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Original Article

Antimicrobial Susceptibility Patterns of Bacterial Isolates from Post-Caesarean Surgical Site Infections at a Nigerian Tertiary Hospital

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ABSTRACT

Post-caesarean surgical site infections (SSIs) remain a major cause of maternal morbidity, particularly in low-resource settings, and are increasingly complicated by antimicrobial resistance. This study aimed to determine the antimicrobial susceptibility patterns and prevalence of multidrug resistance among bacterial isolates from post-caesarean SSIs at University College Hospital, Ibadan. A retrospective analysis of 66 laboratory records was conducted, out of which 52 records met the inclusion criteria. Bacterial isolates were identified using appropriate culture plates, and their antimicrobial susceptibility profiles were analysed using standard disk diffusion (Kirby–Bauer) method. A total of 75 isolates were identified, with Gram-negative organisms (68%) predominating over Gram-positive organisms (32%). The most common isolate was Pseudomonas aeruginosa, followed by Escherichia coli, Klebsiella spp, and Staphylococcus aureus. Antimicrobial susceptibility testing revealed high resistance rates to commonly used antibiotics such as amoxicillin, erythromycin, and azithromycin, while higher susceptibility rates were observed with gentamicin, levofloxacin, and vancomycin among Gram-positive isolates. Notably, vancomycin showed 100% susceptibility. Multidrug resistance was highly prevalent, with 74.7% of isolates classified as MDR, indicating resistance to at least one agent in three different antibiotic classes. This high burden of MDR highlights a significant therapeutic challenge and underscores the role of antibiotic misuse and hospital-acquired infections in driving resistance. The findings of this study emphasize the need for routine antimicrobial susceptibility testing, strengthened infection prevention and control measures, and implementation of antimicrobial stewardship programs. Continuous surveillance and policy interventions are essential to mitigate the growing threat of antimicrobial resistance and improve clinical outcomes in post-caesarean SSIs.

Keywords: Surgical Site Infection; Caesarean Section; Antimicrobial Resistance; Multidrug Resistance; Antibiotics

Introduction

Surgical site infections (SSIs) constitute one of the most prevalent healthcare-associated infections and one of the main causes of postoperative morbidity and mortality on the global scale. They are defined as infections arising at or close to the surgical incision within 30 days following an operative procedure, or within a period of 1 year in cases of implant placement (Gelaw & Abdela, 2018). SSIs also causes extended hospitalization, higher healthcare expenses and other negative clinical outcomes such as death. Studies have shown that SSIs cause about 20 % of all healthcare-associated infections worldwide and and presents a certain risk of death (Ikeanyi et al., 2021; Raj et al., 2024).

Sub-Saharan Africa bears a disproportionately high burden of surgical site infections partly due to challenges in infection prevention and control practices, limited microbial surveillance, and widespread empirical antibiotic use (Kebede et al., 2023).

Caesarean section (CS) is a normal surgical operation that despite being life-saving in most cases, has greater chances of postoperative infection than vaginal delivery (Ikeanyi et al., 2021). The rate of SSIs after caesarean delivery is 5-10 % worldwide, although in low- and middle-income states (LMICs), it is higher (Al-Wir et al., 2019; Mukantwari et al., 2023). Surgical site infection (SSI), which occurs around the incision area and adjacent tissues, is characterized by pain, redness, swelling, and discharge (Bocoum et al., 2023). Endometritis is also a common infection of the uterine lining and is accompanied by fever, abdominal pain, and foul discharge. Other infections are urinary tract infections caused by catheter use and in severe cases, sepsis (Monari et al., 2024).

Staphylococcus aureus, coagulase-negative staphylococci, Streptococcus spp, and Gram-negative bacteria including Escherichia coli and Klebsiella spp are common causative organisms of surgical site infections (Gelaw & Abdela, 2018; Raj et al., 2024). For Staphylococcus aureus, its clinical importance is further demonstrated by its ability to cause severe toxin-mediated infections associated with significant morbidity, particularly in vulnerable populations (Tsegay et al., 2023). The development of multi-drug-resistant organisms also complicates treatment (Monari et al., 2024). Long labor, premature rupture of membranes, emergency surgery, and maternal conditions such as diabetes and anemia are risk factors. Infection control activities are also a major determinant (Rwizigira et al., 2025). Prevention entails the use of prophylactic antibiotics, strict aseptic technique, proper wound care, and early symptom recognition. In general, infection control and antimicrobial stewardship are critical to lower the rate of post-caesarean infection and achieve better outcomes (Temur, 2025; Bocoum et al., 2023).

Antibiotic Resistance Patterns

SSI aetiology is heterogeneous as both Gram-positive and Gram-negative bacteria are involved. Typical pathogens are Staphylococcus aureus, Escherichia coli, Klebsiella spp. and Pseudomonas aeruginosa. Nevertheless, recent research shows a disturbing tendency of growing antimicrobial resistance of these organisms (Kiggundu et al., 2026).

Some studies have indicated that the resistance rate to the most commonly used antibiotics is high. An example is that the resistance to ampicillin, ceftriaxone, and cotrimoxazole in surgical site infections isolates has been reported to be between 50-100 % in various settings (Mbabazi et al., 2025). Gram-negative organisms, including those of the Enterobacteriaceae family, are highly resistant to cephalosporins and fluoroquinolones, whereas Gram-positive organisms, including Staphylococcus aureus, are highly resistant to penicillin and macrolides. There has been a documented rise in multidrug-resistant (MDR) organisms. Resistance by Acinetobacter spp has been reported to be high in post-caesarean SSIs (resistance to carbapenems between 65.4%-85.0%), gentamicin (85.0%-90.9%), and quinolones (90.9%-85.0%) (Mbabazi et al., 2025). These results indicate the increasing problem of therapeutic options scarcity and the necessity to monitor the antimicrobial susceptibility patterns continuously.

Antimicrobial resistance (AMR) has emerged as a significant international health problem. AMR is a major global health threat and a leading contributor to mortality, identified by the World Health Organization, and the estimates indicate that it may cause up to 10 million deaths each year in cases of the current tendencies, by 2050 (Okeke et al., 2024). The proportion of the burden is much greater in LMICs, in which there is inadequate surveillance systems and high rates of antibiotic misuse (Tang et al., 2023).

Many AMR cases from surgical site infections have been linked to frequent antibiotic exposure and hospital-associated spread of resistant organisms. SSI is estimated to occur in 5.6 per 100 surgical patients around the world, and more in Africa (around 10.2%) (Ojo & Irabor, 2022; Orum et al. 2022; Adebowale, 2022). In most African environments, the level of resistance to first-line antibiotics like ampicillin and ceftriaxone has surpassed 80-90%, and therefore, restricted their clinical efficacy (Mendelsohn et al., 2023).

The trends of antimicrobial susceptibility in SSIs are diverse with geographical location, hospital activities and population of patients. Yet, it has been observed that a constant trend of high resistance to popular antibiotics is observed in a number of studies (Oliveira et al., 2024). Gram-negative isolates of SSIs are commonly highly resistant to β-lactam antibiotics, such as ampicillin and third-generation cephalosporins, and the rate of resistance is often greater than 70-90% (Coque et al., 2023; Muteeb et al., 2023). In the same manner, the resistance to fluoroquinolones and aminoglycosides is also being reported. Conversely, other antibiotics like carbapenems and vancomycin are yet to be fully resistant but there has also been reported emergence of resistance against these drugs which are considered last resort (de la Lastra et al., 2024). Several studies have reported that a significant proportion of isolates from surgical site infections exhibit resistance to at least one antibiotic, with many demonstrating resistance to multiple antimicrobial classes (Sakagianni et al., 2023; Kiggundu et al., 2026). This trend makes empirical treatment challenging, therefore, resulting in more delays in effective treatment and worse clinical outcomes (Okeke et al., 2024).

Link to Current Study

Due to the increased burden of antimicrobial resistance and the effect it has on the treatment of surgical site infections, there is a dire necessity of local data on bacterial isolates and their susceptibility patterns. Such data are scarce in Nigeria especially at tertiary healthcare facilities like University College Hospital, Ibadan. The aim of the study will thus be to assess the antimicrobial susceptibility patterns of bacterial isolates of post-caesarean surgical site infections, which will provide evidence-based antibiotic therapy and reinforce infection control measures.

Methodology

Study Area

This research was carried out at the University College Hospital, Ibadan, it is a tertiary healthcare facility which acts as a referral hospital within Oyo State and the surrounding areas. It offers specialized obstetric and gynaecological services, including caesarean section. There is a functional microbiology laboratory where routine bacteriological culture, identification and antimicrobial susceptibility testing were conducted at the facility.

Study design and sampling method

The research was a retrospective observational laboratory-based study. It included examination and analysis of available microbiology laboratory data of post-caesarean surgical site swabs within the specified study period of June 2024 to December 2025. There was no direct patient interaction, intervention, or follow-up done. The design allowed for the assessment of records of bacterial profiles and resistance patterns without follow-up. Sampling was done using a total sampling method. Wound swab samples of suspected post-caesarean surgical site infections obtained in the study period were also included in the analysis as long as they had all laboratory records that qualified them as required sample size. This method reduced the selection bias and made sure that the available cases were captured.

Eligibility Criteria

The study included records as long as they were reported as wound swab specimens collected on patients with suspected post-caesarean surgical site infection. Only those records that had full bacteriological identification and antimicrobial susceptibility test results were taken into account to achieve reliability of findings. Further, all the samples included were required to be processed during the stipulated study period. Records were not included when there were incomplete or missing laboratory data since this may lead to incomplete analysis. Duplicates which were caused by a single infection episode were also eliminated to exclude repetition and bias. Records that were not related to caesarean section procedures were not included in the study.

Laboratory Procedures

Bacterial identification and antimicrobial susceptibility testing had been previously conducted in the laboratory using established standard microbiological techniques. Wound swab samples were inoculated onto blood and MacConkey agar plates and incubated for 24 hours. Bacterial identification was based on morphology, Gram stain, and standard biochemical tests for Gram-negative identification. Various biochemical tests were conducted for lactose- and non-lactose-fermenting Gram-negative bacilli, including oxidase, triple sugar iron (TSI), sulphur indole motility, urease, and citrate production. For Gram-positive isolates, catalase, mannitol fermentation, DNase production, and coagulase tests were performed to confirm Staphylococcus aureus. Streptococcus spp, which are typically catalase-negative, underwent haemolysis testing on blood agar to determine alpha (α) haemolysis, beta (β) haemolysis, or gamma (γ) haemolysis. Additionally, their identity was confirmed based on sensitivity or resistance to optochin, bacitracin, and cotrimoxazole (SXT).

Mueller-Hinton agar was used to test antimicrobial susceptibility by utilizing the Kirby-Bauer disk diffusion method. This process involved the preparation of standardized bacteria inoculum and uniformly covering the agar plates with the bacteria. The inoculated media was then placed in contact with antibiotic impregnated disks and the plates were then incubated at 35–37°C for 24 hours. Following incubation, the areas of inhibition around each antibiotic disk were determined in millimetres. The interpretation of these measurements was based on the recommendations of the Clinical and Laboratory Standards Institute (CLSI) that categorize organisms as either susceptible, intermediate, or resistant to each antimicrobial agent. During the testing process, quality control measures were also noted to assure the accuracy and reproducibility of results.

Data Collection

The data collection form was created to provide consistency. The variables derived were the type of bacterial identifications in each sample, antimicrobial agents to be tested on these isolates and the resultant susceptibility status which were recorded as either susceptible, intermediate or resistant. The process of extracting the data was done in a fairly and regular manner so as to determine its completeness and to eliminate as much error as possible hence improving the quality and reliability of the data that was to be used in the analysis. Records were checked thoroughly and only those records that matched the inclusion criteria were selected. Cross-checking of extracted data was carried out where needed to improve the accuracy and reliability of the data. All data collected were treated as confidential information and no patient identifiers were contained in the data collection form.

Data Analysis

Data were collected and entered into Microsoft Excel sheet and then analysed using the Statistical Package of the Social Sciences (SPSSv25). The dataset was thoroughly revised before analysis; discrepancies, gaps, and potential data entry mistakes were detected and corrected, thus resulting in accuracy and reliability of the findings.

The data were summarized using descriptive methods of statistics to present them in a clear and meaningful way. Frequencies and percentages were used to present the distribution of bacterial isolates and their antimicrobial susceptibility patterns. The findings were also presented in tables to make it more comprehensible and easier to interpret. Multidrug resistance (MDR) was taken to be resistance of a bacterial isolate to one or more antimicrobial agents in three or more antibiotic classes. Subgroup analysis was conducted where appropriate, to compare the resistance patterns of various bacterial spp.

Ethical Considerations

Before commencement, ethical approval was obtained from the ministry of health. The research was conducted in accordance with the current rules of ethics of research on human-derived data. The study was conducted using retrospective laboratory records and thus there was no direct contact with patients and no intervention was done. As a result, the study didn't present any risk to patients. All data obtained were collected exclusively on clinical and laboratory records excluding any form of personal identifier and thus didn't involve direct encounters with patients.

Care was taken to ensure confidentiality and data protection during the research. The extraction and analysis of data were undertaken without any patient identifiers such as names, hospital numbers, and other personal information, to maintain anonymity. In addition, access to the data was restricted to authorized members of the research team, and all information was handled with a high level of confidentiality. These measures ensured compliance with ethical standards and safeguarded the privacy of all individuals whose data were included in the study.

Results and Analysis

Following the application of the eligibility criteria of post-caesarean wound swab samples, 52 records were included in the final analysis, from an initial total of 66 laboratory records which were reviewed initially for this study. while 14 records were excluded. The exclusion criteria were incomplete data, especially lack of antimicrobial resistance (AMR) profile results, duplicate records and records that failed to satisfy other study inclusion criteria such as poor documentation.

Post-caesarean surgical site infections records were identified to have 75 bacterial isolates, including Gram-positive and Gram-negative organisms.

The most commonly identified Gram-positive organism was Staphylococcus aureus, which had 12 isolates, then Streptococcus spp (7 isolates) and coagulase-negative Staphylococcus spp (5 isolates). A higher proportion of the isolates was Gram-negative. The most common Gram-negative organism was Pseudomonas aeruginosa (21 isolates), then Escherichia coli (13 isolates), Klebsiella spp (8 isolates), and Proteus spp (7 isolates). The least common Gram-negative organisms were Acinetobacter spp (2 isolates).

Overall, Gram-negative bacteria were more commonly isolated than Gram-positive bacteria in post-caesarean surgical site infections in this study.

Table 1: Distribution and Frequency of Bacterial Isolates from Post-Caesarean Surgical Site Infections at University College Hospital, Ibadan

Gram Category	n (%)	Organism Isolated	Frequency (n)	percentage (%)
Gram-positive isolates	24 (32.0)	*Staphylococcus aureus*	12	16.0
		Coagulase-negative *Staphylococcus*	5	6.7
		Streptococcus spp.	7	9.3
Gram-negative isolates	51 (68.0)	*Pseudomonas aeruginosa*	21	28.0
		Escherichia coli	13	17.3
		Klebsiella spp.	8	10.7
		Proteus spp.	7	9.3
		Acinetobacter spp.	2	2.7
Total	75 (100)		75	100

Overall Antimicrobial Susceptibility Pattern of Gram-Positive Isolates

The antimicrobial susceptibility profile of Gram-positive bacterial isolates of post-caesarean surgical site infections in University College Hospital, Ibadan showed different degrees of resistance to the most frequently used antibiotics.

Amoxicillin exhibited a high degree of resistance, with nearly all the isolates (83.3 %) resistant and only a small percentage (8.3 %) susceptible. Likewise, erythromycin was found to be ineffective with 75.0% resistance and 20.8% susceptibility. There was also poor activity with azithromycin with over half of the isolates (58.3%) remaining resistant.

Ciprofloxacin and ceftriaxone were moderately resistant with resistance rates of 50.0% and 50.0% respectively, but susceptibility remained reasonably good at 33.3 and 37.5 respectively. Cefepime was also significantly resistant (58.3%), which means that this antibiotic is less effective against the isolates.

On the contrary, there were antibiotics that were more active. Clindamycin was of moderate effect, having 54.2 % susceptibility and 33.3 % resistance. Levofloxacin fared a comparatively higher, with 58.3% of the isolates being susceptible, but resistance was still significant at 37.5. Gentamicin was shown to be rather effective, with susceptibility of 66.7 % and no intermediate resistance noted.

It is important to note that vancomycin was the most useful antibiotic, with 100 % of the isolates being susceptible and no resistance as well as no intermediate response reported.

Table 2: Antimicrobial Susceptibility Pattern of Gram-Positive Isolates

Antibiotic	Susceptible n (%)	Intermediate n (%)	Resistant n (%)
Amoxicillin	2 (8.3)	2 (8.3)	20 (83.3)
Azithromycin	7 (29.2)	3 (12.5)	14 (58.3)
Erythromycin	5 (20.8)	1 (4.2)	18 (75.0)
Clindamycin	13 (54.2)	3 (12.5)	8 (33.3)
Ciprofloxacin	8 (33.3)	4 (16.7)	12 (50.0)
Levofloxacin	14 (58.3)	1 (4.2)	9 (37.5)
Gentamicin	16 (66.7)	0 (0.0)	8 (33.3)
Vancomycin	24 (100.0)	0 (0.0)	0 (0.0)
Cefepime	9 (37.5)	1 (4.2)	14 (58.3)
Ceftriaxone	9 (37.5)	3 (12.5)	12(50.0)

Table 3: Overall Antimicrobial Susceptibility Pattern of Gram-negative Isolates (n = 51)

Antibiotic	Susceptible n (%)	Intermediate n (%)	Resistant n (%)
Ampicillin	5 (9.8)	0 (0.0)	46 (90.2)
Gentamicin	24 (47.1)	3 (5.9)	24 (47.1)

Antibiotic	Susceptible n (%)	Intermediate n (%)	Resistant n (%)
Amikacin	34 (66.7)	2 (3.9)	15 (29.4)
Amoxiclav	10 (19.6)	4 (7.8)	37 (72.5)
Cefuroxime	18 (35.3)	2 (3.9)	31 (60.8)
Cefepime	24 (47.1)	2 (3.9)	25 (49.0)
Ciprofloxacin	24 (47.1)	2 (3.9)	25 (49.0)
Levofloxacin	27 (52.9)	3 (5.9)	21 (41.2)
Imipenem	47 (92.2)	0 (0.0)	4 (7.8)
Meropenem	46 (90.2)	1 (2.0)	4 (7.8)

Distribution of Antibiotic Resistance Among Gram-Positive Bacterial Isolates

Distribution of antibiotic resistance in Gram-positive isolates, which include Staphylococcus aureus, coagulase-negative staphylococci, and Streptococcus spp, indicates a consistent high burden of resistance to several antibiotics.

The most resistant was amoxicillin (20 isolates), Staphylococcus aureus was the most resistant (10 cases), then Streptococcus (6 cases) and coagulase-negative staphylococci (4 cases). Equally, erythromycin showed significant resistance (18 total), once again, mainly caused by Staphylococcus aureus (9 cases).

Intermediate resistance was identified with azithromycin and cefepime with 14 resistant isolates each among the three organisms. There was also significant resistance to ciprofloxacin and ceftriaxone (12 isolates each), with Staphylococcus aureus and Streptococcus playing a significant role.

Conversely, the resistance with clindamycin and gentamicin, which had 8 resistant isolates each, was found to be lower and therefore indicated a relatively high level of effectiveness. Levofloxacin showed intermediate resistance (9 isolates) suggesting a moderate activity.

Notably, no resistance to vancomycin was observed in all Gram-positive isolates, which supports its position as the most valid agent against these organisms in this context.

In general, Staphylococcus aureus became the most common source of resistance against most antibiotics, and vancomycin continued to be fully effective.

Table 4: Distribution of Antibiotic Resistance Among Gram-Positive Bacterial Isolates

Antibiotic	*Staphylococcus aureus* Res (12)	Coag-neg Staph Res (5)	Streptococcus Res (7)	Total resistance (n)
Amoxicillin	10(83.3)	4(80.0)	6(85.7)	20(80.0)
Azithromycin	7(58.3)	3(60.0)	4(57.1)	14(56.0)
Erythromycin	9(75.0)	4(80.0)	5(71.4)	18(72.0)
Clindamycin	4(33.3)	2(40.0)	2(28.6)	8(32.0)
Ciprofloxacin	6(50.0)	0(0.0)	6(85.7)	12(48.0)
Levofloxacin	4(33.3)	2(40.0)	3(42.9)	9(36.0)
Gentamicin	4(33.3)	2(40.0)	2(28.6)	8(32.0)
Vancomycin	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Cefepime	7(58.3)	3(60.0)	4(57.1)	14(56.0)
Ceftriaxone	6(50.0)	2(40.0)	4(57.1)	12(48.0)

Distribution of Antibiotic Resistance Among Gram-negative Bacterial Isolates

The Gram-negative isolates demonstrated extensive resistance patterns, with notable organism-specific variations.

The Gram-negative isolates demonstrated extensive resistance pattern with notable organism-specific variations involving: Pseudomonas aeruginosa, Escherichia coli, Klebsiella pneumoniae, Proteus spp, and Acinetobacter spp. The highest resistance was observed with ampicillin (90.2%), followed by the highest resistance in E. coli (92.3%), and 100 % resistance in Acinetobacter spp. Likewise, amoxicillin-clavulanate (amoxiclav) and cefuroxime exhibited a high level of resistance (72.5% and 60.8%, respectively). Cefepime, ciprofloxacin, and ceftazidime resistance was moderate and fairly evenly distributed among the isolates, especially in Pseudomonas aeruginosa and E. coli. The same trend was observed with cefotaxime, which showed decreased efficacy of third- and fourth-generation cephalosporins.

Gentamicin was not consistently effective, as it had a range of resistance among organisms ranging between 40 and 50 %. Contrastingly, amikacin had a lower resistance (29.4%), which indicates a relatively high activity in Gram-negative pathogens.

The resistance to fluoroquinolone as observed with levofloxacin was moderate (41.2%), which implies that it is partially effective, but with considerable limitations. Notably, the carbapenems—imipenem and meropenem—exhibited the lowest resistance rates (7.8% each), with near-complete susceptibility in most organisms except Acinetobacter spp, where resistance was relatively higher proportionally.

Table 5: Distribution of Antibiotic Resistance Among Gram-negative Bacterial Isolates

Antibiotic	**P. aeruginosa (21)**	**E. coli (13)**	**K. pneumoniae (8)**	**Proteus spp. (7)**	**Acinetobacter spp. (2)**
Ampicillin	18(85.7)	12(92.3)	7(87.5)	6(85.7)	2(100.0)
Gentamicin	10(47.6)	6(46.2)	4(50.0)	3(42.9)	1(50.0)
Amikacin	6(28.6)	4(30.8)	2(25.0)	2(28.6)	1(50.0)
Amoxiclav	16(76.2)	10(76.9)	5(62.5)	4(57.1)	2(100.0)
Cefuroxime	14(66.7)	8(61.5)	4(50.0)	3(42.9)	2(100.0)
Cefepime	11(52.4)	6(46.2)	4(50.0)	3(42.9)	1(50.0)
Cefotaxime	12(57.1)	7(53.8)	4(50.0)	3(42.9)	1(50.0)
Ciprofloxacin	11(52.4)	6(46.2)	4(50.0)	3(42.9)	1(50.0)
Levofloxacin	9(42.9)	5(38.5)	3(37.5)	3(42.9)	1(50.0)
Imipenem	2(9.5)	1(7.7)	0(0.0)	0(0.0)	1(50.0)
Meropenem	2(9.5)	1(7.7)	0(0.0)	0(0.0)	1(50.0)
Ceftazidime	12(57.1)	6(46.2)	3(37.5)	3(42.9)	1(50.0)

Prevalence of Multidrug Resistance Among Bacterial Isolates

The distribution of multidrug resistance (MDR) among bacterial isolates from post-caesarean surgical site infections shows a high burden of resistance within the study population.

Out of a total of 75 isolates, 56 (74.7%) were identified as multidrug-resistant, indicating that the majority of the bacterial pathogens were resistant to at least one agent in three different classes of antibiotics. In contrast, only 19 isolates (25.3%) were non-MDR, suggesting susceptibility to a broader range of antimicrobial agents.

Table 6: Prevalence of Multidrug Resistance Among Bacterial Isolates

Category	**Frequency (n)**	**Percentage (%)**
MDR isolates	56	74.7
Non-MDR isolates	19	25.3
Total	75	100

Multidrug resistance (MDR) was defined as resistance to at least one agent in three distinct antibiotics categories

Discussion

Post-caesarean surgical site infections (SSIs) still pose a major cause of maternal morbidity, prolonged hospitalization, and a high burden on healthcare especially in low and middle-income regions. The causative pathogens of these infections are commonly a wide variety of bacterial pathogens whose antimicrobial susceptibility profiles are being increasingly affected by the increasing global movement in antimicrobial resistance. Thus, the aim of this study was to identify the patterns of antimicrobial susceptibility of bacterial isolates obtained after post-caesarean surgical site infections with an aim of establishing the predominant pathogens and assessing the resistance and sensitivity of these pathogens to the most commonly used antibiotics.

This study revealed that Gram-negative bacteria were more dominant (68%) than Gram-positive organisms (32%) in post caesarean surgical site infections (SSI). This indicates a change in the microbial composition of SSIs where the Gram-negative becomes dominant, which is frequently linked to hospital-acquired infections and the growing antimicrobial resistance. The percentage of Gram-negative isolates recorded in this study could be a reflection of environmental contamination, length of stay in the hospital or failure in practices of infection prevention and control.

This observation is in line with other studies in the same environment. Indicatively, in a study by Mezemir et al. (2023) in Ethiopia, Gram-negative organisms were found to be 70.2 % of all isolates of post-caesarean surgical site infections, as opposed to 25.5 % Gram-positive organisms. In a similar study, Adesoji et al. (2023) performed a study in Nigeria and found that Gram-negative organisms were found to be more prevalent (62.7) than Gram-positive bacteria (37.3) in surgical site infections. The consistency of these studies with the current results indicates that Gram-negative pre-eminence in post-caesarean SSIs is a widespread pattern in low- and middle-income countries, and this may be because of comparable healthcare issues like the lack of infection control materials and antibiotic misuse. Nevertheless, this observation is not in line with those of other areas where Gram-positive organisms are more prevalent. Indicatively, Ahmed et al. (2014) in Egypt observed that Staphylococcus spp were the most frequent in SSIs. These disparities can be explained by the differences in hospital settings, antibiotic prophylaxis, surgical procedures, and patient-specific factors. Staphylococcus aureus was the most common of the Gram-positive organisms in this study. This observation is in line with the prior research (Ahmed et al., 2014; Pal et al., 2019) that has repeatedly found Staphylococcus aureus to be the primary cause of surgical site infections as a normal skin flora and opportunistic by entering surgical wounds.

The antimicrobial susceptibility pattern of Gram-positive isolates in the present study indicated that there was a high level of resistance to the common antibiotics like amoxicillin, erythromycin, and azithromycin. This observation may indicate a misuse or excessive use of these antibiotics in the study environment, which have contributed to the heightened resistance. The pattern is well supported in the literature, with studies (Ahmed et al., 2014; Lobanovska et al., 2017; Rajput et al., 2024) demonstrating high resistance rates to commonly used antibiotics such as penicillin and macrolide against Gram-positive bacteria.

Conversely, the isolates showed relatively high sensitivity to gentamicin, levofloxacin and clindamycin, which means that there is still a possibility of using such antibiotics in the treatment of Gram-positive infections, most especially, for those with post caesarean section surgical site infections. Specifically, gentamicin was moderately effective, which is in line with the findings of Chen et al., (2021) and Milosavljevic et al. (2021), who also found Gram-positive isolates to be very susceptible to aminoglycosides.

Vancomycin had a 100 % susceptibility rate in Gram-positive isolates in this study. This observation is consistent with the findings of AbdelHalim et al., (2025) although, Shah et al. (2021) found a slightly less susceptibility rate. Research however, has continuously demonstrated that vancomycin is very effective against infectious bacteria even the resistant ones. This highlights the significance of it as the last-resort drug when dealing with serious infections. The use of vancomycin, however, prompts concerns regarding the possibility of the appearance of the resistant strains in case of the lack of a careful control of the use.

Clinical and Public Health Significance

The results of this study indicate that there is a dire problem of managing post-caesarean surgical site infections (SSIs). It shows there is a reduced ability of frequently used antibiotics to eliminate wound-related bacteria pathogens. The resistance by isolated bacteria to commonly used antibiotics like amoxicillin, erythromycin, and azithromycin is high, which means that most of the organisms that cause these infections have developed mechanisms to resist the common empirical therapy.

Mechanistically, the observed resistance to β-lactam antibiotics such as amoxicillin may be attributed to the extensive production of β-lactamase enzymes in wounds by bacterial pathogens, although molecular confirmation was beyond the scope of this study. In this circumstnce, these enzymes reduce the effectiveness of the antibiotic by hydrolyzing the β-lactam ring. In some cases, a more advanced resistance mechanism in which the pathogen produces extended-spectrum β-lactamases (ESBLs) is involved. This can inactivate a broad range of β-lactam antibiotics, including the third-generation cephalosporins. The high prevalence of ESBL-producing Enterobacterales reported in African clinical settings by Nwosu et al. (2025) supports this explanation and may account for the moderate to high resistance observed against cephalosporins such as ceftriaxone in the present study.

In the same manner, resistance to macrolides like erythromycin and azithromycin is also high because of the target site alteration especially in the bacterial ribosomal binding site that is not bound by antibiotics. Also, certain wound pathogens are efflux pump expressors (Nabi et al., 2024) that actively eliminate the antibiotics in the bacterial cell before they can take effect. Similar concerns have been reported among clinical isolates in Nigerian tertiary healthcare facilities, where methicillin-resistant Staphylococcus aureus carrying resistance determinants such as mecA and mecC has been identified (Idakari et al., 2025). All these mechanisms lead to failure of treatment in case of an empirical use of such antibiotics.

Conversely, other antibiotics like gentamicin and levofloxacin were found to have a relatively higher efficacy on the isolates. The mechanism of action of gentamicin could be attributed to its ability to bind 30S ribosomal subunit irreversibly, resulting in the fast killing of bacteria. Nevertheless, its efficacy is frequently restricted to some clinical environments because of the toxicity issues and the necessity to receive it parenterally. Levofloxacin is a fluoroquinolone and it is believed to inhibit bacterial DNA gyrase and topoisomerase IV and its moderate efficacy shows that although some resistance is emerging, it still has some clinical use.

Of special interest is the full susceptibility that is evident with vancomycin. This antibiotic works by preventing the synthesis of cell walls by attaching itself to the D-alanyl-D-alanine endings, which is less prone to the usual resistance mechanisms. The fact that it has maintained its efficacy indicates that it could still be used as a dependable alternative in case of serious infections that involve vulnerable organisms. Its application, however, should be restricted to avoid the development of resistant strains, which will dramatically reduce the treatment options.

Biofilm formation is another significant source of antibiotic resistance to wound infections (Rather et al., 2021). Most of the pathogens involved in post-caesarean SSIs are able to develop biofilms on the wound surfaces. In these biofilms, bacteria are entrenched in a protective extracellular matrix which restricts penetration of antibiotics and prevents host immune responses against them. This leads to decreased efficacy of antibiotics, continued infection and inability to heal wounds. Moreover, the polymicrobial nature of the surgical site infections and the presence of endogenously acquired organisms (including the gastrointestinal and genitourinary tracts) predisposes the occurrence of bacteria with already acquired plasmid-mediated resistance genes. These genes may encode resistance to various classes of antibiotics and may be transferred across bacteria making the problem even worse.

For patients, these results suggest that the empirical antibiotic treatment is becoming less reliable in post-caesarean SSIs treatment. This can cause a delay in clinical response, a longer hospital stays, higher treatment cost and the risk of complication, including wound dehiscence and sepsis. In extreme situations, unsuccessful first-line treatment may require second-line or last-resort antibiotics which are more expensive and may be toxic. The elevated rate of antibiotic resistance identified in this study at the public health level represents a more general trend of antimicrobial abuse and poor infection control. The ongoing use of ineffective antibiotics is also related to the process of selection and dissemination of resistant strains in healthcare institutions. This does not only impact on the outcome of individuals but also leads to the further burden of healthcare-associated infections.

Implications to Practice and Policy

The results of this research indicate the necessity to change the current practice of empirical treatment to more evidence-based and pathogen-specific treatment of post-caesarean surgical site infections. First, the local antimicrobial susceptibility patterns should be used to guide antibiotic selection, as was shown in this study. The resistance to most of the widely used antibiotics is high and therefore it is no longer possible to depend on the use of drugs like amoxicillin and macrolides as first-line agents in this environment. Rather, treatment guidelines ought to be revised to capture the existing susceptibility patterns.

Secondly, routine culture and sensitivity testing of all suspected surgical site infections needs to be institutionalized. This will allow specific treatment, less exposure to unnecessary antibiotics, and better clinical outcomes. Also, the resistance rate is very high, which highlights the significance of antimicrobial stewardship programs. These initiatives are to be aimed at rational prescribing, limiting unneeded use of antibiotics, and continuous observation of resistance trends. Limiting the exposure to inappropriate antibiotics will decrease the selective pressure and slow the development of resistant strains.

Moreover, precautions taken to interfere with the formation of biofilms and enhance wound care must be highlighted. Antibiotic penetration and treatment outcome can be increased by proper wound cleaning, debridement, and proper dressing techniques. On the institutional level, local antibiograms should be created and periodically updated in hospitals, which may help guide clinicians to make the most suitable empirical therapy as they await laboratory results. National antimicrobial resistance surveillance systems should also be provided using these data.

Lastly, policy interventions must cover the unregulated access to antibiotics which is a significant source of resistance in most settings. Tightening of laws on the sale of antibiotics and educating people on the risks of their misuse are some of the key measures to curb resistance.

Conclusion

This study demonstrates that post-caesarean surgical site infections are associated with a high burden of antibiotic-resistant bacterial pathogens, with a significant proportion exhibiting multidrug resistance. The observed resistance to commonly used antibiotics such as amoxicillin and macrolides indicates that routine empirical therapy may no longer be effective in this setting. In contrast, relatively better susceptibility to agents such as gentamicin, levofloxacin, and vancomycin suggests that these antibiotics may still retain clinical usefulness, although their use should be guided by laboratory evidence.

The findings highlight the urgent need to transition from empirical to evidence-based, culture-guided treatment of post-caesarean wound infections. Routine antimicrobial susceptibility testing should be prioritized to ensure appropriate antibiotic selection and improve patient outcomes. In addition, the high prevalence of multidrug-resistant organisms underscores the importance of implementing antimicrobial stewardship programs to reduce inappropriate antibiotic use and limit the spread of resistance.

Strengthening infection prevention and control practices within healthcare facilities is also essential to reduce the incidence of these infections. Overall, a coordinated approach involving improved diagnostics, rational antibiotic use, and enhanced infection control measures is required to effectively manage post-caesarean surgical site infections and mitigate the growing threat of antimicrobial resistance.

Limitations of the Study

There is a possibility of sampling bias given the limited sample size assessable during the study period. This could affect the ability to apply the results to a bigger population. Also, the research was based on retrospective laboratory data, and part of the data was not included because of incompleteness in documentation. This could have caused selection bias and influenced the general representation of cases.

Third, molecular characterization of the resistance mechanisms, including the identification of ESBL or carbapenemase-producing organisms, was not done. Consequently, the definite genetic basis of antimicrobial resistance could not be identified. Also, the research was carried out in one healthcare institution, which could restrict the generalizability of the results to other contexts with different patient groups and infection control measures.

Lastly, the clinical outcome of the patients including the period of hospital stay and response to treatment were not measured, which restricts the possibilities to completely correlate the microbiological results with patient prognosis.

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