foot care clinics and podiatry care. The Gulf Diabetic Foot Working Group was founded in December 2012 by a group of multidisciplinary team (MDT) of healthcare professionals involved in the prevention and management of DFD in the Gulf.[20] The GDFWG holds an annual conference and twice a year diabetic foot courses to exchange knowledge and present research.

Table 1: Recent Evidence-Based Prevalence of Diabetes and Diabetic Foot Ulcers in Middle East and North Africa (MENA) Countries.[5-19]

Country	**Diabetes Prevalence (publication year)**	**Diabetic Foot Ulcer Prevalence (%)**
Middle Eastern Countries		
Bahrain	9% (2021)	6.56% (2022)
Iran	9.5% (2021)	8% (2-year cumulative incidence)(2024)
Iraq	9.4% (2021)	2.7% (2017)
Jordan	14.8% (2021)	5.3% (2017)
Kuwait	25.5% (2021)	3.4% (2018)
Lebanon	8.9% (2021)	no articles on prevalence of DFU*, PVD** 18.3% (2008)
Oman	11.8% (2021)	no articles on prevalence of DFU*, DPN*** 9% (2014)
Palestine	6.8% (2021)	6% (2023)
Qatar	16.4% (2021)	6.3% (2020)
Saudi Arabia	17.7% (2021)	11.85% (2017)
Syria	13.6% (2021)	44.4% (2010)
Turkey	14.5 % (2021)	17.1 % (2025)
Unite Arab Emirates	12.3% (2021)	no articles on prevalence of DFU*, DPN***34.7% (2019)
Yemen	4% (2021)	no articles on prevalence of DFU*, DPN*** 40.7% (1997)
North African Countries		
Algeria	7.4% (2021)	11.9%
Egypt	18.4% (2021)	4.2% (2017)
Libya	9% (2021)	no articles on prevalence of DFU*
Morocco	9.7% (2021)	no articles on DFU*, PVD** 2.7%; DPN*** 15.4% (2018)
Sudan	16% (2021)	18% (2017 study)
Tunisia	10.8% (2021)	no articles on prevalence of DFU*, DPN*** 18.7% (2014)

DFU: Diabetic Foot Ulcer, PVD**: Peripheral Vascular Disease, DPN***: Diabetic Polyneuropathy.*

This narrative review aims to explore the key barriers, emerging innovations, and strategic opportunities to improve diabetic foot care in Oman. Drawing on clinical experience and regional context, we

present a perspective intended to inform practice, stimulate dialogue, and support progress in managing this complex condition.

Methods

This is a narrative literature review supported by clinical and regional insights into DFD care in Oman and the Gulf region. We reviewed relevant literature published between 2000 and 2024, sourced from MEDLINE/PubMed, Scopus, and Google Scholar. Search terms included combinations of "T2DM," "diabetic foot," "DFU," "amputation," "peripheral vascular disease," "Oman," "Gulf region," "multidisciplinary care," and "podiatry." Grey literature was also included, such as national health reports, Ministry of Health publications, regional clinical guidelines, and materials from the Gulf Diabetic Foot Working Group, including proceedings from conferences and training courses. Reference lists of selected articles were screened to identify additional relevant sources.

This review is further informed by the senior authors' direct experience in diabetic foot care delivery, multidisciplinary service development, and health system challenges in Muscat. By combining published evidence with clinical insights, we highlight key barriers, regionally relevant innovations, and propose actionable strategies tailored to the local healthcare context.

Discussion

DFD continues to represent one of the most serious and resource-intensive complications of diabetes, particularly in regions like Oman where prevalence rates are rising. This discussion explores key clinical and systemic factors shaping DFD outcomes in Oman, organized under focused subheadings to address risk profiles, classification patterns, care gaps, and potential strategies for improvement.

Risk Factors and Classifications of Diabetic Foot Ulcers: Diabetic foot complications often arise due to a combination of neuropathy, PAD, and other contributing factors such as barefoot walking, inadequate education among patients and healthcare workers, and lack of proper foot protection services.[3,21] When not managed properly, these issues can lead to severe consequences. Neuropathy, by causing a loss of protective sensation, leaves individuals unaware of foot injuries and contributes to foot deformities and problems with skin integrity. On the other hand, peripheral arterial disease (PAD) restricts blood flow to the feet, impairing the body's ability to heal wounds and increasing the risk of ulcers and infections. When both neuropathy and PAD coexist, even minor injuries can quickly escalate into severe complications, including chronic ulcers, gangrene, and in extreme cases, amputation. The risk of developing a DFU is assessed using a classification system that categorizes patients into low, moderate, and high risk based on key clinical factors (Table 2).[22]

Table 2: Risk Categories for Developing Diabetic Foot Ulcers.

Risk Category	Low Risk	Medium Risk	High Risk
Sensory Function	Intact sensation	Peripheral neuropathy	Severe neuropathy
Vascular Status	Adequate perfusion	Diminished perfusion	Critical ischemia
History of Ulceration	No prior ulcers	No prior ulcers	Recurrent ulcers
Foot Deformities	No deformities	No deformities	Present (e.g., Charcot foot, claw toes)
Visual Acuity	Normal vision	Normal vision	Impaired vision (e.g., diabetic retinopathy)
Mobility	Normal gait	Mild gait impairment	Significant gait impairment

Diabesity and Its Implications for Diabetic Foot Diseases: Obesity is a critical driver in the development of T2DM, primarily by inducing insulin resistance through dysregulated adipokine production and chronic low-grade inflammation.[23] In obese individuals, excess adipose tissue releases pro-inflammatory cytokines such as TNF-α and interleukin-6, which impair insulin signaling and contribute to hyperglycemia. Recent evidence from large-scale cohort studies reinforces that a higher body mass index (BMI) significantly increases the risk of

developing T2DM.[23,24] Once diabetes is established, its complications, particularly DFD, become a major clinical challenge. The pathogenesis of DFD is multifactorial, involving peripheral neuropathy, vascular insufficiency, and impaired wound healing.[21] When the metabolic derangements of diabetes are compounded by obesity-induced inflammation and endothelial dysfunction, the risk of developing DFUs escalates markedly.[23,24] A study by Smyth S et al., titled '*Diabetes and Obesity: The Twin Epidemics'*, demonstrates that obese individuals have a higher likelihood of developing diabetes, which in turn places them at significantly greater risk for DFUs and subsequent lower-extremity amputations compared to their non-obese counterparts.[25] Beyond these metabolic factors, biomechanical and lifestyle elements further influence the development of DFUs. While neuropathy and PAD undoubtedly heighten the risk of diabetic foot disease, it is often a traumatic event that serves as the primary trigger. Obesity, which can both result from and contribute to reduced physical activity, exacerbates this risk by limiting mobility and increasing plantar pressure.[25] Contrary to the common assumption that a sedentary lifestyle lowers the risk of ulceration, research suggests otherwise. A study on individuals with neuropathy found that those taking the fewest steps per day were at the highest risk of developing foot ulcers (Najafi B et al., 2017).[26] Additionally, infection rates are significantly higher in diabetic patients, further complicating ulcer healing. Not only does infection hinder the healing process, but it also substantially increases the risk of hospitalization and lower-limb amputation. This interplay of metabolic dysfunction, reduced mobility, and increased infection susceptibility underscores the urgent need for comprehensive prevention strategies that integrate weight management, glycemic control, patient education, and early screening to mitigate the devastating consequences of diabetic foot disease.

Diabetic Foot Attack: A "diabetic foot attack" is a severe and rapidly progressing condition characterized by acute inflammation, tissue necrosis, and systemic symptoms.[27,28] It can start from a minor injury but escalate quickly, threatening the limb. It may present suddenly in patients with a known neuropathic DFU or ischemia, with delayed recognition leading to a high risk of limb loss. Another form, the "ischemic diabetic foot attack," involves critical limb ischemia, with or without tissue loss, and requires quick intervention to prevent further damage. Additionally, acute Charcot neuroarthropathy (CN), which leads to bone collapse, can also be considered an atypical form of a diabetic foot attack.[28,29] A collage of images depicting diabetic foot attack is presented in *Figure 1*.

Figure 1: Collage of Images Depicting Diabetic Foot Attack.

Early recognition and immediate intervention are critical. The term *'diabetic foot attack'* are of two types:[27]

1. Typical Infected Diabetic Foot Attack: Severe infection with necrosis, usually in neuropathic feet. Treatment focuses on infection control, followed by managing ischemia.

2. Atypical Diabetic Foot Attack:

    - Ischemic: Severe limb ischemia, requiring revascularization.

    - Charcot Neuroarthropathy: A hot, swollen foot, without ulceration, requiring diagnosis and off-loading.

A *'diabetic foot attack'* is often likened to an acute cardiac or cerebrovascular event due to its urgency. Symptoms may be subtle, with patients reporting flu-like feelings, and the lack of typical signs due to neuropathy can delay treatment.[28,30] However, compared to conditions like stroke or heart attack, tissue damage in the foot progresses more slowly, allowing for intervention. The "golden hour" concept used in other emergencies is applicable to diabetic foot attack, but the high rate of amputations suggests need for proactive care. Immediate treatment can save both limb/lives.

Management of Diabetic Foot Attack: The Emergency Referral Pathway for Diabetic Foot Attack (DFA) follows the principle "Time is tissue, delay is disaster," underscoring the urgency of early intervention to preserve the ulcer, limb, and patient. The structured clinical pathway at Sultan Qaboos University Hospital, University Medical City—illustrated in *Figure 2*—guides management from initial presentation through to definitive care. Patients presenting to the Emergency Department undergo baseline laboratory investigations, foot imaging (anteroposterior and oblique X-rays), and, when indicated, tissue biopsy or vascular imaging (computed tomography angiography [CTA] or magnetic resonance angiography [MRA]). Severity is assessed using classification systems such as WIfI or SINBAD. Management is then guided by clinical presentation: infected wounds prompt general and vascular surgical assessment, with treatment options including conservative care, debridement, or amputation, depending on individual case characteristics. Outpatient follow-up includes podiatry for off-loading footwear, wound care nursing, and ophthalmology for vision assessment. Cases involving ischemia (with or without infection) are further categorized into dry or infected gangrene. Based on clinical findings, patients are planned for open vascular or endovascular intervention. Admission or outpatient follow-up is determined at the discretion of the surgical team, based on the acuity and complexity of each case.

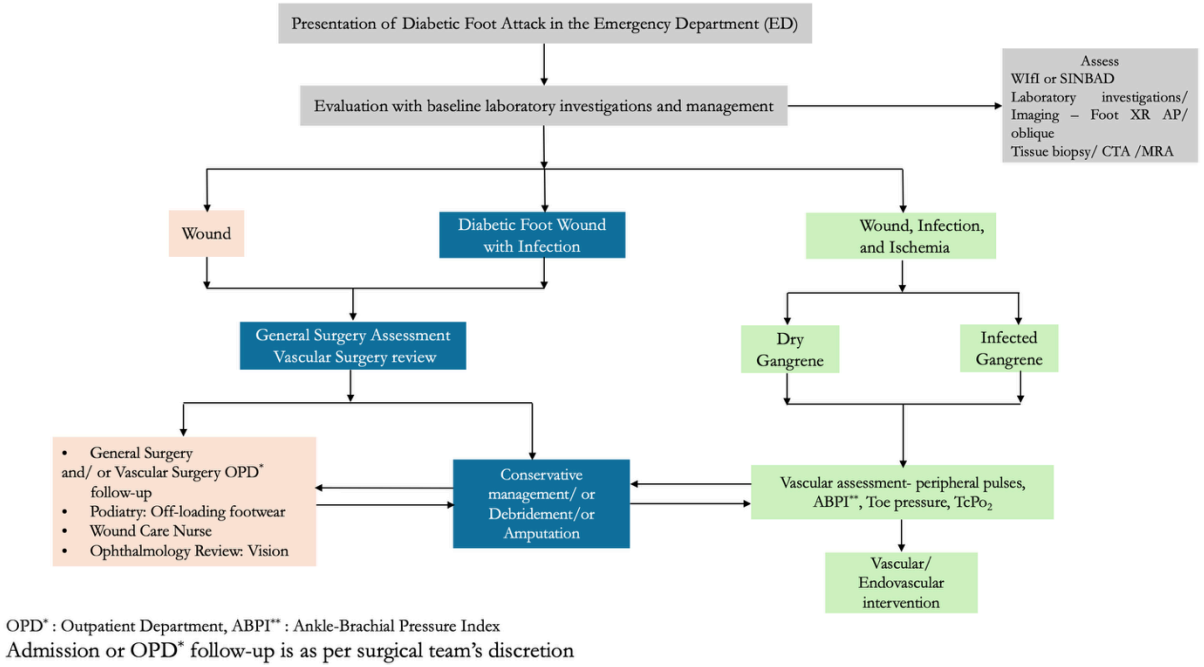


Figure 2: Structured Flowchart for the Management of Diabetic Foot Attack at Sultan Qaboos University Hospital, University Medical City.

'SINBAD' the sailor: The *'SINBAD'* score is a clinical tool used to assess the severity and predict the outcome of DFUs. It evaluates several factors that influence the prognosis of DFUs, helping to determine the risk of complications, such as amputation.[31] The SINBAD score is based on the following factors:

S: Site of ulcer - The location of the ulcer (e.g., forefoot, midfoot, or hindfoot).

I: Ischemia - The presence of peripheral vascular disease (reduced blood flow).

N: Neuropathy - The presence of diabetic neuropathy (nerve damage).

B: Bacterial infection - The presence of an infection in the ulcer.

A: Area of the ulcer - The size of the ulcer.

D: Duration of the ulcer - How long the ulcer has been present.

Each factor is assigned a score (0-2), and the total SINBAD score ranges from 0 to 12. A higher score indicates a greater risk of poor outcomes, such as infection or amputation.[31] The SINBAD score helps clinicians in decision-making for treatment and predicting the prognosis of diabetic foot ulcers.

The 'WIfI' connectivity - The WIfI classification system is used to assess the severity of diabetic foot infections (DFIs) based on three key factors: Wound (size and severity), Ischemia (degree of peripheral vascular disease), and foot Infection (severity of infection) (*see Figure 3*).[32,33]

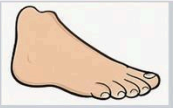
	WOUND	ISCHECMIA ($TcpO_2$)	FOOT ISCHEMIA
O	 No ulcer/ gangrene	> 60mmHg	 Non infected
1	 Small ulcer and no gangrene	40-59mmHg	 Mild (<2cm cellulitis)
2	 Deep ulcer and gangrene limited to toes	30-39mmHg	 Moderate (> 2cm cellulitis/ purulence)
3	 Extensive ulcer or extensive gangrene	< 30mmHg	 Severe (systemic response/ sepsis)

Figure 3: WIfI Classification System for Diabetic Foot Ulcers.

Bane –the cause behind the Increase: The epidemiology and risk factors for T2DM are influenced by various factors such as age, gender, lifestyle, genetics, and environmental conditions. The prevalence of T2DM increases with age, particularly in individuals over 40, with men having higher rates of impaired fasting glucose, while women exhibit a higher overall incidence due to metabolic and lifestyle factors.[34] Obesity is a significant risk factor for T2DM, where women have higher obesity rates than men, underscoring the urgent need to address metabolic syndrome.[24,25,34] Additionally, rapid urbanization has led to a more sedentary lifestyle and higher processed food consumption, which further elevate the risk of T2DM, especially in urban areas. If these risk factors are not properly managed, they significantly increase the risk of developing DFUs. Genetic predisposition also plays a role, with populations in the Middle East showing greater susceptibility to insulin resistance and beta-cell dysfunction.[35] Women who have a history of gestational diabetes mellitus (GDM) are at an increased risk of developing T2DM later in life, highlighting the importance of ongoing postpartum monitoring.[36] Oman's T2DM burden is reflective of neighbouring countries like Saudi Arabia, the United Arab Emirates, and Kuwait, where the prevalence exceeds 20%, yet lifestyle interventions are still underutilized. If these factors remain unmanaged, the risk of DFUs and other complications escalates.

Dietary and environmental influences further contribute to the growing prevalence of T2DM.[34] The shift from traditional, nutritious diets to processed foods has significantly increased insulin resistance in the Gulf region.[25,37] Vitamin D deficiency, observed in over 60% of individuals with T2DM in the Middle East, suggests that supplementation may help in preventing diabetes.[34] Additionally, alterations in gut microbiota in T2DM patients highlight the potential of dietary interventions targeting gut health. Environmental factors, including exposure to endocrine-disrupting chemicals (EDCs) and air pollution, have also been linked to insulin resistance, while the growing sedentary lifestyle exacerbates obesity and diabetes risks.[34,37] If not adequately controlled, these factors can lead to serious diabetic foot complications.

Healthcare System Challenges and Socioeconomic Impact of DFU: Despite advancements in healthcare infrastructure, accessibility to foot care remains a significant challenge, especially in rural areas. The International Diabetes Federation (IDF) projects that by 2030, the Middle East will face an economic impact exceeding $35 billion due to diabetes, with Oman contributing significantly to this cost.[38,39] This burden includes

both direct medical expenses and indirect costs such as lost productivity, further straining the healthcare system and economy. A study by Susanne F. Awad et al., *Forecasting the Type 2 Diabetes Mellitus Epidemic and the Role of Key Risk Factors in Oman up to 2050*, utilized mathematical modelling to predict a significant increase in type 2 diabetes mellitus (T2DM) prevalence—from 15.2% in 2020 to 23.8% in 2050.[40] The number of individuals living with T2DM is expected to rise from 190,489 in 2020 to 570,227 by 2050, with incidence rates increasing from 8.3 to 12.1 per 1,000 person-years.[40] This growing burden will have profound economic consequences, with diabetes-related health expenditures projected to increase by 36%, from 21.2% in 2020 to 28.8% in 2050.[40]

Cultural and behavioral factors also influence the prevalence and management of T2DM. Traditional medicine, deeply rooted in cultural beliefs, remains widely practiced, with herbal remedies still commonly used. However, our observations indicate that many patients present with severe complications and deterioration following the use of herbal treatments, including '*Wasm'* (fire branding). (*Figure 4*) In some communities, societal perceptions of body image contribute to higher obesity rates, particularly among women, where a higher BMI is sometimes viewed positively.[41] This cultural norm can lead to resistance in adopting weight management strategies, which further complicates efforts to manage diabetes and its complications effectively. Additionally, cultural and social beliefs and practices, such as barefoot walking, may contribute to an increased risk of foot injuries and infections, complicating the management of diabetic foot disease.[42] In Oman, the hot and dry climate leads many to prefer chappals over closed shoes and socks, increasing the risk of DFU due to heat, dryness, and injuries. Walking barefoot on the beach further raises the risk of foot injuries and complications in individuals with diabetes. Proper nail trimming, encouraged by both religious and cultural practices for hygiene, should be done carefully to prevent unnecessary injuries that could lead to DFU.

Figure 4: 'WASM' Treatment for Gangrenous Toes.

Challenges in Management of Diabetic Foot Disease (DFD): Managing DFD in Oman comes with certain challenges, despite the widespread availability of diabetic foot clinics. However, there is a need for more specialized care in DFU/DFA, along with improved communication among healthcare providers at the primary, secondary, and tertiary levels, and better resource allocation (e.g.: doppler ultrasound) at Local Healthcare Centres (LHCs). The rural terrain in Oman is challenging in places making provision of consistent healthcare a challenge. The other challenge is patient compliance, particularly in adhering to essential preventive measures such as avoiding walking barefoot, wearing appropriate footwear with a back strap, maintaining proper foot hygiene, and prioritizing podiatry and skincare.

Proposed Solutions to Improve Management

Specialized Training and Fellowships for Healthcare Providers: To address these gaps, it is essential to increase interest and provide specialized training for junior /doctors, nurses in key areas including GS, vascular surgery, endocrinology, podiatry, and orthotics. Fellowship courses or specialized training programs in these fields will ensure that healthcare providers are equipped to diagnose, manage basic care and learn to refer early and appropriately. Moreover, fostering communication among treating teams and specialists in the field through early referrals will facilitate real-time consultations and collaborative care.

Multidisciplinary Teams (MDT) and Specialized Clinics: Augmenting diabetic foot clinics in secondary and tertiary hospitals with trained specialized personnel is crucial. These clinics could host bi-weekly or monthly MDT meetings, where specialists from various fields, including vascular surgery, general surgery, endocrinology, podiatry, clinical pharmacy, and emergency physicians, collaborate to offer holistic care. Emergency physicians play a critical role in the initial management of acute diabetic foot infections or injuries, ensuring timely interventions to prevent complications. Clinical pharmacists can also be pivotal in managing polypharmacy, ensuring proper medication management, and reducing the risk of drug interactions.

Setting Up Diabetic Foot Clinics: Setting up dedicated diabetic foot clinics is an effective solution for initial assessments and ongoing care. These clinics should be equipped with the necessary tools for wound debridement, vascular assessment, and appropriate dressing. Incorporating Doppler ultrasound at local healthcare centers would improve the accuracy of vascular evaluations and guide treatment decisions.

Raising Awareness and Funding: Raising public awareness about diabetic foot care through social media campaigns, community programs, and events such as walkathons is essential for promoting early intervention and self-care. Investing in mobile clinics, supported by corporate funding under corporate social responsibility (CSR) initiatives, can enhance support for LHCs and their patient populations. Additionally, providing specialized footwear and developing educational materials for patients can further contribute to effective foot care and prevention strategies

Nurse led Home Visits: Implementing nurse-led mobile home visits after initial care can significantly improve patient access, especially in remote or underserved areas. These mobile units will help monitor patient progress, offer education, and ensure adherence to treatment plans, reducing the risk of complications and facilitate early review when needed.

Integrating Diabetic Foot Care into the Medical Curriculum: It is critical to integrate diabetic foot care into the medical curriculum at both the undergraduate and postgraduate levels. Training clinicians, paramedical staff, and emergency physicians in recognizing, preventing, and managing diabetic foot disease will ensure a future healthcare workforce that is better prepared to tackle this growing public health issue.

Promoting Research and Evidence-Based Practices: Research plays a key role in improving the management of any disease. There is a pressing need for more localized studies to identify the unique challenges and treatment outcomes specific to the region. (20)Encouraging collaboration between healthcare providers and academic institutions can stimulate research that explores novel interventions, improves patient outcomes, and informs best practices. Funding for research on the effectiveness of existing treatments, as well as the development of new therapies, is crucial in enhancing the care of diabetic foot patients.

Conclusion

The increasing prevalence of T2DM in Oman, along with the rise in diabetic foot disease, poses a significant public health challenge with far-reaching socio-economic consequences. Beyond management and diagnosis, it

is crucial to address underlying risk factors such as obesity, dietary changes, urbanization, and genetic predisposition. Additionally, environmental, psychosocial, and behavioral factors play a pivotal role in disease progression. The concept of 'diabesity' highlights the intricate link between obesity and diabetes, which in turn increases the incidence of diabetic foot disease, emphasizing the need for integrated prevention strategies. Future research should focus on precision medicine, genetic screening, and innovative preventive approaches to effectively combat the diabetes epidemic. With concerted efforts from government authorities, healthcare professionals, and the community, it is possible to curb the rising burden of diabetic foot disease and improve health outcomes for individuals across Oman.

Disclosure

There are no conflicts of interest.

Ethical Clearance/ Consent

This review article is based on our clinical practice and a compilation of the most recent available literature from Middle Eastern countries. As it does not involve direct patient research, interventional studies, or confidential patient data, Institutional Review Board (IRB) approval was not sought. The images included do not reveal any identifiable patient information, such as facial features or personal details; therefore, written or informed consent was not obtained. Additionally, we have ensured the originality of our work by verifying it through plagiarism detection software (iThenticate), confirming that the content is free of plagiarism.

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