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ORIGINAL RESEARCH ARTICLE

Healthcare-associated infections in a resource-limited setting: Microbial contamination and antimicrobial resistance in a Cameroonian referral hospital

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Abstract

Antimicrobial resistance is a silent pandemic threatening the lives of millions on the African continent. This exploratory study investigates microbial contamination of surfaces and medical devices, evaluates antibiotic resistance profiles, and identifies high-risk pathogens within a referral hospital in Yaoundé, Cameroon. A descriptive cross-sectional study was conducted from May to July 2024 in the obstetrics–gynecology department. Thirty samples were collected using sterile swabs from high-touch surfaces and from medical devices. Bacterial isolates were identified using standard culture and biochemical methods, and antibiotic susceptibility testing was performed through disk diffusion, with methicillin-resistant *Staphylococcus aureus* confirmed using cefoxitin discs. Data were analyzed using R Statistics version 4.4.2. The findings revealed that all samples were contaminated, yielding 55 bacterial isolates. Gram-positive bacteria were predominant (60%), primarily *S. aureus* (36%), and other *Staphylococcus* spp. (24%). Gram-negative pathogens included *Proteus mirabilis* (13%) and *Klebsiella* spp. (7%). Taps (14 isolates) and trolleys (100% contamination rate) were identified as the most contaminated sites. Antibiotic resistance was high: 70% of *Staphylococcus* species were methicillin-resistant, and 100% of Gram-negative isolates exhibited multidrug resistance (MDR), including resistance to penicillin (≥70%), cephalosporins (≥80%), and fosfomycin (≥75%). Carbapenems and quinolones remained effective against Gram-negative strains. These findings highlight widespread contamination of hospital environments with MDR pathogens, posing significant risks to maternal and neonatal health. The predominance of methicillin-resistant *S. aureus* and MDR Gram-negative bacteria underscores the urgent need to strengthen infection protocols, antimicrobial stewardship, and national antimicrobial resistance surveillance in Cameroon. Implementation of the World Health Organization infection prevention and control guidelines and targeted staff training is essential to reduce preventable healthcare-associated infections in resource-limited settings.

Keywords: Healthcare-associated infections; Antimicrobial resistance; *Staphylococcus aureus*; Methicillin-resistant *Staphylococcus aureus*; Infection prevention and control; Obstetrics–gynecology; Cameroon

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1. Introduction

Maternal mortality remains critically high, with an estimated 260,000 women dying during or after pregnancy and childbirth in 2023. Most of these deaths (92%) occurred in low- and lower-middle-income countries, where the vast majority were preventable.[1] The postpartum stage is the most vulnerable for child survival, with 2.3 million newborn deaths reported in 2022.[2] Scientific evidence indicates that the leading causes of maternal death globally are hemorrhage, followed by hypertensive disorders of pregnancy.[3] In addition, sepsis and other complications often occur during the postpartum period, contributing to maternal deaths.[4]

Sepsis, which can prolong hospital stay or cause maternal death, results from untreated, poorly treated, or complicated puerperal infections, such as urinary tract infections, endometritis, pneumonia, and perineal or cesarean wound infections.[5] These puerperal infections occurring during hospital stay are often attributed to healthcare-associated infections (HAIs).[6] The risk of such infections increases with poor compliance with infection prevention and control (IPC) measures, which are protocols derived from guidelines designed to minimize pathogen transmission within healthcare settings.[7,8]

Adherence to IPC guidelines among healthcare workers is critical, particularly since Cameroon lacks a fully effective national IPC program. Only certain components of the World Health Organization (WHO)'s IPC core components have been implemented.[9] As a result, inconsistent adherence to standard precautions, including poor hand hygiene and inadequate use of personal protective equipment, can facilitate the transfer of pathogens from the healthcare environment to mothers and newborns, causing early neonatal infections.[10,11]

Studies indicate that biofilms are commonly found on the surfaces of hospital instruments and body tissues and have become significant contributors to global health problems due to antibiotic resistance.[12] A bacterial biofilm comprises a structured community of microorganisms, including bacteria, fungi, archaea, protozoa, and yeasts, encased in an extracellular matrix with channel structures that regulate the movement of gases, nutrients, and antimicrobials.[13]

These biofilms are often rich in multidrug-resistant (MDR) bacteria, resulting from frequent exposure to antibiotics that are present in non-bactericidal doses within healthcare environments. They can also originate from residual body fluids of severely ill patients who have either irrationally used antibiotics or poorly adhered to prescribed regimens. In gynecological and obstetrical departments, infections caused by these MDR bacteria can lead to prolonged hospital stays and even maternal and neonatal death, largely due to limited treatment options.[14]

In Cameroon, suboptimal adherence to standard precautions and a lack of comprehensive antimicrobial resistance surveillance are further complicated by limited evidence, with only two prior studies assessing bacterial flora in healthcare settings.[15,16] Therefore, this study aims to identify high-risk microbial pathogens in gynecological and obstetric departments, evaluate their antibiotic resistance profiles, and generate actionable data to advocate for full adoption of the WHO IPC guidelines. By bridging this critical evidence gap, our findings may inform targeted IPC interventions and empirical treatment protocols, ultimately reducing preventable maternal and neonatal deaths in resource-limited contexts.

2. Methods

2.1. Study design and period

This descriptive cross-sectional study, conducted from May to July 2024, focused on healthcare workers and the healthcare environment to characterize the microbial flora and assess the risk of pathogen exposure.

2.2. Settings

The study was conducted in Yaoundé, the capital city of Cameroon, which has a population of approximately 3.2 million and is served by a tiered healthcare system comprising first-, second-, third-, and fourth-level facilities. The healthcare setting studied is a fourth-level referral center within the healthcare pyramid. It provides both short- and long-term specialized care and plays a key role in the training of healthcare workers.[17,18] The hospital has a capacity of 138 beds and receives between 500 and 1,000 patients/week. In 2023, the hospital recorded 35,945 outpatient consultations and 4,329 admissions, totaling 21,518 hospital days, with an average hospital stay of 5 days/inpatient.[17,19] In 2023, the obstetrics–gynecology department reported approximately 300 deliveries, 8 deaths, 625 prenatal consultations, and 77 cesarean sections. In addition, the department managed 101 obstetric complications and 33 post-abortion complications.[19]

2.3. Sampling

In this study, a total of 30 samples were collected from medical equipment (e.g., delivery table, trolley, drip stand, nursing table) and high-touch surfaces (e.g., taps, door handles). A purposive sampling design was employed. Ten samples were collected weekly for 3 weeks, divided into two phases of five samples, each collected 1 day apart.

Surface and medical device samples were collected in the early morning using sterile swabs premoistened with 0.9% sodium chloride solution (Missionpharma, Denmark), which were streaked across the surface in parallel lines and then cross-streaked perpendicularly. Swabs were placed in labeled cryotubes containing brain–heart infusion broth (Jiangsu Kangjie Medical Devices Co., Ltd., China) and immediately transported to the laboratory for bacteriological examination.[16,20]

2.4. Microbial analysis

Upon arrival at the bacteriology laboratory, each cotton swab was aseptically transferred to a tube containing 2 mL of sterile physiological solution, from which 0.1 to 0.4 mL aliquots were pipetted into selective culture media (eosin methylene blue agar for Gram-negative bacteria and mannitol salt agar for *Staphylococcus* spp.). The inoculated media were incubated at 37°C for 24–48 h to isolate specific pathogens. After incubation, bacterial isolates were identified using standard biochemical methods. Gram-negative bacilli were characterized based on their reactions to glucose, lactose, citrate, hydrogen sulfide, urea, indole, and gas production.

Antibiotic susceptibility testing was performed using the Müller–Hinton agar disk diffusion technique.[16] Bacterial suspensions were prepared according to the 0.5 McFarland standard. Discs were placed on inoculated agar and incubated at 37°C ± 2°C for 18–24 h. Selection and interpretation of the antibiotic discs were performed according to the guidelines of the European Committee on Antimicrobial Susceptibility Testing 2023.[21] Detected *Staphylococcus aureus* strains were tested for methicillin resistance using a cefoxitin disc, with strains exhibiting an inhibition diameter of <27 mm considered methicillin-resistant *S. aureus* (MRSA).[20,22] MDR bacteria were defined as microorganisms resistant to at least one antibiotic from three or more different antimicrobial classes.[23] To minimize potential bias, rigorous quality control was ensured through culture conditions, media preparation, antibiotic authenticity, equipment calibration, and reagent validation to ensure the reliability and accuracy of the results.

2.5. Data analysis

Data were coded and analyzed using R Statistics version 4.4.2 (R Core Team, Austria). Fisher's exact test was used to compare proportions. A $p<0.05$ was considered statistically significant.

3. Results

3.1. Microbiological analysis of environmental surfaces and medical devices

A total of 15 samples were collected from each subunit—the inpatient and maternity subunits. The findings revealed that all collected samples were bacterially contaminated. A total of 55 isolates were identified, most of which were Gram-positive (60%) and originated from the inpatient subunit (62%). Tap surfaces were identified as the most contaminated surfaces, with 14 isolates detected (Table 1).

The most prevalent microbial strains in the department included *S. aureus* (36%), other *Staphylococcus* species (24%), *Proteus mirabilis* (13%), and *Klebsiella* spp. (7%). Non-enterobacterial Gram-negative bacilli were the least represented (Figure 1).

In the maternity ward, most isolates were *Staphylococcus* spp. (70%), with *S. aureus* the most prevalent species (42%). However, a nearly equivalent distribution was observed between *Staphylococcus* spp. (52%) and Enterobacteria (45%) (Table 2).

Most microorganisms (74%) on door handles were *Staphylococcus* spp., with *S. aureus* the most prevalent species (57%). In contrast, the trolley surfaces were primarily contaminated with *Enterobacteriaceae* (66%), with *P. mirabilis* (33%) and *Klebsiella* (33%) spp. most frequently isolated (Table 3).

3.2. Antibiotic susceptibility of isolated staphylococcal strains

Most *Staphylococcus* isolates were found to be penicillinase producers (≥90%). Significant antibiotic resistance was also detected for fosfomycin, rifampicin, fusidic acid, and cotrimoxazole (≥70%). In contrast, the most effective antibiotics against the isolates were ciprofloxacin, erythromycin, and vancomycin, to which the bacteria exhibited low or no resistance (Table 4).

Table 1. Bacterial contamination of surfaces and medical devices by Gram category

Characteristic	Gram-negative (*n* [%])	Gram-positive (*n* [%])	Total	*p*-value[a]
Number of isolates	22 (40)	33 (60)	55 (100)	-
Subunit				
Inpatient	16 (47)	18 (53)	34	0.258
Maternity	6 (29)	15 (71)	21	
Surface and devices				
Trolley	4 (40)	6 (60)	10	0.723
Door handle	3 (25)	9 (75)	12	
Drip stand	4 (67)	2 (33)	6	
Tap	6 (43)	8 (57)	14	
Delivery table	2 (40)	3 (60)	5	
Nursing table	3 (37)	5 (63)	8	

Note: [a]Fisher's exact probability test.

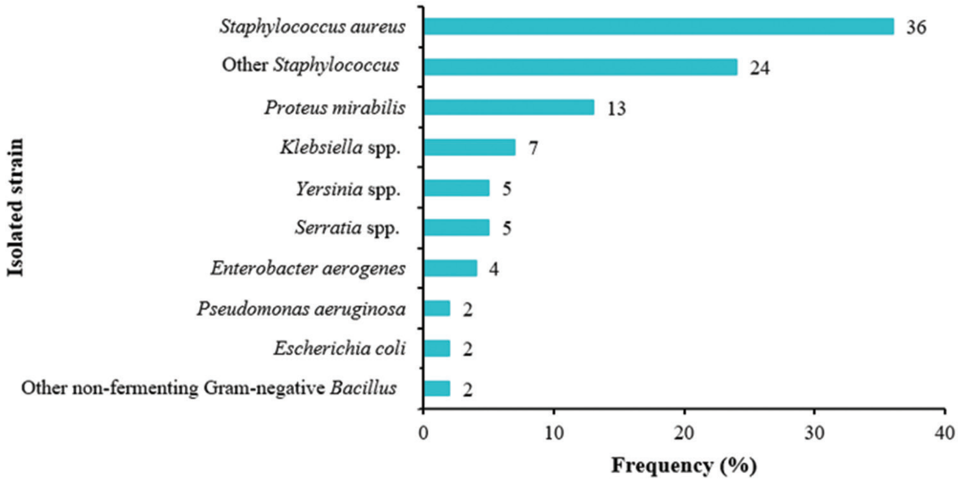

Figure 1. Bacterial profile on environmental surfaces and medical devices (n = 55)

Table 2. Bacterial strains isolated from the inpatient and maternity subunits

Isolated bacteria	Subunit (*n* [%])		Total	*p*-value[a]
	Inpatient	Maternity		
Number of isolates	34 (100)	21 (100)	55 (100)	0.291
Staphylococcus spp.				
Staphylococcus aureus	11 (31)	9 (42)	20	-
Others	7 (21)	6 (28)	13	
Total	18 (52)	15 (70)	33	
Enterobacteria				
Proteus mirabilis	7 (21)	0 (0)	7	-
Klebsiella spp.	3 (9)	1 (5)	4	
Serratia spp.	1 (3)	2 (10)	3	
Yersinia spp.	2 (6)	1 (5)	3	
Enterobacter aerogenes	1 (3)	1 (5)	2	
Escherichia coli	1 (3)	0 (0)	1	
Total	15 (45)	5 (25)	20	
Other Enterobacteria				
Pseudomonas aeruginosa	1 (3)	0 (0)	1	-
Other non-fermenting Gram-negative *Bacillus*	0 (0)	1 (5)	1	
Total	1 (3)	1 (5)	2	

Note: [a]Fisher's exact probability test.

Methicillin resistance was observed in 70% of the isolated *Staphylococcus* strains, with no significant difference between the two departmental subunits (p=0.722). The most frequently contaminated medical devices were the trolley surfaces (100%), delivery tables (100%), and door handles (78%) (Table 5).

3.3. Antimicrobial susceptibility of Gram-negative bacterial strains

Most of the identified Gram-negative bacteria were found to be penicillinase (≥70%) and cephalosporinase (≥80%) producers, particularly showing resistance to cefuroxime, cefepime, and cefoxitin. In contrast, cefotaxime and quinolone antibiotics (e.g., nalidixic acid, ciprofloxacin, and levofloxacin) were the most effective agents against these isolates.

High resistance (approximately 100%) was observed among Gram-negative bacteria to aztreonam, fosfomycin, and trimethoprim when used individually. However, their combination with sulfonamides (e.g., cotrimoxazole) was found to overcome this resistance. The bacteria also exhibited high susceptibility to carbapenems (e.g., imipenem and meropenem) and vancomycin (Table 6).

3.4. MDR assessment

MDR was observed in 100% of the bacteria isolated from the inpatient subunit. Nearly all environmental surfaces and medical devices were found to be contaminated with MDR bacteria (Table 7).

4. Discussion

HAIs represent a significant threat to patient safety, resulting in serious complications, additional healthcare costs, and increased mortality.[14] These infections affect a substantial number of hospitalized patients, underscoring the need for effective prevention and control measures.[24] The One Health approach emphasizes the role of the environment in the development and transmission of infectious agents, including emerging and re-emerging pathogens. In Cameroon, maternal and neonatal mortality

Table 3. Classification of bacterial strains isolated from environmental surfaces and medical devices

Isolated bacteria	Surface and medical device (*n* [%])						Total	*p*-value[a]
	Trolley	Door handle	Drip stand	Tap	Delivery table	Nursing table		
Number of isolates	10 (100)	12 (100)	6 (100)	14 (100)	5 (100)	8 (100)	55 (100)	-
Staphylococcus spp.								
Staphylococcus aureus	3 (30)	7 (57)	1 (17)	4 (29)	1 (20)	4 (51)	20	0.177
Others	3 (30)	2 (17)	1 (17)	4 (29)	2 (40)	1 (12)	13	
Total	6 (60)	9 (74)	2 (34)	8 (58)	3 (60)	5 (63)	33	
Enterobacteria								
Proteus mirabilis	0 (0)	1 (9)	2 (33)	2 (14)	0 (0)	2 (25)	7	-
Klebsiella spp.	0 (0)	0 (0)	2 (33)	2 (14)	0 (0)	0 (0)	4	
Serratia spp.	1 (10)	2 (17)	0 (0)	0 (0)	0 (0)	0 (0)	3	
Yersinia spp.	2 (20)	0 (0)	0 (0)	0 (0)	1 (20)	0 (0)	3	
Enterobacter aerogenes	1 (10)	0 (0)	0 (0)	1 (7)	0 (0)	0 (0)	2	
Escherichia coli	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (12)	1	
Total	4 (40)	2 (26)	4 (66)	5 (35)	1 (20)	3 (37)	20	
Non-Enterobacteria								
Pseudomonas aeruginosa	0 (0)	0 (0)	0 (0)	1 (7)	0 (0)	0 (0)	1	-
Other non-fermenting Gram-negative *Bacillus*	0 (0)	0 (0)	0 (0)	0 (0)	1 (20)	0 (0)	1	
Total	0 (0)	0 (0)	0 (0)	1 (7)	1 (20)	0 (0)	2	

Note: [a]Fisher's exact probability test.

rates remain alarmingly high.[25,26] To address this issue, the country has committed to implementing universal health coverage.[27-29]

4.1. Microbial flora profile of surfaces and equipment

Most of the identified isolates originated from the inpatient unit, likely reflecting greater interaction between healthcare workers, patients, and visitors, compared with the more restricted maternity unit, where access is restricted to healthcare workers and patients. Furthermore, the implementation of IPC measures, such as hygiene sessions and regular cleaning of medical equipment in the maternity unit, could also have contributed to these outcomes.

Tap surfaces were found to be the most contaminated sites, while the trolley surfaces exhibited the highest contamination rate relative to the number of samples analyzed. Hand-washing areas, frequently used by healthcare workers for hand and equipment hygiene, serve as primary sites for bacterial colonization, particularly in the absence of regular and appropriate cleaning by cleaning staff. Bacterial contamination of these areas can seriously compromise hand hygiene and facilitate the transmission of pathogens to patients. Similarly, trolleys used to transport drugs and nursing equipment can act as vehicles for the transmission of bacteria from one patient to another if hand hygiene precautions—such as hand washing, wearing gloves, and the use of hydroalcoholic gel—are not systematically followed. Our findings corroborate those observed at Treichville University Hospital in Côte d'Ivoire and the Jordan Medical Services in Cameroon, where wash stations and trolleys were also reported to be the most contaminated sites.[16,20]

The most common microbial strains identified were *S. aureus*, which has a remarkable capacity to adapt to both the healthcare environment and human hosts. *S. aureus* is part of the commensal microbiota of the nasal mucosa in approximately 20–40% of the general population, but is also responsible for transient colonization of the nasal mucosa in at least 60% of the remaining population. This may explain its predominance in this study.[30,31] It is the most clinically relevant staphylococcal species due to its involvement in HAIs and is the second most common pathogen responsible for this type of infection after *Escherichia coli.*[31] *S. aureus* infects humans when skin and mucosal barriers are disrupted—for example, as a result of chronic skin conditions, wounds, or surgical procedures—allowing access to underlying tissues or the bloodstream and causing infection. Individuals with invasive medical

Table 4. Antibiotic resistance profile of isolated *Staphylococcus* spp. (*n*=33)

Tested antibiotic	*Staphylococcus* spp. (*n* [%])	
	Staphylococcus aureus	***Others***
Number of isolates	20 (100)	13 (100)
Penicillin		
Penicillin G	20 (100)	13 (100)
Ampicillin	18 (90)	12 (92)
Oxacillin	18 (90)	13 (100)
Cephalosporin		
Cefoxitin	6 (30)	5 (38)
Aminoglycoside		
Gentamicin	3 (15)	4 (31)
Quinolone		
Ofloxacin	3 (15)	1 (8)
Ciprofloxacin	1 (5)	0 (0)
Norfloxacin	1 (5)	1 (8)
Cycline		
Tetracycline	8 (40)	4 (31)
Fusidanine		
Fusidic acid	15 (75)	9 (69)
Glycopeptide		
Vancomycin	1 (5)	0 (0)
Sulfonamide and Diaminopyrimidine		
Sulfamethoxazole+Trimethoprim	15 (75)	9 (69)
Macrolide		
Erythromycin	5 (25)	0 (0)
Streptogramin (synergistin)		
Pristinamycin	4 (20)	1 (8)
Phosphonic acid		
Fosfomycin	18 (90)	13 (100)
Rifamycin		
Rifampicin	17 (85)	13 (100)

devices or weakened immune systems, including pregnant women and premature newborns, are particularly susceptible to *S. aureus* infection.[30-32] Studies conducted at Yaoundé University Teaching Hospital have identified this bacterium as a common pathogen in skin and soft tissue HAIs.[17] Our findings were similar to those reported at the Douala General Hospital, where *S. aureus* was the most frequently isolated bacterium.[33]

P. mirabilis and *Klebsiella* spp. were the primary pathogenic Enterobacteria isolated in the obstetrics–gynecology department. These infectious agents are responsible for HAIs, especially in obstetrics–gynecology wards.[17,24,34] *P. mirabilis* is commonly found in abundance

Table 5. Prevalence and distribution of methicillin-resistant *Staphylococcus* spp. (*n*=33)

Variable	Count (*n*)	Frequency (%)	Total	*p*-value[a]
Staphylococcus spp.				
Staphylococcus aureus	14	70	20	>0.999
Others	9	69	13	
Subunit				
Inpatient	12	67	18	0.722
Maternity	11	73	15	
Surface and medical device				
Trolley	3	50	6	0.667
Door handle	7	78	9	
Drip stand	2	100	2	
Tap	5	62	8	
Delivery table	3	100	3	
Nursing table	3	60	5	

Note: [a]Fisher's exact probability test.

in soil and water. Although this bacterium is part of the normal human intestinal flora,[34-36] it is frequently responsible for infections of the human urinary tract, where it causes urinary tract infections and catheter-associated infections.[37] This is of concern given that the obstetrics–gynecology department regularly performs cesarean sections requiring the use of urinary catheters in parturient women. The circulation of this pathogen in the department increases the risk of women developing iatrogenic urinary tract infections after delivery.[36,38]

Klebsiella spp. are responsible for infections characterized by high morbidity and mortality and by their potential to disseminate within the host and cause sepsis. Risk factors for this infection include local healthcare practices, antibiotic misuse, and compliance with infection control procedures.[39,40] Poor compliance with standard precautions in the obstetrics–gynecology department could lead to environmental contamination, as this bacterium has also been implicated in severe neonatal sepsis.[41] In addition, *Klebsiella pneumoniae* is one of the most commonly isolated pathogens in healthcare settings and is responsible for HAIs in Cameroon, Côte d'Ivoire, and Mali.[16,17,20,24,33]

4.2. Susceptibility profile of isolated staphylococcal strains

Antimicrobial resistance analysis revealed that most *Staphylococcus* spp. isolates were penicillinase producers (≥90%). In addition, significant resistance rates were observed for fosfomycin, rifampicin, fusidic acid, and cotrimoxazole (≥70%).

Table 6. Antibiotic resistance profile of Gram-negative bacilli in the inpatient and maternity subunit (*n*=22)

Tested antibiotic	Enterobacteria (*n* [%])						Non-Enterobacteria (*n* [%])	
	Proteus mirabilis	*Klebsiella* spp.	*Yersinia* spp.	*Serratia* spp.	*Enterobacter aerogenes*	*Escherichia coli*	*Pseudomonas aeruginosa*	Other Gram-negative non-fermenting *Bacillus*
Number of isolates	7 (100)	4 (100)	3 (100)	3 (100)	2 (100)	1 (100)	1 (100)	1 (100)
Penicillin								
Amoxicillin	5 (71)	3 (75)	2 (67)	3 (100)	2 (100)	0 (0)	1 (100)	1 (100)
Amoxicillin+clavulanate	5 (71)	3 (75)	2 (67)	3 (100)	2 (100)	0 (0)	1 (100)	1 (100)
Aminoglycoside								
Kanamycin	3 (43)	3 (75)	3 (100)	1 (33)	0 (0)	0 (0)	1 (100)	0 (0)
Cephalosporin								
Ceftazidime	4 (57)	1 (25)	2 (67)	2 (67)	1 (50)	0 (0)	1 (100)	0 (0)
Cefuroxime	7 (100)	4 (100)	3 (100)	3 (100)	2 (100)	1 (100)	1 (100)	1 (100)
Cefepime	6 (86)	4 (100)	3 (100)	3 (100)	2 (100)	0 (0)	1 (100)	1 (100)
Cefotaxime	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ceftriaxone	2 (29)	3 (75)	2 (67)	3 (100)	2 (100)	1 (100)	0 (0)	0 (0)
Cefoxitin	6 (86)	4 (100)	3 (100)	3 (100)	1 (50)	1 (100)	1 (100)	1 (100)
Quinolone								
Nalidixic acid	0 (0)	0 (0)	0 (0)	0 (0)	1 (50)	0 (0)	0 (0)	0 (0)
Ciprofloxacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Levofloxacin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Carbapenem								
Meropenem	0 (0)	0 (0)	0 (0)	1 (33)	0 (0)	0 (0)	0 (0)	1 (100)
Imipenem	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Glycopeptide								
Vancomycin	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Phosphonic acid								
Fosfomycin	6 (86)	3 (75)	3 (100)	2 (67)	2 (100)	1 (100)	1 (100)	1 (100)
Diaminopyrimidine								
Trimethoprim	7 (100)	3 (75)	2 (67)	2 (67)	2 (100)	1 (100)	1 (100)	1 (100)
Sulfonamide and diaminopyrimidine								
Sulfamethoxazole+Trimethoprim	1 (14)	0 (0)	1 (33)	0 (0)	0 (0)	0 (0)	1 (100)	0 (0)
Monobactam								
Aztreonam	4 (57)	3 (75)	2 (67)	3 (100)	1 (50)	0 (0)	1 (100)	1 (100)

This proportion of penicillin-resistant strains was similar to that observed in studies conducted in Cameroon and higher than that reported at the University Hospital of Treichville, Côte d'Ivoire (28%).[16,20,42] This difference indicates more inappropriate antibiotic use in Cameroon, which may explain the high resistance to commonly used agents and limited effectiveness in the treatment of staphylococcal infections. Penicillin resistance is a major public health problem, as it complicates the treatment of infections and increases the risk of complications and mortality.[43]

Most *Staphylococcus* strains isolated (70%) were resistant to methicillin. MRSA is a major cause of morbidity and mortality in neonates admitted to neonatal intensive care units. Neonatal MRSA colonization is attributed to multiple sources, including mothers, healthcare workers, and environmental surfaces. It can lead to life-threatening infections, prolonged hospital stays, and significant economic costs.[32,44]

A meta-analysis of the worldwide distribution of MRSA revealed varying prevalence rates depending on

Table 7. Distribution of multidrug-resistant bacteria by subunit, surface/device, and bacterial species (*n*=55)

Variable	Characteristic	Count (*n*)	Frequency (%)	Total	*p*-value[a]
Location	Subunit				
	Inpatient	34	100	34	0.051
	Maternity	18	86	21	
	Surface and medical device				
	Tap	13	93	14	0.725
	Trolley	10	100	10	
	Door handle	10	83	12	
	Nursing table	8	100	8	
	Drip stand	6	100	6	
Bacterial isolates	*Staphylococcus* spp.				
	Staphylococcus aureus	17	85	20	0.726
	Others	13	100	13	
	Enterobacteria				
	Proteus mirabilis	7	100	7	-
	Klebsiella spp.	4	100	4	
	Yersinia spp.	3	100	3	
	Serratia spp.	3	100	3	
	Enterobacter aerogenes	2	100	2	
	Escherichia coli	1	100	1	
	Non-Enterobacteria				
	Pseudomonas aeruginosa	1	100	1	-
	Other non-fermenting Gram-negative *Bacillus*	1	100	1	

Note: [a]Fisher's exact probability test.

the populations studied, ranging from 0.3% to 5.1% for mothers of newborns, from 3.1% to 18.4% for healthcare workers, with the highest rates (3.5–36%) observed in environmental samples, thereby confirming the findings of our study.[44] In addition, MRSA is a common cause of HAIs in many countries, including Cameroon and Côte d'Ivoire, where methicillin-resistant strains have been identified in 71–81% of *Staphylococcus* spp. isolated from hospitals.[16,20,45] It is therefore essential to monitor antibiotic resistance and develop new strategies to combat penicillin-resistant staphylococcal infections.

4.3. Susceptibility profile of Gram-negative bacterial strains

Most of the Gram-negative bacteria identified were both penicillinase and cephalosporinase producers. A similar bacterial resistance profile was observed at Jordan Medical Services in Yaoundé.[16]

The majority of the bacteria identified (85–100%) exhibited MDR, which remains a significant concern for vulnerable patients in obstetrics–gynecology departments, particularly pregnant women, women in the immediate postpartum period, and their newborns. A meta-analysis conducted in Cameroon on human and environmental samples showed lower rates of MDR compared to those observed in our study.[46,47] The specific characteristics of the samples analyzed in our study may explain these differences.

4.4. MDR to antibiotics

Resistance to the most commonly prescribed antimicrobials leads to a significant increase in mortality, length of hospital stays, and healthcare costs. Faced with these MDR infections and delays in obtaining microbiological results, clinicians often resort to broad-spectrum antibiotics as empirical therapy. This practice can lead to the overuse and misuse of antibiotics, contributing to the development of resistance.[48]

The high prevalence of MDR bacterial strains underscores the existence of contributing factors, which include poor compliance with regulations and a lack of control over the sale and use of antibiotics by healthcare workers and the general public.[49,50] In addition, the scarcity of accurate epidemiological data on antibiotic use and bacterial resistance in Cameroon complicates the development of effective strategies.[51,52]

5. Limitations

It is important to recognize that the study was conducted in a specific hospital department. Consequently, the results obtained may not accurately reflect the situation in the entire health facility. The decision not to use automated systems, such as Vitek, for bacterial identification and susceptibility testing was primarily due to resource constraints and the need for a cost-effective surveillance model for resource-limited settings like Cameroon. These methods offer reliable results without the substantial financial and maintenance demands of automated systems, making our protocol directly applicable to the typical clinical laboratories where such interventions are most urgently needed. In addition, the sample size did not provide sufficient power to detect statistical significance for certain variables that were observed but not considered significant. These limitations highlight the need for a more comprehensive study with a larger sample size.

6. Conclusion

This study highlights the critical threat of HAIs in the obstetrics–gynecology department of a referral hospital in

Cameroon, revealing widespread bacterial contamination of surfaces and medical devices, with *S. aureus* and MDR Gram-negative pathogens, such as *P. mirabilis* and *Klebsiella* spp., predominating. Most of the staphylococcal isolates were methicillin-resistant, and all Gram-negative bacteria exhibited MDR, underscoring the urgent need for enhanced IPC measures. These findings demonstrate how suboptimal IPC compliance, along with inadequate antimicrobial stewardship, promotes resistance, disproportionately endangering vulnerable maternal and neonatal populations. As an exploratory study, these findings highlight the urgent need for evidence-based cleaning protocols within the unit. Therefore, this study calls for a multi-level response, including the full implementation of WHO IPC guidelines, targeted staff training within the department, and hospital-wide action, whereby the administration expands environmental surveillance to all departments to inform a comprehensive, institution-wide strategy. Establishing robust antimicrobial resistance surveillance systems across Cameroon's healthcare facilities is critical, as addressing these gaps is essential to reducing preventable morbidity and mortality.

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Conflict of interest

The authors declare that they have no competing interests.

Author contributions

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Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data

All data generated or analyzed during this study are provided in the manuscript.

Further disclosure

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References

1. WHO. *Maternal Mortality*. Geneva: WHO; 2025. Available from: https://www.who.int/news/room/fact/sheets/detail/maternal/mortality [Last accessed on 2025 Jun 18].
2. WHO. *Newborn Mortality*. Geneva: WHO; 2024. Available from: https://www.who.int/news-room/fact-sheets/detail/newborn-mortality [Last accessed on 2025 Aug 10].
3. Merlin B, Nadia M, Mforteh AA, *et al*. Evolution and risk factors of maternal mortality in Cameroon: A case control study. *Open J Obstet Gynecol*. 2023;13(7):1259-1277.

   doi: 10.4236/ojog.2023.137107
4. Cresswell JA, Alexander M, Chong MYC, *et al*. Global and regional causes of maternal deaths 2009-20: A WHO systematic analysis. *Lancet Global Health*. 2025;13(4):e626-e634.

   doi: 10.1016/S2214-109X(24)00560-6
5. Ngunyi YL, Halle-Ekane G, Tendongfor N, *et al*. Determinants and aetiologies of postpartum pyrexia; A retrospective analysis in a tertiary health facility in the littoral region of Cameroon. *BMC Pregnancy Childbirth*. 2020;20(1):167.

   doi: 10.1186/s12884-020-02867-2
6. Cheuyem FZL, Lyonga EE, Takougang I. *Healthcare Associated Infection Risk Analysis at the Obstetrics and Gynecology Department of a Referral Hospital in Cameroon*. [medRxiv Preprint]; 2025.

   doi: 10.1101/2025.05.03.25326934
7. Takougang I, Cheuyem FZL, Lyonga EE, Ndungo JH, Mbopi-Keou FX. Observance of standard precautions for infection prevention in the covid-19 Era: A cross-sectional study in six district hospitals in Yaounde, Cameroon. *Am J Biomed Sci Res*. 2023;19(5):590-598.

   doi: 10.34297/AJBSR.2023.19.002628
8. Takougang I, Cheuyem FZL, Ze BRS, Tsamoh FF, Moneboulou HM. Awareness of standard precautions, circumstances of occurrence and management of occupational exposures to body fluids among healthcare workers in a regional level referral hospital (Bertoua, Cameroon). *BMC Health Serv Res*. 2024;24(1):424.

   doi: 10.1186/s12913-024-10855-x
9. Nteungue BAK, Tandi E, Campbell J, *et al*. Assessing the state of infection prevention and control in Cameroon:

A cross-sectional workshop evaluation using socioecological models. *Infect Prev Pract*. 2024;6(4):100408.

doi: 10.1016/j.infpip.2024.100408

10. Djuikoue CI, Grace YW, Armandine MPA, *et al*. Health professionals' hand hygiene best practice on infection and resistance reduction at district health facilities, Cameroon. *World J Public Health*. 2021;6(4):181-187.

doi: 10.11648/j.wjph.20210604.17

11. Chiabi A, Fomenky C, Kan K, *et al*. Referral and outcome of out born neonates to the neonatology unit of the Bamenda regional hospital, Cameroon. *Ann Community Med Prim Health Care*. 2025;3(1):1025.

12. Schulze A, Mitterer F, Pombo JP, Schild S. Biofilms by bacterial human pathogens: Clinical relevance - development, composition and regulation - therapeutical strategies. *Microb Cell*. 2021;8(2):28-56.

doi: 10.15698/mic2021.02.741

13. Zhao A, Sun J, Liu Y. Understanding bacterial biofilms: From definition to treatment strategies. *Front Cell Infect Microbiol*. 2023;13:1137947.

doi: 10.3389/fcimb.2023.1137947

14. Cassini A, Högberg LD, Plachouras D, *et al*. Attributable deaths and disability-adjusted life-years caused by infections with antibiotic-resistant bacteria in the EU and the European economic Area in 2015: A population-level modelling analysis. *Lancet Infect Dis*. 2019;19(1):56-66.

doi: 10.1016/S1473-3099(18)30605-4

15. Njall C, Adiogo D, Bita A, *et al*. Bacterial ecology of nosocomial infection in the intensive care unit of laquintinie hospital Douala, Cameroon. *Pan Afr Med J*. 2013;14:140.

doi: 10.11604/pamj.2013.14.140.1818

16. Amvomo NLD, Sama CKK, Bouopda R, *et al*. Bacterial ecology and antibiotic susceptibility profile of isolated strains from surfaces and medical devices in some departments of the Jordan medical services, Cameroon: A descriptive cross-sectional study. *PAMJ-One Health*. 2023;11:6.

doi: 10.11604/pamj-oh.2023.11.6.38513

17. Nouetchognou JS, Ateudjieu J, Jemea B, Mesumbe EN, Mbanya D. Surveillance of nosocomial infections in the Yaounde University teaching hospital, Cameroon. *BMC Res Notes*. 2016;9(1):505.

doi: 10.1186/s13104-016-2310-1

18. Cheuyem FZL, Lyonga EE, Takougang I. *Standard Precautions Perception and Practice among Health Workers in the Obstetrics-Gynecology Department of a Referral Hospital in Cameroon*. [medRxiv Preprint]; 2025.

doi: 10.1101/2025.04.21.25326141

19. Rapport Mensuel d'Activité I - Grands Hôpitaux. DHIS2. *Ministère de la Santé Publique, Yaoundé, Cameroun*; 2024. Available from: https://dhis-minsante-cm.org/dhis-web-reports/index.html#/data-set-report [Last accessed on 2024 Aug 20].

20. Ango PD, Konan KD, Kouamé KA, *et al.* Microbial ecology of surfaces and medical devices in the intensive care unit of Treichville university hospital. *Health Sci Dis*. 2020;21(1):23-27.

21. *Breakpoint Tables for Interpretation of MICs and Zone Diameters, Version 13.1. The European Committee on Antimicrobial Susceptibility Testing. EUCAST, Växjö, Sweeden*; 2023. Available from: https://www.eucast.org/clinical_breakpoints [Last accessed on 2023 Nov 22].

22. Felten A, Casin I. Simple detection of methicillin-resistant staphylococci with cefoxitin or latamoxef disks. *Rev Fran Lab*. 2003;2003(352):27-30.

doi: 10.1016/S0338-9898(03)80499-7

23. Magiorakos AP, Srinivasan A, Carey RB, *et al*. Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: An international expert proposal for interim standard definitions for acquired resistance. *Clin Microbiol Infect*. 2012;18(3):268-281.

doi: 10.1111/j.1469-0691.2011.03570.x

24. Bocoum A, Fané S, Traoré Y, *et al*. Bacteriology of healthcare-associated infections in the gynecology and obstetrics department of CHU gabriel touré. *Open J Obstet Gynecol*. 2019;9(10):1336-1346.

doi: 10.4236/ojog.2019.910129

25. Alkema L, Chou D, Hogan D, *et al*. Global, regional, and national levels and trends in maternal mortality between 1990 and 2015, with scenario-based projections to 2030: A systematic analysis by the UN maternal mortality estimation inter-agency group. *Lancet*. 2016;387(10017):462-474.

doi: 10.1016/S0140-6736(15)00838-7

26. Mah Mungyeh E, Chiabi A, Tchokoteu Pouasse F, *et al*. Neonatal mortality in a referral hospital in Cameroon over a seven-year period: Trends, associated factors and causes. *Afr Health Sci*. 2014;14(3):517-525.

doi: 10.4314/ahs.v14i3.4

27. Couverture Santé Universelle. *HERE WE ARE! Ministère de la Santé Publique, Yaoundé, Cameroun*; 2023. Available from: https://www.minsante.cm/site/?q=en/node/4567 [Last accessed on 2024 Aug 12].

28. Cameroon. *Universal Health Coverage Partnership*. OMS, Genève; 2021. Available from: https://extranet.who.int/uhcpartnership/country-profile/cameroon [Last accessed on 2024 Aug 12].

29. Cynthia AN, Kilic B. Management of universal health coverage in Cameroon. *J Basic Clin Health Sci*. 2022;6:673-681.

doi: 10.30621/jbachs.1011629

30. Lee AS, De Lencastre H, Garau J, *et al*. Methicillin-resistant *Staphylococcus aureus*. *Nat Rev Dis Primers*. 2018;4(1):1-23.

doi: 10.1038/nrdp.2018.33

31. Vincenot F, Saleh M, Prévost G. Virulence factors of *Staphylococcus aureus*. *Rev Francoph Lab*. 2008;2008(407): 61-69.

doi: 10.1016/S1773-035X(08)74868-8

32. Turner NA, Sharma-Kuinkel BK, Maskarinec SA, *et al*. Methicillin-resistant *Staphylococcus aureus*: An overview of basic and clinical research. *Nat Rev Microbiol*. 2019;17(4):203-218.

doi: 10.1038/s41579-018-0147-4

33. Luma HN, Doualla MS, Ebongue CO, Temfack E, Wouafo M, Belley-Priso E. Bacterial reservoirs in a health care environment: Case of the Douala general hospital, Cameroon. *Health Sci Dis*. 2012;13(1):1-5.

34. Fox-Moon SM, Shirtliff ME. Urinary tract infections caused by *Proteus mirabilis*. In: Tang YW, Sussman M, Liu D, Poxton I, Schwartzman J, editors. *Molecular Medical Microbiology.* 2nd ed. United States: Academic Press; 2015. p. 1389-1400.

doi: 10.1016/B978-0-12-397169-2.00077-9

35. Jamil RT, Foris LA, Snowden J. *Proteus mirabilis* Infections. In: *StatPearls*. StatPearls Publishing; 2024. Available from: https://www.ncbi.nlm.nih.gov/books/nbk442017 [Last accessed on 2024 Aug 20].

36. Chakkour M, Hammoud Z, Farhat S, El Roz A, Ezzeddine Z, Ghssein G. Overview of *Proteus mirabilis* pathogenicity and virulence. Insights into the role of metals. *Front Microbiol*. 2024;15:1383618.

doi: 10.3389/fmicb.2024.1383618

37. Trautner BW, Kaye KS, Gupta V, *et al*. Risk factors associated with antimicrobial resistance and adverse short-term health outcomes among adult and adolescent female outpatients with uncomplicated urinary tract infection. *Open Forum Infect Dis*. 2022;9(12):ofac623.

doi: 10.1093/ofid/ofac623

38. Wanke-Rytt M, Sobierajski T, Lachowicz D, Seliga-Gąsior D, Podsiadły E. Analysis of etiology of community-acquired and nosocomial urinary tract infections and antibiotic resistance of isolated strains: Results of a 3-year surveillance (2020-2022) at the pediatric teaching hospital in Warsaw. *Microorganisms*. 2023;11(6):1438.

doi: 10.3390/microorganisms11061438

39. Abbas R, Chakkour M, Zein El Dine H, *et al*. General overview of *Klebsiella pneumonia*: Epidemiology and the role of siderophores in its pathogenicity. *Biology (Basel)*. 2024;13(2):78.

doi: 10.3390/biology13020078

40. Li Y, Kumar S, Zhang L, Wu H, Wu H. Characteristics of antibiotic resistance mechanisms and genes of *Klebsiella pneumoniae*. *Open Med (Wars)*. 2023;18(1):20230707.

doi: 10.1515/med-2023-0707

41. Mukherjee S, Bhadury P, Mitra S, *et al*. Hypervirulent *Klebsiella pneumoniae* causing neonatal bloodstream infections: Emergence of NDM-1-producing hypervirulent ST11-K2 and ST15-K54 strains possessing pLVPK-associated markers. *Microbiol Spectr*. 2023;11(2):e0412122.

doi: 10.1128/spectrum.04121-22

42. Nouetchognou JS, Ateudjieu J, Jemea B, Mbanya D. Accidental exposures to blood and body fluids among health care workers in a referral hospital of Cameroon. *BMC Res Notes*. 2016;9(1):94.

doi: 10.1186/s13104-016-1923-8

43. Lemaoui CE, Layaida H, Badi A, Foudi N. Current strategies to combat antibiotic resistance. *J Anti Infect*. 2017;19(1):12-19.

doi: 10.1016/j.antinf.2017.01.003

44. Keneh NK, Kenmoe S, Bowo-Ngandji A, *et al*. Methicillin-resistant *Staphylococcus aureus* carriage among neonate mothers, healthcare workers, and environmental samples in neonatal intensive care units: A systematic review. *Biomed Res Int*. 2024;2024(1):5675786.

doi: 10.1155/2024/5675786

45. Maddiboyina B, Roy H, Ramaiah M, *et al*. Methicillin-resistant *Staphylococcus aureus*: Novel treatment approach breakthroughs. *Bull Nat Res Centre*. 2023;47(1):95.

doi: 10.1186/s42269-023-01072-3

46. Mouiche MMM, Moffo F, Akoachere JFTK, *et al*. Antimicrobial resistance from a one health perspective in Cameroon: A systematic review and meta-analysis. *BMC Public Health*. 2019;19(1):1135.

doi: 10.1186/s12889-019-7450-5

47. Massongo M, Ngando L, Pefura Yone EW, *et al*. Trends of antibacterial resistance at the national reference laboratory in Cameroon: Comparison of the situation between 2010 and 2017. *Biomed Res Int*. 2021;2021:9957112.

doi: 10.1155/2021/9957112

48. Kalin G, Alp E, Chouaikhi A, Roger C. Antimicrobial multidrug resistance: Clinical implications for infection management in critically Ill patients. *Microorganisms*. 2023;11(10):2575.

doi: 10.3390/microorganisms11102575

49. Geest SV. Medicines in a cameroonian market. *Anthropol Santé*. 2017;14:1-17.

doi: 10.4000/anthropologiesante.2450

50. Castro-Sánchez E, Moore LSP, Husson F, Holmes AH. What are the factors driving antimicrobial resistance? Perspectives from a public event in London, England. *BMC Infect Dis*.

2016;16(1):465.

doi: 10.1186/s12879-016-1810-x

51. Yopa DS, Anya P, Mendjime P, Elouga T, Nnanga-Nga E, Nguefack-Tsague G. Evaluation of the antimicrobial resistance surveillance system in sentinel sites in Cameroon. *Cureus*. 2023;15(6):e40779.

doi: 10.7759/cureus.40779

52. Infections I of Medcine (US) Forum on Emerging Infections, Knobler SL, Lemon SM, Najafi M, Burroughs T. Factors Contributing to the Emergence of Resistance. In: *The Resistance Phenomenon in Microbes and Infectious Disease Vectors: Implications for Human Health and Strategies for Containment: Workshop Summary*. National Academies Press, US; 2003. Available from: https://www.ncbi.nlm.nih.gov/books/nbk97126 [Last accessed on 2024 Aug 22].