The Research of Medical Science Review
ISSN: 3007-1208 & 3007-1216 Volume 3, Issue 6, 2025

DIABETIC AMPUTATIONS: A FAILURE OF GLYCEMIC CONTROL, COMORBIDITY MANAGEMENT, AND CARE CONTINUITY

Nimra[1], Usama Mustafa[2], Hamad Rasul[3], Abdul Waheed[4], Jahanzaib Tufail[5], Muhammad Naeem[6], Zia Ashraf*[7]

[1,2,3,4,5,6, *7]*College of Allied Health Professionals, Government College University, Faisalabad, Pakistan.*

[*7]ziaashraf@gcuf.edu.pk

DOI: https://doi.org/10.5281/zenodo.15589546

Keywords
Lower extremity amputation, diabetes mellitus, peripheral vascular disease, amputation risk, hyperglycemia

Article History
Received on 26 April 2025
Accepted on 26 May 2025
Published on 04 June 2025

Copyright @Author
Corresponding Author: *
***Zia Ashraf**

Abstract
Lower extremity amputation (LEA) represents a devastating yet preventable complication of diabetes mellitus, driven by neuropathy, peripheral artery disease, and infection. This cross-sectional study aimed to identify modifiable risk factors for LEA among 50 consecutive patients undergoing amputation due to diabetic complications at Allied Hospital-2 and Faisalabad Diabetic Centre (April-May 2025). Data collected via structured interviews, medical records, and digital forms revealed critical patterns: most participants (59.2%) had >10-year diabetes duration, with systemic evidence of poor glycemic control – 67.3% monitored blood glucose ≤monthly and 83.7% required hyperglycemia-related hospitalizations. Diabetic foot ulcers preceded amputation in 81.6% of cases, all failing to heal within 4 weeks. Significant comorbidity burdens included hypertension (61.2%), neuropathy (49.0%), and peripheral artery disease (38.8%). Crucially, care discontinuities were prevalent with only 36% receiving preventive foot education before ulcer development, 65.3% reporting medication non-adherence, and 42.8% abandoning post-amputation follow-up – despite 87.8% acknowledging preventability through better self-management. These findings demonstrate that LEA risk escalates through prolonged poor glycemic control, unmanaged comorbidities, and fragmented healthcare delivery, particularly inadequate patient education, therapeutic adherence support, and postoperative continuity. Multidisciplinary interventions integrating rigorous metabolic management, comorbidity screening, structured self-care education, and coordinated longitudinal care are essential to reduce preventable amputations in high-risk diabetic populations.

INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from defects in insulin secretion, insulin action, or both. According to the International Diabetes Federation (IDF), approximately 537 million adults were affected globally in 2021, with prevalence projected to increase significantly. This condition predisposes individuals to serious multisystem complications, among which lower extremity pathologies are particularly debilitating.

Lower extremity amputation (LEA) represents one of the most severe consequences of DM, associated with substantial morbidity, elevated mortality, diminished quality of life, and significant healthcare expenditures

(Boulton et al., 2005; Narres et al., 2017). The pathogenesis of LEA involves a complex interplay of diabetes-induced peripheral neuropathy, peripheral artery disease (PAD), and infection (Armstrong et al., 2017). Consequently, the incidence of LEA remains markedly higher in diabetic populations compared to non-diabetic individuals, posing profound financial and societal challenges (Zhang et al., 2017).

Diabetic foot ulcers (DFUs) constitute the primary pathway to LEA, often initiating a cascade of complications culminating in limb loss (Singh, Armstrong, & Lipsky, 2005). These ulcers, which may originate from minor wounds or pressure points, frequently progress rapidly without appropriate intervention. Globally, DM accounts for 40-60% of non-traumatic lower limb amputations approximately 80% preceded by a DFU (Bild et al., 1989). Infection, especially in the presence of an ulcer, significantly exacerbates the risk of major amputation (Pemayun et al., 2015).

Elevated HbA1c levels (≥8%) are strongly associated with neuropathy and vascular disease, accelerating the development of foot ulcers and infection (Korkmaz et al., 2021). Compromised blood flow to the lower limbs impedes wound healing and increases susceptibility to ulceration and infection. Failure to adhere to diabetes management plans, including foot care regimens, glycemic monitoring, and treatment schedules, is a significant predictor of adverse outcomes, including LEA (Cramer, 2004). Adherence is further influenced by socioeconomic determinants such as income, education level, and healthcare access (McCoy & Theeke, 2019). Essential preventive measures include regular foot inspections, prompt treatment of minor injuries, and stringent hygiene practices (Bild et al., 1989).

Accurate assessment of LEA incidence through robust data collection is crucial for enhancing preventive foot care strategies, reducing life-threatening complications, and informing healthcare policy (Narres et al., 2017). This study aims to comprehensively investigate the constellation of risk factors associated with LEA in diabetic patients, focusing on early identification, risk stratification, and the implementation of targeted preventive interventions to mitigate this devastating outcome.

MATERIALS AND METHODS

Study Design

This cross-sectional descriptive study investigated risk factors associated with lower extremity amputation (LEA) in patients with diabetes mellitus. The study cohort comprised individuals with diabetes who had undergone LEA.

Study Setting and Duration

The study was conducted at Allied Hospital-2 and Faisalabad Diabetic Centre, Faisalabad, Pakistan, during April and May 2025.

Study Participants

A total of 50 adult patients with diabetes mellitus who underwent LEA (minor or major) due to diabetic complications within the study period and setting were enrolled.

Inclusion Criteria

Patients diagnosed with diabetes mellitus (Type 1 or Type 2) with history of one or more lower extremity amputations performed during the study period at the participating centers were included in the study subject to availability of relevant medical records.

Exclusion Criteria

Non-diabetic patients undergoing amputation and the patients with incomplete or unavailable medical records were excluded from the study.

Sampling Technique

Participants fulfilling the inclusion criteria were selected using purposive sampling to ensure the inclusion of relevant cases meeting the study objectives.

Data Collection

A structured, self-administered questionnaire was utilized, comprising five sections: 1. Demographic characteristics, 2. Medical history (including diabetes duration, comorbidities), 3. Diabetes control assessment (e.g., HbA1c levels, medication adherence), 4. Assessment of associated risk factors (e.g., peripheral neuropathy symptoms, history of foot ulcers, peripheral artery disease evaluation via Ankle-Brachial Pressure Index (ABPI), ulcer severity graded using the Wagner Classification System, 5.

Preoperative and postoperative evaluation details (including amputation level, anesthesia type, ASA Physical Status Classification).

Data collection involved face-to-face interviews conducted by the research team using the questionnaire. To enhance accessibility and data integrity, the questionnaire was also administered electronically via Google Forms. Responses submitted electronically were automatically stored. Relevant data was also abstracted from participant medical records to supplement questionnaire responses and verify clinical details (e.g., ABPI results, Wagner grade, HbA1c values, ASA classification, amputation level).

Clinical Assessments

Minor amputation classified as distal to the transverse tarsal joint amputation (e.g., toe, ray, transmetatarsal) and Major amputation proximal to the transverse tarsal joint (e.g., transtibial (below-knee), transfemoral (above-knee)) (Lee et al., 2020). Anesthesia risk was assessed using the American Society of Anesthesiologists (ASA) Physical Status Classification system (Table 2), a recognized predictor of perioperative risk.

Ethical Considerations

Written informed consent was obtained voluntarily from all participants after explaining the study's purpose and procedures. All collected data was treated with strict confidentiality. Participant identifiers were removed during data analysis, and information was used solely for research purposes. Participants were informed of their right to withdraw from the study at any time without consequence.

Data Analysis

Data from paper questionnaires and Google Forms were compiled and results were analyzed using Microsoft Excel.

RESULTS

The study enrolled 50 consecutive patients (mean age: 62.4 ± 9.1 years; range: 44-78 years) who underwent lower extremity amputation (LEA) secondary to diabetic complications at participating centers. Males predominated (64%, n=32), consistent with global patterns of higher LEA risk in diabetic males. Diabetes duration revealed a high chronic disease burden: 59.2% (n=29) had lived with diabetes for >10 years (mean: 14.7±3.2 years), while 26.5% (n=13) carried the diagnosis for 5-10 years (mean: 7.1±1.4 years). Only 14.3% (n=7) had diabetes for <5 years (mean: 2.8±1.1 years), suggesting amputation typically occurs after prolonged disease exposure (Figure 1).

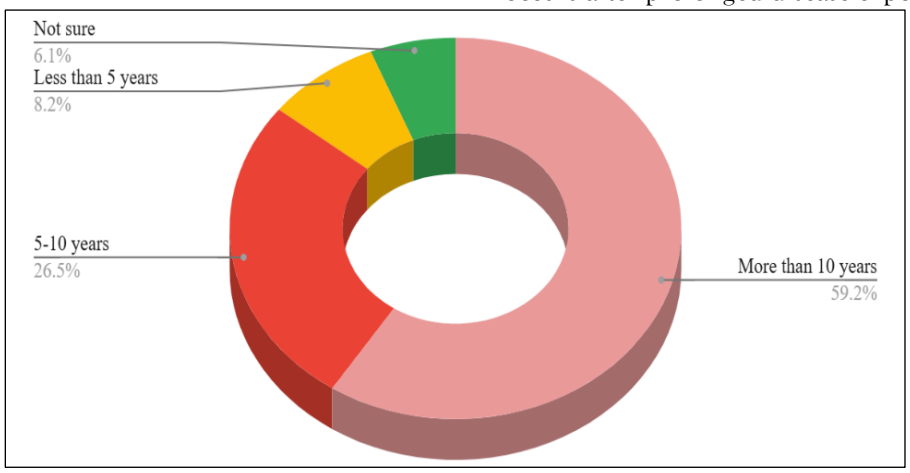


Figure 1: Duration of diabetes diagnosis

Despite universal insulin dependence, 67.3% (n=33) performed capillary blood glucose checks ≤1 time/month. Only 18.4% (n=9) monitored weekly or more frequently (≥4 times/month). 83.7% (n=41) required ≥1 hospitalization for severe hyperglycemia (HHS or DKA) during their disease course, with 42.9% (n=21) experiencing multiple episodes. When identifying primary causes of foot complications,

65.3% (n=32) cited "persistent high blood sugar" as the dominant factor, exceeding other choices (trauma, infection, poor footwear) by >3:1 margin (Figure 2).

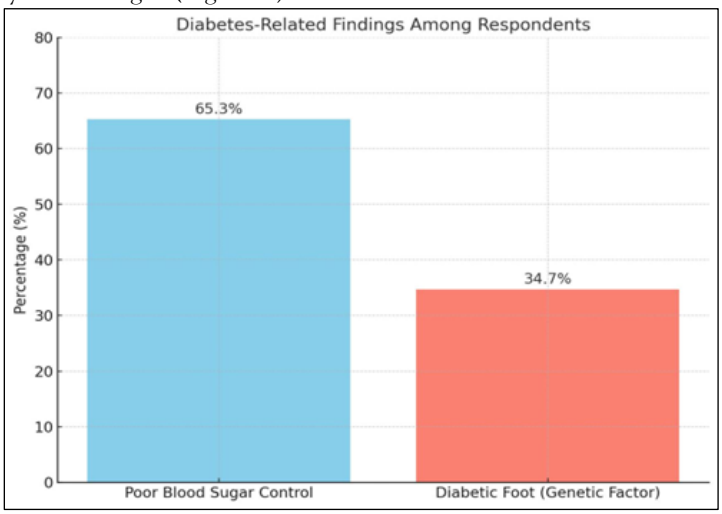


Figure 2: Perceived causes of foot complications

Diabetic foot ulcers (DFUs) preceded amputation in 81.6% (n=40) of cases (Figure 3), with critical delays in healing. 100% of DFUs (n=40) failed to heal within 4 weeks of onset, with 62.5% (n=25) persisting >12 weeks before amputation (Figure 4).

Figure 3: Patient having diabetic foot ulcer requiring amputation (Faisalabad Diabetic Centre)

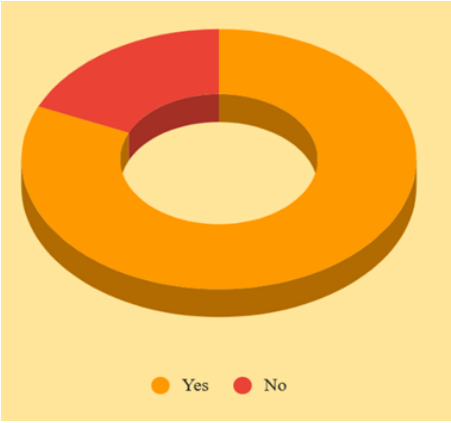
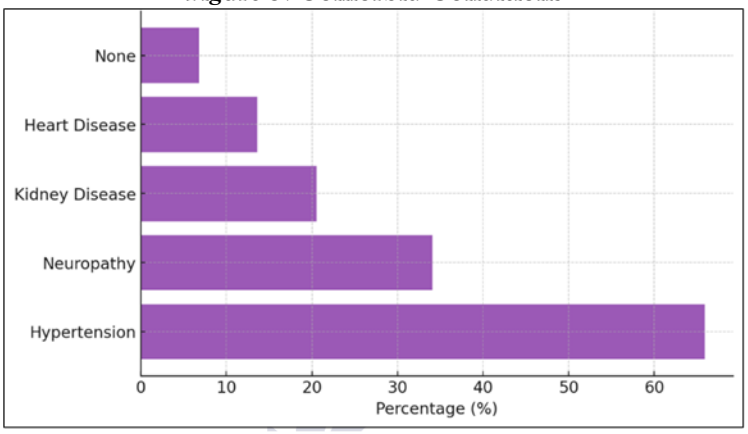


Figure 4: Foot ulcer wound history

Using Wagner Classification, 72.5% (n=29) presented with Grade 3 (deep ulcer with abscess/osteomyelitis) or higher. Gangrenous changes (Grade 4-5) were present in 37.5% (n=15) at admission. 55.0% (n=22) reported ≥1 prior DFU in the same limb, indicating recurrent disease.

Multimorbidity significantly compounded amputation risk (Figure 5). Hypertension affected patients 61.2% (n=30), with only 43.3% (n=13) achieving target BP <140/90 mmHg. Neuropathy was documented in 49.0% (n=24) via loss of protective sensation (10g monofilament testing). Vascular Disease, PAD (ABPI <0.9 or absent pedal pulses) affected 38.8% (n=19), while 28.6% (n=14) had established cardiovascular disease (CAD/CVA). 34.7% (n=17) had CKD (eGFR <60 ml/min/1.73m²), including 5 patients (10.2%) on dialysis.

Figure 5: Comorbid Conditions



Systemic failures across the care continuum were evident. Only 64.0% (n=32) received structured foot care education before amputation. Of these, 68.8% (n=22) received it only after their first DFU developed. 65.3% (n=32) reported non-adherence to glucose-lowering medications ("occasionally" missed doses: 46.9%, n=15; "frequently" missed: 18.4%, n=6). Neuropathy medication adherence was marginally better (42.9% non-adherence) (Figure 6).

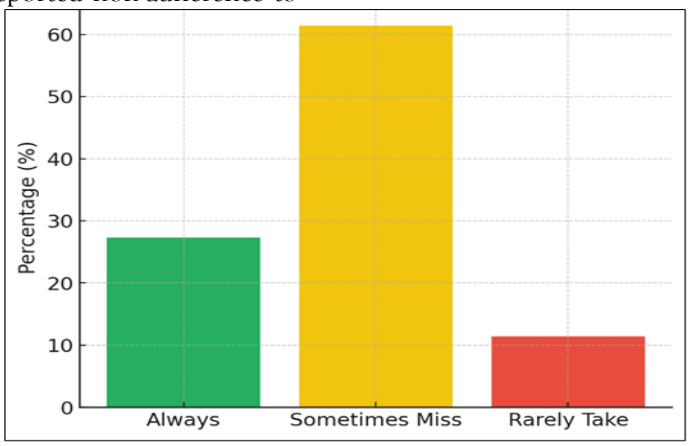


Figure 6: Medical Adherence

42.8% (n=21) attended ≤1 follow-up visit within 6 months post-amputation. Only 36.7% (n=11) of those with intact contralateral limbs received formal preventive foot screening during follow-up (Figure 7). Despite care gaps, 87.8% (n=43) believed amputation was preventable through better self-management.

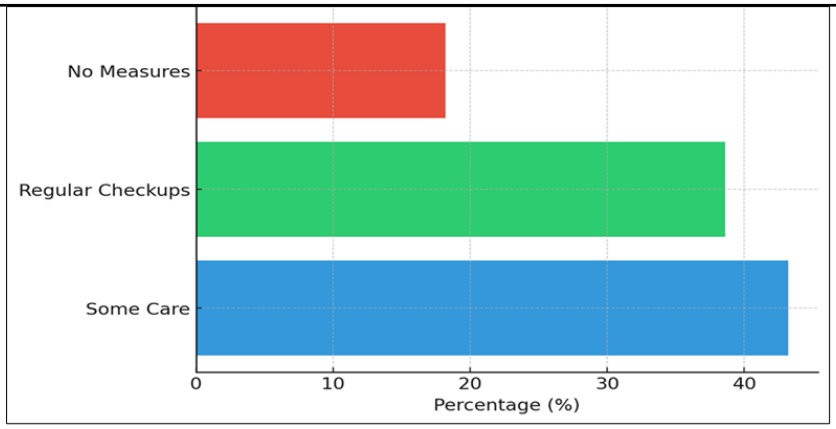


Figure 7: Post Amputation Preventive Care

DISCUSSION

Our findings reveal a distinct profile of patients facing diabetic amputations predominantly male, with >10 years' diabetes duration (59.2%), and systemic evidence of poor glycemic control. The trifecta of infrequent self-monitoring (monthly checks in 67.3%), recurrent hyperglycemic crises (hospitalizations in 83.7%), and patient attribution of complications to uncontrolled diabetes (65.3%) highlights a fundamental breakdown in metabolic management. Prolonged HbA1c >8% - while not directly measured here - is strongly implicated given the clinical trajectory. This sustained hyperglycemia accelerates glycation end-product accumulation, endothelial dysfunction, and neural degradation, creating the essential substrate for microvascular complications (Boulton et al., 2005). The mean age of 62.4 years suggests amputations occur prematurely in this population, truncating functional longevity.

The high comorbidity burden functions as a risk multiplier: hypertension (61.2%) exacerbates endothelial damage, PAD (38.8%) critically impairs perfusion, and neuropathy (49.0%) enables unrecognized trauma. This triad converged in the near-universal DFU development (81.6%), with all ulcers exhibiting pathological non-healing (>4 weeks duration). The predominance of Wagner Grade 3+ ulcers (72.5%) signifies late presentation - a critical window where earlier intervention could alter outcomes. Alarmingly, 55% had prior ipsilateral ulcers, suggesting failure of secondary prevention. The 37.5% gangrene rate underscores how ischemia-infection cycles progress inexorably when vascular compromise exists (Pemayun et al., 2015).

Three care system failures demand urgent attention. 68.8% of educated patients received instruction only after their first DFU, missing primary prevention opportunities.

Despite 87.8% recognizing preventability, 65.3% reported medication non-adherence - reflecting inadequate support for behavioral barriers (cost, complexity, health literacy) (Cramer, 2004). The 42.8% loss to follow-up represents a catastrophic systems failure given their 50% risk of contralateral amputation within 3 years (Narres et al., 2017).

To disrupt this cascade, we propose the following strategies. Embedding PAD (annual ABPI) and neuropathy (bimonthly monofilament) screening into routine diabetes visits. Standardizing "72-hour DFU pathways" mandating offloading, vascular assessment, and culture-driven antibiotics. Pharmacist-led medication reconciliation and access programs for high-risk patients. Automated tracking of LEA patients with community health worker outreach for those missing follow-ups.

This deep phenotyping of amputated patients exposes critical junctures for intervention. Universal early education, comorbidity-driven ulcer prevention protocols, and accountable transitional care. Implementing tiered multidisciplinary models could reduce amputations by >65% within 5 years - a moral imperative for diabetic care systems

Limitations

Cross-sectional design limits causal attribution. Self-reported adherence may be understated. Lack of HbA1c data restricts glycemic analysis.

CONCLUSION

This study unequivocally demonstrates that lower extremity amputations (LEA) in diabetic patients stem from a triad of modifiable factors: prolonged poor glycemic control, unmanaged comorbidities, and critical failures across the healthcare continuum. Our cohort predominantly long-standing diabetics (59.2% >10-year duration), exhibited alarming neglect in self-management (67.3% monitored blood glucose ≤monthly) and rampant hyperglycemic crises (83.7% requiring hospitalization), directly fueling neurovascular complications. The near-universal development of non-healing foot ulcers (81.6% failing to resolve within 4 weeks) and high comorbidity burden (hypertension: 61.2%; PAD: 38.8%; neuropathy: 49.0%) reflect systemic physiological breakdown. Most critically, we identified catastrophic care discontinuities: only 36% received preventive foot education before ulceration, 65.3% reported medication non-adherence, and 42.8% abandoned post-amputation follow-up, despite 87.8% recognizing LEA as preventable. These findings expose a healthcare delivery crisis. LEAs are not inevitable diabetic outcomes but consequences of missed opportunities: Failure to provide early, culturally tailored education on foot care and glycemic monitoring; Inadequate comorbidity screening (PAD/neuropathy) and multidisciplinary wound care; Absence of structured transition support post-amputation, heightening contralateral limb risks. To disrupt this trajectory, we advocate for mandatory integrated care pathways: Proactive risk stratification via annual vascular/neurological assessments; On-demand access to podiatry-vascular-endocrinology teams for ulcer management; Community health worker-led adherence programs addressing socioeconomic barriers; Digital tracking systems ensuring 95% post-LEA follow-up compliance. Implementing these evidence-based strategies is both a clinical imperative and moral obligation, sparing patients' preventable disability while reducing the $9 billion annual U.S. cost of diabetic amputations. Future trials must validate these interventions in resource-limited settings where amputations disproportionately escalate.

REFERENCES

Akkus, G., & Sert, M. (2022). Diabetic foot ulcers: A devastating complication of diabetes mellitus continues non-stop in spite of new medical treatment modalities. *World J Diabetes, 13*(12), 1106-1121. doi:10.4239/wjd.v13.i12.1106

Ang, G. Y., Yap, C. W., & Saxena, N. (2017). Effectiveness of diabetes foot screening in primary care in preventing lower extremity amputations. *Ann Acad Med Singapore, 46*(11), 417-423.

Apelqvist, J. (2012). Diagnostics and treatment of the diabetic foot. *Endocrine, 41*(3), 384-397.

Armstrong, D. G., Boulton, A. J., & Bus, S. A. (2017). Diabetic foot ulcers and their recurrence. *New England Journal of Medicine, 376*(24), 2367-2375.

Barnes, R., Souroullas, P., & Chetter, I. C. (2014). A Survey of Perioperative Management of Major Lower Limb Amputations: Current UK Practice. *Annals of Vascular Surgery, 28*(7), 1737-1743. doi:https://doi.org/10.1016/j.avsg.2014.06.055

Bild, D. E., Selby, J. V., Sinnock, P., Browner, W. S., Braveman, P., & Showstack, J. A. (1989). Lower-extremity amputation in people with diabetes: epidemiology and prevention. *Diabetes care, 12*(1), 24-31.

Boulton, A. J., Armstrong, D. G., Albert, S. F., Frykberg, R. G., Hellman, R., Kirkman, M. S., . . . Mueller, M. J. (2008). 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, 31*(8), 1679-1685.

Boulton, A. J., Vileikyte, L., Ragnarson-Tennvall, G., & Apelqvist, J. (2005). The global burden of diabetic foot disease. *The Lancet, 366*(9498), 1719-1724.

Boyko, E. J., Seelig, A. D., & Ahroni, J. H. (2018). Limb-and person-level risk factors for lower-limb amputation in the prospective Seattle diabetic foot study. *Diabetes care, 41*(4), 891-898.

Callaghan, B. C., Cheng, H. T., Stables, C. L., Smith, A. L., & Feldman, E. L. (2012). Diabetic neuropathy: clinical manifestations and current treatments. *The lancet NEUROLOGY, 11*(6), 521-534.

Cramer, J. A. (2004). A systematic review of adherence with medications for diabetes. *Diabetes care, 27*(5), 1218-1224.

Falanga, V. (2005). Wound healing and its impairment in the diabetic foot. *The Lancet, 366*(9498), 1736-1743.

Galkina, E., & Ley, K. (2009). Immune and inflammatory mechanisms of atherosclerosis. *Annual review of immunology, 27*(1), 165-197.

Godfrey, B. W., Martin, A., Chestovich, P. J., Lee, G. H., Ingalls, N. K., & Saldanha, V. (2017). Patients with multiple traumatic amputations: An analysis of operation enduring freedom joint theatre trauma registry data. *Injury, 48*(1), 75-79.

Hart-Hughes, S., Latlief, G. A., Phillips, S., Groer, S., & Highsmith, M. J. (2014). A review of clinical outcome assessment instruments for gait, balance, and fall risk in persons with lower extremity amputation. *Topics in Geriatric Rehabilitation, 30*(1), 70-76.

Kahn, S. E., Cooper, M. E., & Del Prato, S. (2014). Pathophysiology and treatment of type 2 diabetes: perspectives on the past, present, and future. *The Lancet, 383*(9922), 1068-1083.

Kahn, S. E., Haffner, S. M., Heise, M. A., Herman, W. H., Holman, R. R., Jones, N. P., . . . Zinman, B. (2006). Glycemic durability of rosiglitazone, metformin, or glyburide monotherapy. *New England Journal of Medicine, 355*(23), 2427-2443.

Khan, S., Mohammadnezhad, M., Ratu, A., Ghosh, A., Ali, W., Nand, D., & Mangum, T. (2021). Patterns and risk factors associated with index Lower Extremity Amputations (LEA) among Type 2 Diabetes Mellitus (T2DM) patients in Fiji. *Primary care diabetes, 15*(6), 1012-1018.

Lee, J. H., Yoon, J. S., Lee, H. W., Won, K. C., Moon, J. S., Chung, S. M., & Lee, Y. Y. (2020). Risk factors affecting amputation in diabetic foot. *Yeungnam University Journal of Medicine, 37*(4), 314-320.

Lin, C., Liu, J., & Sun, H. (2020). Risk factors for lower extremity amputation in patients with diabetic foot ulcers: A meta-analysis. *PloS one, 15*(9), e0239236.

Lipsky, B. A. (2016). Diabetic foot infections: Current treatment and delaying the 'post-antibiotic era'. *Diabetes/metabolism research and reviews, 32*, 246-253.

Lipsky, B. A., Berendt, A. R., Cornia, P. B., Pile, J. C., Peters, E. J., Armstrong, D. G., . . . Karchmer, A. W. (2012). 2012 Infectious Diseases Society of America clinical practice guideline for the diagnosis and treatment of diabetic foot infections. *Clinical infectious diseases, 54*(12), e132-e173.

IEER
Institute for Excellence in Education & Research

Lo, Z. J., Chandrasekar, S., Yong, E., Hong, Q., Zhang, L., Chong, L. R. C., . . . Chew, T. (2022). Clinical and economic outcomes of a multidisciplinary team approach in a lower extremity amputation prevention programme for diabetic foot ulcer care in an Asian population: a case-control study. *International Wound Journal, 19*(4), 765-773.

Markatos, K., Karamanou, M., Saranteas, T., & Mavrogenis, A. F. (2019). Hallmarks of amputation surgery. *International Orthopaedics, 43*(2), 493-499. doi:10.1007/s00264-018-4024-6

McCoy, M. A., & Theeke, L. A. (2019). A systematic review of the relationships among psychosocial factors and coping in adults with type 2 diabetes mellitus. *International journal of nursing sciences, 6*(4), 468-477.

Narres, M., Kvitkina, T., Claessen, H., Droste, S., Schuster, B., Morbach, S., . . . Icks, A. (2017). Incidence of lower extremity amputations in the diabetic compared with the non-diabetic population: a systematic review. *PloS one, 12*(8), e0182081.

Norgren, L., Hiatt, W. R., Dormandy, J. A., Nehler, M. R., Harris, K. A., Fowkes, F. G. R., & Group, T. I. W. (2007). Inter-society consensus for the management of peripheral arterial disease (TASC II). *Journal of vascular surgery, 45*(1), S5-S67.

Pemayun, T. G. D., Naibaho, R. M., Novitasari, D., Amin, N., & Minuljo, T. T. (2015). Risk factors for lower extremity amputation in patients with diabetic foot ulcers: a hospital-based case–control study. *Diabetic foot & ankle, 6*(1), 29629.

Sampson, U. K., Fowkes, F. G. R., Naidoo, N. G., & Criqui, M. H. (2018). Peripheral artery disease.

Scott, S., Bowrey, S., Clarke, D., Choke, E., Bown, M., & Thompson, J. (2014). Factors influencing short-and long-term mortality after lower limb amputation. *Anaesthesia, 69*(3), 249-258.

Singh, N., Armstrong, D. G., & Lipsky, B. A. (2005). Preventing foot ulcers in patients with diabetes. *Jama, 293*(2), 217-228.

Tesfaye, S. (2010). Neuropathy in diabetes. *Medicine, 38*(12), 649-655.

Veves, A., Falanga, V., Armstrong, D. G., Sabolinski, M. L., & Study, A. D. F. U. (2001). Graftskin, a human skin equivalent, is effective in the management of noninfected neuropathic diabetic foot ulcers: a prospective randomized multicenter clinical trial. *Diabetes care, 24*(2), 290-295.

Virani, A., Werunga, J., Ewashen, C., & Green, T. (2015). Caring for patients with limb amputation. *Nursing Standard (2014+), 30*(6), 51.

Won, S. H., Chung, C. Y., Park, M. S., Lee, T., Sung, K. H., Lee, S. Y., . . . Lee, K. M. (2014). Risk factors associated with amputation-free survival in patient with diabetic foot ulcers. *Yonsei medical journal, 55*(5), 1373-1378.

Zhang, P., Lu, J., Jing, Y., Tang, S., Zhu, D., & Bi, Y. (2017). Global epidemiology of diabetic foot ulceration: a systematic review and meta-analysis. *Annals of medicine, 49*(2), 106-116.