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# Bacterial and Fungal Infections in Diabetic Patients: Patterns, Resistance, and Implications for Antimicrobial Stewardship in Nigeria

**Nyakairu Doreen G.**

**Faculty of Science and Technology Kampala International University Uganda**

**ABSTRACT**

Diabetic patients in Nigeria are disproportionately affected by bacterial and fungal infections, with hyperglycemia, immune dysfunction, and comorbidities increasing susceptibility and complicating clinical outcomes. Common pathogens include Staphylococcus aureus, Escherichia coli, Klebsiella spp., Pseudomonas aeruginosa, and Candida spp., with rising rates of multidrug-resistant organisms such as MRSA, ESBL-producing Gram-negative bacteria, and azole-resistant fungi. These resistance patterns challenge empirical therapy, prolong hospital stays, increase morbidity and mortality, and escalate healthcare costs. Effective management requires a multifaceted approach incorporating accurate microbiological diagnosis, empiric therapy guided by local antibiograms, timely de-escalation, and non-antibiotic interventions including glycemic control, wound offloading, debridement, and vascular assessment. Early involvement of multidisciplinary teams, strengthened infection prevention and control measures, and implementation of context-specific antimicrobial stewardship programs are critical to reducing resistance and improving patient outcomes. Enhanced surveillance, research, and community education further support evidence-based policy and clinical decision-making to optimize infection management in diabetic populations.

**Keywords:** Diabetes mellitus, bacterial infections, fungal infections, antimicrobial resistance.

## INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by hyperglycaemia resulting from defects in insulin secretion, insulin action, or both. Globally, the prevalence of diabetes has risen dramatically over the past few decades, driven by rapid urbanization, sedentary lifestyles, changing dietary patterns, and genetic predispositions [1]. The International Diabetes Federation (IDF) estimates that over 700 million adults will be living with diabetes by 2045, with a substantial proportion residing in low- and middle-income countries (LMICs) like Nigeria. In Nigeria specifically, recent epidemiological data suggest that the prevalence of diabetes ranges from 2% to 5% in rural areas and up to 10% in urban populations, reflecting both lifestyle changes and increased life expectancy [2]. This rising burden poses significant public health challenges, particularly when compounded by the increased susceptibility of diabetic patients to infections.

Diabetic patients are more prone to bacterial and fungal infections due to several pathophysiological mechanisms. Hyperglycaemia impairs both innate and adaptive immune responses, including neutrophil chemotaxis, phagocytosis, and intracellular killing of pathogens. Additionally, microvascular complications of diabetes, such as peripheral arterial disease and neuropathy, compromise tissue perfusion and reduce the delivery of immune cells and antimicrobial agents to sites of infection. Frequent breaches of the skin and mucosal barriers—caused by diabetic foot ulcers, surgical interventions, and recurrent catheterizations—further facilitate pathogen entry [3]. Consequently, infections in diabetic patients often have more severe clinical manifestations, slower healing, and increased risk of recurrence compared to non-diabetic individuals.

In Nigeria, the burden of infections among diabetic patients is compounded by structural and systemic healthcare challenges. Hospitals frequently report prolonged admissions, high rates of treatment failure, and an elevated incidence of limb amputations resulting from diabetic foot infections [4,5]. Common bacterial pathogens isolated from these patients include *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella spp.*, *Pseudomonas aeruginosa*, and

*Enterococcus spp*., while fungal infections particularly candidiasis are also increasingly recognized as significant contributors to morbidity. Notably, antimicrobial resistance (AMR) has emerged as a major concern, with multidrug-resistant organisms complicating treatment regimens, increasing healthcare costs, and undermining the effectiveness of empirical therapy. The growing prevalence of resistant strains such as methicillin-resistant *Staphylococcus aureus* (MRSA), extended-spectrum beta-lactamase (ESBL)-producing Gram-negative bacteria, and azole-resistant *Candida* spp. underscores the urgent need for robust antimicrobial stewardship programs [6].

Despite the evident clinical and economic burden of infections in diabetic populations, there is a paucity of comprehensive data in Nigeria summarizing the microbiological patterns, resistance trends, and implications for clinical practice. Existing studies often focus on isolated case series, single hospital audits, or regional surveys, leaving gaps in understanding the nationwide landscape of infections among diabetic patients. These knowledge gaps hinder the development of context-specific guidelines for infection prevention, empirical therapy, and antimicrobial stewardship, ultimately compromising patient outcomes [7,8].

The management of infections in diabetic patients in Nigeria presents multifaceted challenges. First, diabetic patients are inherently more vulnerable to infections due to immunological impairment and comorbidities, increasing the likelihood of complications, prolonged hospital stays, and mortality. Second, the increasing prevalence of antimicrobial-resistant pathogens complicates empirical treatment, often resulting in therapeutic failures and heightened risk of adverse outcomes [9]. Third, Nigeria's healthcare system faces limitations in laboratory capacity, infection control practices, and implementation of antimicrobial stewardship programs, impeding the timely diagnosis and effective management of infections. Collectively, these factors contribute to significant clinical, economic, and social burdens, emphasizing the need for comprehensive research to inform policy, clinical practice, and public health interventions.

Infections in diabetic patients have long been recognized as a major contributor to morbidity and mortality worldwide. While bacterial infections such as urinary tract infections, respiratory infections, skin and soft tissue infections, and bloodstream infections are common, fungal infections including candidiasis and mucormycosis are increasingly being reported [10]. In the Nigerian context, studies have documented high rates of diabetic foot infections, urinary tract infections, and sepsis among diabetic patients, often associated with multidrug-resistant organisms. The rapid emergence of resistance is partly driven by indiscriminate antibiotic use, self-medication, lack of adherence to treatment guidelines, and limited laboratory-based surveillance. Antimicrobial stewardship, which encompasses strategies to optimize the use of antibiotics and antifungals, remains underdeveloped in many Nigerian hospitals, limiting the capacity to curb resistance trends effectively [11]. This study seeks to bridge these gaps by providing an overview of the microbiological patterns of infections, examining resistance trends, and exploring the implications for infection control and stewardship practices in Nigeria. This study aims to investigate bacterial and fungal infections in diabetic patients in Nigeria, focusing on pathogen prevalence, antimicrobial resistance, clinical outcomes, and stewardship practices. Specifically, it seeks to identify the most common microbial pathogens affecting diabetics, evaluate their resistance patterns, assess associated clinical outcomes, and explore challenges in antimicrobial stewardship within Nigerian healthcare facilities. Key research questions include determining predominant pathogens, current resistance trends, infection impacts on patient outcomes, existing stewardship practices, and strategies to strengthen infection control and antimicrobial management. The significance of this study lies in its potential to consolidate knowledge on microbiological patterns and resistance trends, addressing a critical gap in clinical practice and policy formulation. Findings are expected to guide hospital administrators, clinicians, and policymakers in implementing targeted interventions to curb antimicrobial resistance, improve infection management, and allocate healthcare resources more efficiently. By highlighting the clinical and economic burden of infections in diabetic patients, the study supports public health planning and the development of national guidelines. Bacterial and fungal infections in diabetic patients represent a growing public health concern in Nigeria, compounded by hyperglycemia, immune dysfunction, and healthcare system limitations. A comprehensive understanding of pathogen patterns, resistance trends, and stewardship practices is essential to improve clinical outcomes, inform policy, and strengthen antimicrobial stewardship across Nigerian healthcare settings.

**Microbial patterns in diabetic infections**

The microbiology of diabetic infections is heavily shaped by the site of infection. Diabetic foot infections (DFIs) and foot ulcers are the most studied complication and typically show polymicrobial cultures: Gram-positive cocci (notably *Staphylococcus aureus* and coagulase-negative staphylococci) and Gram-negative bacilli (including *Pseudomonas aeruginosa, Escherichia coli*, and Klebsiella spp.) are commonly isolated. Fungi especially yeasts like *Candida* spp. can colonize or infect wounds and intertriginous skin, though reported fungal infection rates vary across studies and are often lower than bacterial isolation rates [12]. A large regional systematic review and multiple single-centre studies report polymicrobial infections in a majority of DFIs, with *S. aureus* among the most frequently isolated organisms. Clinical implication: polymicrobial infections and the frequent presence of Gram-negative organisms mean empiric antimicrobial choices for moderate severe infections must cover both Gram-positive and Gram-negative pathogens while awaiting cultures [13].

**Antimicrobial resistance trends observed**

Recent studies from Nigeria and the broader region highlight concerning trends in antimicrobial resistance (AMR) among isolates from diabetic foot infections (DFIs) and other wound infections. Multi-drug resistance (MDR) is prevalent, particularly among Gram-negative bacteria, with many isolates showing resistance to commonly used first-line oral antibiotics and, in some cases, extended-spectrum beta-lactams [14]. Pseudomonas species and members of the Enterobacterales family exhibit notably high proportions of MDR, complicating treatment strategies. Staphylococcus aureus remains a leading isolate in diabetic wound infections, with methicillin-resistant S. aureus (MRSA) detected in several cohorts, though prevalence varies across studies and settings. Fungal organisms, particularly Candida species, are frequently isolated as colonizers and occasionally as pathogens in chronic or deep infections. While antifungal resistance data are limited, monitoring is essential, given the potential need for systemic antifungal therapy in recalcitrant cases. These emerging resistance patterns significantly undermine the efficacy of standard empirical therapies, often necessitating the use of broader-spectrum or parenteral agents, which increases treatment costs and logistical complexity [15]. The combined effect of bacterial and fungal resistance heightens the risk of adverse clinical outcomes, including prolonged infection, poor wound healing, and increased rates of limb amputation, underscoring the urgent need for surveillance, antimicrobial stewardship, and context-specific therapeutic guidelines to manage DFIs effectively.

**Drivers of resistance in the Nigerian context**

In Nigeria, antimicrobial resistance (AMR) in diabetic infections is driven by a combination of structural and behavioral factors. Widespread, often unregulated access to antibiotics through community pharmacies and informal providers leads to misuse and subtherapeutic dosing, promoting resistance [16, 17]. Compounding this issue is the limited laboratory capacity for routine culture and susceptibility testing, which forces clinicians to rely heavily on empiric therapy without microbiological guidance. In healthcare facilities, inconsistent infection prevention and control (IPC) practices, coupled with inadequate antimicrobial stewardship (AMS) programs, facilitate the circulation and persistence of resistant organisms. While national policies and frameworks to combat AMR exist, their implementation is uneven across states and healthcare institutions, creating gaps in regulation, monitoring, and enforcement. Collectively, these structural weaknesses, behavioral practices, and systemic inconsistencies contribute to the rising prevalence of AMR among diabetic patients, posing significant challenges for effective infection management and public health outcomes in Nigeria. Addressing these drivers requires coordinated efforts to strengthen laboratory capacity, enforce rational antibiotic use, implement robust AMS and IPC programs, and ensure consistent policy application nationwide to curb the spread of resistant infections [18].

**Infection prevention and control measures**

Infection prevention and control (IPC) measures are essential for reducing both the incidence of infections and the transmission of antimicrobial-resistant organisms, particularly among diabetic patients who are at increased risk of wound-related complications. Key strategies include routine education on foot care and early clinical review of minor lesions to prevent progression to severe infections. In inpatient settings, adherence to standard precautions such as strict hand hygiene, aseptic dressing changes, and regular environmental cleaning forms the cornerstone of effective IPC. Wound-care bundles, when consistently implemented, help minimize infection risks and improve patient outcomes [19]. High-risk units, including surgical and wound care wards, may benefit from targeted screening and, where appropriate, decolonization of organisms like methicillin-resistant Staphylococcus aureus (MRSA) to limit cross-transmission. Strengthening outpatient wound clinics and community-based education programs ensures timely access to professional care, reducing delays between wound onset and intervention. Evidence from Nigerian hospitals demonstrates that facility-level IPC improvements significantly decrease infection-related complications and prevent the spread of resistant pathogens. Overall, integrating these measures across hospital and community settings enhances patient safety, lowers the burden of infections among diabetic populations, and supports broader public health efforts to curb antimicrobial resistance [20].

**Implications for antimicrobial stewardship (AMS)**

Antimicrobial stewardship (AMS) programs in Nigeria must be tailored to local realities, with a focus on diabetic infections, which are major drivers of antibiotic use and resistance. Strengthening diagnostics and reporting is critical: expanding access to microbiology services for diabetic foot infections (DFIs), generating and disseminating local antibiograms, and establishing referral pathways to regional laboratories where testing is unavailable ensures empiric therapy aligns with local susceptibility patterns [21]. Facility-level antibiograms should inform empiric therapy guidelines, stratified by infection severity and likely pathogens, promoting narrow-spectrum therapy and timely de-escalation. Multidisciplinary AMS teams, including physicians, pharmacists, microbiologists, and nurses, should train clinicians on appropriate antibiotic selection, duration, dose adjustments for renal function, and the AWaRe classification, all essential for diabetes care. Integration of AMS with infection prevention and control (IPC) activities, such as wound-care audits, ensures antibiotic decisions consider wound management and device-related risks. Community engagement is also vital: enforcing regulations on antibiotic sales, educating the public on the dangers of self-medication, and involving community pharmacists in stewardship activities can reduce inappropriate

use. Collectively, these measures strengthen stewardship, reduce resistance, and improve outcomes for diabetic patients while supporting broader national AMS objectives [22].

**Priority research and surveillance needs**

To effectively guide policy and clinical practice in Nigeria, research and surveillance efforts should focus on improving the management of diabetic wound infections. Priority areas include the regular development and publication of facility- and regional-level antibiograms, specifically targeting isolates from diabetic wounds, to provide clinicians with up-to-date data on pathogen prevalence and resistance patterns. Prospective studies are needed to quantify clinical outcomes, such as wound healing time, rates of amputation, and mortality, in relation to the causative organisms and their antimicrobial resistance profiles [23]. In addition, surveillance of fungal pathogens in diabetic wounds should be strengthened, as these infections remain under-reported and poorly understood, limiting effective treatment strategies. Another critical area is operational research on antimicrobial stewardship (AMS) models, focusing on identifying approaches that are effective and feasible across different levels of healthcare facilities, including tertiary, secondary, and peripheral centers. Collectively, these research and surveillance priorities aim to generate actionable evidence that can inform targeted interventions, optimize antimicrobial use, reduce complications, and improve patient outcomes in diabetic wound care. Strengthening these systems will support evidence-based decision-making, enhance infection control, and contribute to the overall reduction of morbidity and mortality associated with diabetic wound infections in Nigeria.

**Practical recommendations for clinicians managing diabetic infections in Nigeria**

Effective management of diabetic infections in Nigeria requires a structured, evidence-based approach tailored to local healthcare settings. Clinicians should begin with thorough wound assessment, classifying infection severity and obtaining microbiological cultures before initiating systemic antibiotics whenever feasible. Empiric antibiotic therapy should target the most likely pathogens based on local antibiogram data, with adjustments made once culture results and susceptibilities are available to ensure precision and minimize resistance [23]. It is important to distinguish between superficial colonization and invasive infection, avoiding unnecessary systemic antibiotics for colonized wounds that show no clinical signs of infection. Non-antibiotic measures are equally critical for successful outcomes, including stringent glycemic control, proper offloading to reduce pressure on affected areas, regular wound debridement, vascular assessment to ensure adequate perfusion, and appropriate dressing techniques to promote healing. Early involvement of multidisciplinary teams enhances patient care and outcomes; collaboration among diabetologists, endocrinologists, surgeons or podiatrists, infectious disease specialists, microbiologists, and nursing staff ensures comprehensive evaluation, timely intervention, and coordinated management. Implementing these practical strategies can improve infection control, reduce complications such as amputation, and optimize overall wound healing in diabetic patients, particularly in resource-limited settings in Nigeria, where coordinated clinical protocols are essential for improving patient outcomes.

## CONCLUSION

Diabetic patients in Nigeria face a substantial burden from bacterial and fungal infections, with hyperglycemia, immune dysfunction, and comorbidities heightening susceptibility and complicating clinical outcomes. The prevalence of multidrug-resistant organisms including MRSA, ESBL-producing Gram-negative bacteria, and azole-resistant fungi poses additional challenges, undermining empiric therapy and increasing morbidity, mortality, and healthcare costs. Effective management requires integrated strategies combining accurate microbiological diagnosis, empiric therapy guided by local antibiograms, and timely de-escalation based on culture results. Non-antibiotic interventions, such as glycemic control, wound offloading, debridement, and vascular assessment, are critical, alongside early engagement of multidisciplinary teams. Strengthening infection prevention and control measures and implementing context-specific antimicrobial stewardship programs are essential to curb resistance and improve patient outcomes. Furthermore, enhanced surveillance, operational research, and community education are needed to inform policy and clinical practice. Collectively, these measures can optimize infection management, reduce complications such as amputation, and support sustainable, evidence-based approaches to improving diabetic patient care in Nigeria.

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