JOURNAL OF SCIENCE & DISEASES

High prevalence of multidrug-resistant bacteria in diabetic foot infections: a series of 59 cases at a district hospital in Cameroon

Prévalence de bactéries multirésistantes dans les infections du pied diabétique : à propos de 59 cas dans un hôpital de district au Cameroun

Ngono CS [1,2], Nko'o MHJ [1,2], Nguea Ndjame AG [3,4], Noah Onana MN [2], Obono Fouda P [1], Kemgou FR [5], Ateba Ateba NS [1], Atangana Ekobo HN [1], Ntone Enyime SV [1], Bidjogo Gwet MM[1], Zeh Mabiom GA[2], Noah Noah D [1,2]

Original Article

1. Faculty of Medicine and Pharmaceutical Sciences, University of Ebolowa
2. Sangmélima Referral Hospital
3. Faculty of Medicine and Pharmaceutical Sciences, University of Douala.
4. Central Hospital of Yaoundé
5. University Institute of Science and Technology, Yaoundé
6. Yaoundé General Hospital

Corresponding author : Ngono Claire Sandrine, Department of Internal Medicine and Specialties, Faculty of Medicine and Pharmaceutical Sciences, University of Ebolowa, Sangmélima Reference Hospital, Email: clairesngono12@gmail.com, Tel : (+237) 659147829

Key words: Diabetic foot, infection, antibiogram, multidrug resistance, sub-Saharan Africa

Mots-clés : Pied diabétique, infection, antibiogramme, bactéries multirésistantes, Afrique subsa-harienne.

Date de soumission: 28/07/2025
Date d'acceptation: 03/12/2025

ABSTRACT

Introduction: Diabetic foot infections (DFI) represent a common and significant healthcare challenge, particularly in low-resource settings like Sub-Saharan Africa. This study aimed to outline the epidemiological, clinical, and microbiological aspects along with the patterns of anti-biotic susceptibility relevant to DFI in Yaoundé.

Materials and Methods: A cross-sectional study was conducted at Cité Verte District Hospital from October 15, 2022, to July 21, 2023. We enrolled diabetic patients with infected foot ulcers. Bacteriological samples were taken to identify the causative pathogens and determine their anti-biotic susceptibility profile.

Results: The study sample comprised 59 patients, mostly male, with a mean age of 52 (± 11.8) years. A significant proportion of patients had type 2 diabetes (88%) which lasted for less than a decade. Foot ulcers were chronic and severe (66% Wagner grade 3), and only 39% had received some form of education on foot care. The predominant pathogens identified were gram-negative bacilli, including Klebsiella pneumoniae (20%), Proteus mirabilis (10%), Escherichia coli (8%), followed by gram-positive cocci Staphylococcus saprophyticus (36%). There was polymicrobial infection in 17% of cases. Other notable findings included high level resistance to amoxicillin-clavulanic acid, cephalosporins, and vancomycin. These findings suggest the presence of com-mon multidrug resistant and strains resistant to methicillin.

Conclusion: The study highlights the prevalence of multidrug-resistant bacteria in DFI in Ya-oundé, limiting therapeutic options. Strengthening preventive education, improving microbiolog-ical diagnostic capacity, and adapting antibiotic stewardship are critical in such resource-limited settings.

RESUME

Introduction : L'infection du pied diabétique (IPD) est une complication grave du diabète, particulièrement redoutable en Afrique subsaharienne en raison des ressources limitées. Cette étude visait à décrire les aspects épidémiologiques, microbiologiques et les profils de résistance des bactéries isolées dans les IPD à Yaoundé.

Méthodes : Une étude transversale descriptive a été réalisée entre le 15 octobre 2022 et le 21 juillet 2023 à l'Hôpital de District de la Cité Verte. Tous les patients diabétiques présentant une ulcération du pied infectée ont été inclus. Les prélèvements bactériologiques effectués ont per-mis d'identifier les germes et d'évaluer leur sensibilité aux antibiotiques.

Résultats : Cinquante-neuf patients ont été inclus, majoritairement des hommes (61 %), d'un âge moyen de 52 ± 11.8 ans, avec un diabète de type 2 (88 %). Les ulcères étaient anciens (>1 mois dans 98 %), sévères (66 % de grade 3 selon Wagner), et 39 % des patients avaient reçu une éducation préventive. Les pathogènes isolés étaient majoritairement des bacilles Gram négatifs (Klebsiella pneumoniae 20 %, Proteus mirabilis 10 %, Escherichia coli 8 %) et des cocci Gram positifs (Staphylococcus saprophyticus 36 %). Les infections polymicrobiennes concernaient 17 % des prélèvements. Une résistance élevée aux antibiotiques a été observée, notamment aux bêta-lactamines et à la vancomycine.

Conclusion : La forte prévalence des bactéries multirésistantes dans les IPD à Yaoundé appelle à renforcer la prévention, l'accès au diagnostic microbiologique et à des protocoles antibiotiques adaptés.

DOI : https://doi.org/10.64294/jsd.v3i4.193

Introduction

Infected diabetic foot ulcers (DFUs) are a common and serious complication of diabetes mellitus, particularly in sub-Saharan Africa where access to specialized care remains limited (1,2). This condition is a major cause of hospitalization and non-traumatic amputation in the region [1,3]. Similar to other low to middle-income nations, Cameroon case series illustrate a male predominance, averaging around 50 years of age, associated to a short duration of diabetes prior to ulcer development. DFU prevention and therapeutic education remain underdeveloped which contributes to delays in care-seeking as well as the onset of deep infections (2,3). From a microbiological standpoint, bacterial profiles associated with DFUs in Africa diverge from those in higher income countries. While Staphylococcus aureus often predominates in Western countries, several African studies report a predominance of Gram-negative bacilli like Klebsiella pneumoniae and Escherichia coli (4–6). The rising rates of antimicrobial resistance coupled with high rates of multidrug resistant bacteria is problematic (7–9). In this respect, we would like to report the epidemiological and microbiological data along with the resistance patterns pertaining the infections to diabetic foot (10) in Cité Verte District Hospital, Yaoundé, with the intent of enhancing the local intelligence for better clinical outcomes.

Materials and Methods

A descriptive cross-sectional study took place at the Cité Verte District Hospital in Yaoundé, Cameroon, which is a reference center for the management of diabetic foot ulcers (DFUs), between October 15, 2022, and July 21, 2023. The diagnosis of diabetic foot ulcer was made as per the International Working Group on the Diabetic Foot (IWGDF) 2023 criteria. The microbiological analyses were performed in collaboration with SANTE PLUS laboratory which is accredited for clinical bacteriological examinations. Patients number with diabetes and foot infection ulcers that were seen outpatient or inpatient and gave their informed consent to participate were included consecutively. A clinical and microbiological data collection form was used to collect the data from the patients anonymously. The data entered into Microsoft Word were then transferred into Microsoft Excel 2013 and IBM SPSS Statistics version 21. Quantitative variables were described using means, standard deviations, and medians, while qualitative variables were expressed as frequencies and percentages. The research has been given the green light by the ethics committee in charge.

Results

Fifty-nine (59) patients with infected diabetic foot ulcers (DFU) were involved in the study. The study population was predominantly male (61%), with a sex ratio of 1.5. The mean age was 52 years (± 11.8) with a range of 49 to 89 years. The 40 - 49 age group was the most represented (51%). Type 2 diabetes mellitus was diagnosed in most patients (88%, n=52) and in 73% of the cases, the duration of diabetes was less than a decade. Ulcer location-wise, blisters were the leading cause (35%). The wounds were very severe with 66% of them being classified as Wagner grade 3 and had been developing for more than one month in 98% of cases. The duration of the ulcer in 47% of patients was more than four months. Most patients (90%) reported recent antibiotic use. Participants who received education on diabetic foot prevention accounted for only 39%. Bacteriological profile of wounds Bacterial organisms was obtained in all the samples.

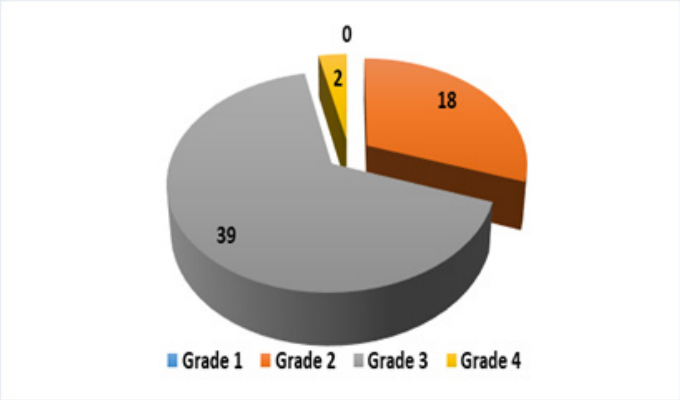

Figure 1: distribution of samples by infection severity

Bacteria were isolated from all samples. Isolated gram-positive cocci (GPC) were found in 46% of instances (n=27), mostly Staphylococcus saprophyticus (36%, n=21). Gram negative bacilli (GNB) were isolated in 66% of cases (n=39), with Klebsiella pneumoniae (24%, n=14) as the most common. There were polymicrobial infections in 17% of cases (n=10).

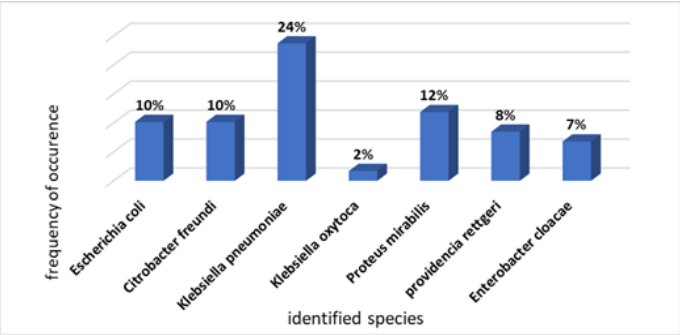

Figure 2: distribution of isolated Gram-negative bacteria

Isolates of Staphylococcus aureus showed notable resistance to vancomycin (100%) and oxacillin (80%). Staphylococcus saprophyticus showed 95% resistance to vancomycin and 75% to oxacillin. Isolates from Proteus mirabilis, Citrobacter freundii, Enterobacter cloacae, and Klebsiella pneumoniae showed significant resistance to penicillin (100%) as well as first- and second-generation cephalosporins. However, all tested GNB isolates exhibited sensitivity to carbapenems.

Citation as **J Sci Dis 2025, Vol 3 (4): 70 - 73**

Table I: bacteriological profile of infected diabetic foot ulcers (n=59)

Type of organism	Species	Number (n)	Percentage (%)
Gram-positive cocci (GPC)	All GPC	27	46
	Staphylococcus aureus	5	8
	Staphylococcus epidermidis	1	2
	Staphylococcus saprophyticus	21	36
Gram negative bacilli (GNB)	All GNB	39	54
	Escherichia coli	6	10
	Citrobacter freundi	6	10
	Klebsiella pneumoniae	14	24
	Klebsiella oxytoca	1	2
	Proteus mirabilis	7	12
	Providencia rettgeri	5	8
	Enterobacter cloacae	4	7
Polymicrobial	-	10	17

Table II: antibiotic resistance patterns of bacteria isolated from diabetic foot ulcers

Bacterial species	Antibiotics with resistance ≥ 50%	Antibiotics with preserved susceptibility (>70%)
Staphylococcus aureus	Vancomycin (100%), Oxacillin (80%), Tetracycline (80%), Norfloxacin (60%)	Erythromycin, Lincomycin, Gentamicin (80%)
Staphylococcus saprophyticus	Vancomycin (95%), Oxacillin (75%), Norfloxacin (50%), Tetracycline (55%)	Erythromycin, Lincomycin (80–100%)
Staphylococcus epidermidis	No significant resistance	Susceptible to all tested antibiotics (100%)
Proteus mirabilis	Amoxicillin, Amox-clav, TMP-SMX (100%), Cefuroxime, CRO (86%)	Imipenem, Amikacin (100%), CIP (86%)
Klebsiella pneumoniae	Amoxicillin (100%), Amox-clav (93%), CRO (71%)	Imipenem (93%), Amikacin (100%), CIP (86%)
Citrobacter freundii	Amoxicillin, Amox-clav, TMP-SMX (100%), FOX, CXM (100%)	Imipenem (100%), Amikacin (83%)
Enterobacter cloacae	Amoxicillin, Amox-clav, CRO, CXM, TMP-SMX (100%)	Imipenem (100%)
Providencia rettgeri	Amox-clav (100%), Amoxicillin (80%)	Imipenem (100%), CIP, Amikacin, Chloramphenicol (60%)
Klebsiella oxytoca	Amoxicillin, Amox-clav, CXM, CRO, CAZ, FEP, CIP, Amikacin, TMP-SMX (100%)	Imipenem, ATM (100%)

Abréviations :

- CRO = Ceftriaxone, CXM = Cefuroxime, CAZ = Ceftazidime, FEP = Cefepime, ATM = Aztreonam
- TMP-SMX = Trimethoprim-sulfamethoxazole, CIP = Ciprofloxacin, FOX = Cefoxitin
- Amox-clav = Amoxicillin-clavulanic acid

Discussion

In this study, patients with infected DFUs were mostly middle-aged men, a characteristic typically described in low- and middle-income countries (11,12). Increased trauma exposure and low use of preventive care may account for this male predominance (11). The observed mean age is in line with data from sub-Saharan Africa and Cameroon, where diabetes is frequently diagnosed after the fact (1,12). Therapeutic education remains a difficulty in resource-limited contexts (2,3). Less than 40% of our patients had received advice on preventing DFU, which is consistent with deficiencies found in earlier studies conducted in Africa (3). Delays in seeking care, which exacerbate diabetic foot infections, are a result of this lack of education (2,3). Chronicity of wounds increases the risk of amputation and bacterial colonization (4,11).

From a microbiological perspective, we detected a prevalence of Gram-negative bacilli such as Klebsiella pneumoniae and Escherichia coli, consistent with regional findings (5,6). This picture contrasts with high-income countries where Staphylococcus aureus remains the main isolated pathogen (4). Some African series have reported the presence of Staphylococcus saprophyticus, which raises concerns regarding its pathogenicity or possible environmental contamination (6). Our study's polymicrobial infection rate was lower than other African studies, which may have been caused by sampling methods or past antibiotic use (5). However, polymicrobial infections are still prevalent in chronic DFUs and need to be properly managed.

One of the biggest challenge to treating DFUs in Africa is antibiotic resistance (7,8). High resistance to fluoroquinolones and beta lactams was noted in our series, consistent with regional pattern (7,8).

The presence of multidrug-resistant strains and methicillin-resistant Staphylococcus aureus (MRSA) complexifies therapeutic management (9). Although carbapenems retain their effectiveness, their high cost and limited availability restrict their use in our setting (7,8).

The WHO emphasizes the urgency of strengthening strategies to combat antimicrobial resistance, notably through rational antibiotic use, appropriate prescribing, and systematic use of antibiograms prior to antibiotic therapy (9). These measures are useful to decrease morbidity and improve functional outcomes for diabetic patients with DFUs in resource-limited

Citation as **J Sci Dis 2025, Vol 3 (4): 70 - 73**

settings (3,5).

Our study contributes to documenting the local specificities of DFU infections in Cameroon and highlights the need to develop prevention policies, structured therapeutic education, and microbiological surveillance to optimize DFU management. Strengthening the capacity of healthcare providers and improving access to effective antibiotics remain priorities in combating DFU complications in our context.

Conclusion

Diabetic foot infections are still a frequent and serious problem in our environment. This study points out the main contribution of Gram-negative bacilli as well as multidrug-resistant profiles that are very alarming and allow only a few therapeutic options. Prevention is inadequate and there is not enough education for therapy, which means that the patient becomes more and more aware of the problem. The use of antibiograms should be part of the strategy for adjusting antibiotic treatment and preventing the spread of multidrug-resistant strains. The implementation of microbiological surveillance programs and the revision of the management protocols are important for improving the outcomes in diabetic patients.

Acknowledgement

We wish to express our heartfelt gratitude to Dr. NGONO Hélène Valérie, medical biologist from the SANTE PLUS laboratory, for her support and supervision of the bacteriological analyses. We also express our sincere thanks to the staff of the SANTE PLUS laboratory and the Cité Verte District Hospital for their availability and collaboration. Our appreciation goes also to the patients who have accepted to participate in this study, thus becoming the co-creators of the new knowledge.

Author contributions

Ngono Claire Sandrine (a,b) Nko'o Moise Henry Julien (a,b), Nguea Ndjame Arlette Géraldine (a,b), Noah Onana Marie Noelle (b), Obono Fouda Mballa Patrick (b), Kemgou Franklin Roosvelt (b), Ateba Ateba Nelly Stella (b), Atangana Ekobo Huguette Noelle (b), Ntone Enyime Samuel Vianney (b), Bidjogo Gwet Marina Madeleine (b), Zeh Mabiom Gabriel Arsène (b), Noah Noah Dominique (c)

(a) "conception and design, acquisition of data, analysis and interpretation of data", (b) "drafting the article, revising it critically for important intellectual content", (c) "final approval of the version to be published".

Conflicts of interest: Authors declare no conflict of interest

References

1. Hall V, Thomsen RW, Henriksen O, Lohse N. Diabetes in Sub Saharan Africa 1999-2011: Epidemiology and public health implications. a systematic review. BMC Public Health. 14 juill 2011;11:564.
2. Pastakia SD, Pekny CR, Manyara SM, Fischer L. Diabetes in sub-Saharan Africa – from policy to practice to progress: targeting the existing gaps for future care for diabetes. Diabetes Metab Syndr Obes Targets Ther. 22 juin 2017;10:247 63.
3. Ndip EAA, Tchakonte B, Mbanya JC. A Study of the Prevalence and Risk Factors of Foot Problems in a Population of Diabetic Patients in Cameroon. Int J Low Extrem Wounds. juin 2006;5(2):83 8.
4. Lipsky BA, Berendt AR, Cornia PB, Pile JC, Peters EJG, Armstrong DG, et al. 2012 Infectious Diseases Society of America Clinical Practice Guideline for the Diagnosis and Treatment of Diabetic Foot Infectionsa. Clin Infect Dis. 15 juin 2012;54(12):e132 73.
5. Wada FW, Mekonnen MF, Sawiso ED, Kolato S, Woldegiorgis L, Kera GK, et al. Bacterial profile and antimicrobial resistance patterns of infected diabetic foot ulcers in sub-Saharan Africa: a systematic review and meta-analysis. Sci Rep. 5 sept 2023;13(1):1 10.
6. Luisa Nang EO, Milca A. Microbial Profile of Diabetic Foot Ulcers of Patients Attending the Regional Hospital Bamenda (Cameroon). Acta Sci Med Sci. 1 févr 2024;19 24.
7. Makeri D, Odoki M, Eilu E, Agwu E. Update on prevalence and antimicrobial resistance of Staphylococcus aureus and Pseudomonas aeruginosa isolated from diabetic foot ulcers in Africa: a systematic review and meta-analysis. Bull Natl Res Cent. 10 oct 2023;47(1):145.
8. Lawal OU, Ayobami O, Abouelfetouh A, Mourabit N, Kaba M, Egyir B, et al. A 6-Year Update on the Diversity of Methicillin-Resistant Staphylococcus aureus Clones in Africa: A Systematic Review. Front Microbiol. 3 mai 2022;13:860436.
9. World Health Organization. Global action plan on antimicrobial resistance [Internet]. Geneva: World Health Organization; 2015 [cité 27 juin 2025]. 28 p. Disponible sur: https://iris.who.int/handle/10665/193736
10. Fitridge R, Game F, Senneville É. Nicolaas C. Schaper (chair), Jaap J. van Netten.
11. World Health Organization. Global report on diabetes [Internet]. Geneva: World Health Organization; 2016 [cité 27 juin 2025]. 83 p. Disponible sur: https://iris.who.int/handle/10665/204871
12. Tindong M, Palle JN, Nebongo D, Aminde LN, Mboue-Djieka Y, Mbarga NTF, et al. Prevalence, Clinical Presentation, and Factors Associated With Diabetic Foot Ulcer in Two Regional Hospitals in Cameroon. Int J Low Extrem Wounds. mars 2018;17(1):42 7.