

Assessing Adherence to Prophylactic Antibiotic Guidelines in Cesarean Sections in Rwanda

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Abstract

Background:

Surgical site infections (SSIs) remain a leading cause of maternal morbidity and mortality following cesarean sections, particularly in low- and middle-income countries. Although the World Health Organization (WHO) provides clear guidelines for prophylactic antibiotic use during cesarean delivery, adherence remains inconsistent across facilities, contributing not only to preventable infections but also to rising antimicrobial resistance (AMR). The WHO guideline recommends four key criteria for appropriate antibiotic prophylaxis: correct antibiotic type, correct dosage, timely administration (30–60 minutes before incision), and avoidance of unnecessary postoperative use. This study sought to assess adherence to these criteria as well as identify gaps in implementation at two Rwandan hospitals.

Methods:

A prospective observational study was conducted at Kirehe District Hospital and Ruhengeri Level 2 Teaching Hospital between June and July 2025. Data was collected using a checklist adapted from WHO guidelines, capturing antibiotic type, dosage, timing, and postoperative use. Descriptive statistics and chi-square tests were used for analysis, with statistical significance set at $p \leq 0.05$.

Results:

A total of 295 cesarean sections were observed and analyzed. Nearly all mothers (99%) received prophylactic antibiotics although full adherence to WHO guidelines was achieved in only 17.6% of cases. Adherence to individual checklist components varied as follows; correct antibiotic type and dosage (56.6%), correct timing (61%), and rational postoperative use (51.2%), meaning antibiotics were given only when clinically justified and avoided when unnecessary. Ampicillin was the most frequently used antibiotic (57.1%), followed by ceftriaxone (40.4%). Nearly half (48.5%) of women received additional antibiotics postoperatively, most often without clinical justification.

Conclusion:

Although prophylactic antibiotic administration was nearly universal, adherence to WHO guidelines remained low, with inappropriate antibiotic selection and unnecessary postoperative use as major deviations. These practices maintain unnecessary and increase the risk of antimicrobial resistance. They also undermine infection prevention efforts, while imposing unnecessary costs. Strengthening antibiotic stewardship through continuous professional training, improved documentation, reliable access to first-line antibiotics, and regular audits is critical to ensure rational antibiotic use in cesarean sections in Rwanda.

INTRODUCTION

The Cesarean section (C-section) is one of the most frequently performed surgical procedures worldwide and is a critical intervention in reducing maternal and neonatal mortality when medically indicated (WHO, 2021b). However, it is also associated with a significant risk of postoperative infections, particularly surgical site infections (SSIs), which contribute substantially to prolonged hospital stays, increased healthcare costs, and increased morbidity among postpartum women (Sibomana et al., 2024). The World Health Organization (WHO) has established evidence-based guidelines recommending the timely administration of a single dose of prophylactic antibiotics before surgical incision as an effective strategy to prevent SSIs (WHO, 2021b). Despite these clear recommendations, adherence to prophylactic antibiotic protocols remains inconsistent, particularly in low- and middle-income countries (LMICs), where the health systems constraints often hinder optimal implementation (Noha et al., 2025).

Globally, SSIs secondary to cesarean section account for a major proportion of maternal infections. However, the burden of post-cesarean SSI remains disproportionately higher in sub-Saharan Africa compared to other regions of the world. Recently a systematic review and meta analysis done in Africa found a prevalence of at least 10.2% (Mekonnen & Mittiku, 2021; Baklola et al., 2025). Studies have shown that incidence of SSI in LMICs can be up to three times higher than that reported in developed settings, reflecting systemic challenges such as limited infection prevention infrastructure, inconsistent guideline adherence, shortage of healthcare workers and shortages of essential antibiotics (Aiken et al., 2012). Despite the availability of WHO guidelines for prophylaxis, the persistence of a high burden of SSIs in developing countries underscores the complex interplay between the ideal and real-world clinical practice. In such settings, challenges such as resource constraints, antibiotic stewardship, and low institutional capacity persist (Jury & Hirst, 2021).

In Rwanda, cesarean sections represent an increasing proportion of health facility deliveries with the current rate at 15% and it is projected to rise, reflecting broader changes in obstetric care practices (Kibe et al., 2022). However, post-cesarean SSIs remain a significant cause of maternal morbidity in various health facilities across the country. According to a systemic review, the prevalence of post cesarean section SSI is 6.85% (Sibomana et al., 2024). Despite prophylactic antibiotics having been proven to be effective at reducing post cesarean section SSI, local studies and facility reports indicate varying adherence to antibiotic prophylaxis guidelines, often influenced by factors such as staff workload,

supply chain limitations, and varying perceptions of infection risk (Velin et al., 2021). These variations suggest a potential gap between national and international recommendations and the realities of day-to-day clinical practice.

Given the rising rates of cesarean delivery and the persistent burden of SSIs, understanding how prophylactic antibiotic guidelines are implemented within the Rwandan healthcare settings is crucial. Strengthening adherence to these evidence-based practices has the potential to improve surgical outcomes, reduce unnecessary antibiotic use, limit the spread of antimicrobial resistance, and optimize resource utilization. Furthermore, addressing these gaps will contribute to safer obstetric care and inform context-specific interventions aimed at improving antibiotic stewardship in Rwanda.

Although WHO has recommended evidence-based prophylactic antibiotic practices for cesarean delivery for decades, implementation challenges persist, particularly in low-resource settings, contributing to a higher burden of post-cesarean surgical site infections. As such, in Rwanda, as in other countries in sub-Saharan Africa, the incidence of post-cesarean SSIs remains a pressing concern. This study therefore investigated adherence to WHO prophylactic antibiotic guidelines in cesarean sections at selected Rwandan hospitals with the aim of proposing practical interventions that will promote appropriate antibiotic use, improve outcomes and mitigate the burden of antimicrobial resistance.

METHODS

Setting

The study was conducted at both Kirehe District hospital and Ruhengeri Level 2 Teaching hospital. Kirehe District Hospital is a government hospital located in Kirehe district, Eastern Province of Rwanda. Since 2006, the hospital has been supported by Partners in Health, an international non-governmental organization that is passionate about improving health outcomes in developing countries. The hospital serves a catchment area of 420,000 people, including 60,000 residents in the Mahama Refugee Camp. In the year 2023–2024, Kirehe District Hospital reported 5,742 deliveries of which 3,122 (54.4%) were C-sections. Ruhengeri Level two teaching hospital is also a government hospital located in Musanze district, in the Northern Province of Rwanda. It serves a population of 406,557 and receives referrals from 16 health centers surrounding it. In the year 2023–2024, the hospital reported 6644 deliveries of which 2704 (40.7%) were cesarean sections.

Study Design

This was a cross-sectional observational study in which data was collected before, during and after cesarean section procedures at the two facilities.

Study population and sample size

This study included observations of prophylactic antibiotic administration and cesarean sections conducted between June and July 2025. A total of 295 cesarean sections were observed.

Data collection tools and Procedures

Data collection was conducted using a checklist that assessed the administration of prophylactic antibiotics in the cesarean section. The questionnaire consisted of 4 sections: demographics, prophylactic antibiotics administration, cesarean section duration, and additional antibiotics. It was developed based on the WHO guidelines on prophylactic antibiotics in the cesarean section.

Upon obtaining the necessary approvals, the research assistant and lead researchers used the checklist to record data at both facilities concurrently. Data collectors maintained a non-participatory presence within the surgical and clinical areas to systematically observe cesarean section procedures, accompanying each case from the labor ward to the operating room, and post-operatively, subsequently reviewing patient records to obtain additional case-specific clinical information.

Key Outcome Measures:

The study had 5 key outcome measures:

1. Adherence to prophylactic antibiotics, presented as the percentage of using the correct type of prophylactic antibiotics divided by the total number of samples.
2. Adherence to the dose of prophylactic antibiotics, presented as the percentage of using the correct dosage of prophylactic antibiotics divided by the total number of samples.

3. Adherence to correct timing, presented as the percentage of administering the prophylactic antibiotics within correct time divided by total number of samples
4. Adherence to rational postoperative antibiotic use, presented as percentage of cases that antibiotics were given only when clinically justified and avoided when unnecessary, divided by total cases.
5. Full adherence, presented as percentage of cases in which all of the above four adherence were fulfilled, divided by number of cases.

Data analysis:

Data were analyzed using SPSS version 26. Descriptive statistics were used to summarize participants' demographic characteristics and key study variables, with findings presented as frequencies and percentages (Table 1). The Chi-square (χ^2) test was used to assess associations between demographic characteristics and key adherence measures to the WHO prophylactic antibiotic use criteria - antibiotic type, dosage, timing, and postoperative use (Tables 2 and 3). Statistical significance was set at $p < 0.05$, with a 95% confidence level and a 5% margin of error.

RESULTS

A total of 295 cesarean sections were observed, recorded, and analyzed, of which, 184 (62.4%) were from Kirehe District Hospital and 111 (37.6%) from Ruhengeri Referral Hospital. Of the 295 cesarean sections, 116 mothers (39.3%) were above 30 years, and 207 (70.2%) were multigravida. Prophylactic antibiotics were administered in 292 (99%) cases. Of these, 167 (56.6%) received ampicillin, 118 (40%) ceftriaxone, and 7 (2.4%) cefotaxime. Regarding the timing of administration, 111 (37.6%) of prophylactic antibiotics were administered < 30 minutes before cesarean section, 178 (60.3%) administered between 30–60 minutes before the skin incision and 3 (1%) midway during surgery. Documentation of antibiotic use was found in 177 (60.6%) of the records. Of all the total C-sections done, 284 (96.3%) cesarean sections lasted 30 minutes to 2 hours, and 34 (11.5%) had mild intraoperative complications. Postoperatively, 143 (48.5%) received additional antibiotics, mainly a combination of ceftriaxone and metronidazole (85.3%) while 113 (79%) participants took additional antibiotics for 48 hours (Table 1).

Table 1
Demographic and clinical characteristics of C-sections done at Ruhengeri Level 2 Teaching hospital and Kirehe District Hospital

Variables		n (%)
Sample		295
Hospital	Kirehe	184 (62.4%)
	Ruhengeri	111 (37.6%)
Age	Less than 16	2 (0.7%)
	16–20	22 (7.5%)
	21–25	89 (30.2%)
	26–30	66 (22.4%)
	Above 30	116 (39.3%)
Parity	Primigravida	88 (29.8%)
	Multigravida	207 (70.2%)
Indication of cesarean section	CPD	49 (16.6%)
	NRFHR	49 (16.6%)
	Previous uterine scar	164 (55.6%)
	Severe oligohydramnios	3 (1%)
	Uterine rupture	1 (0.3%)
	Placenta abruption	5 (1.7%)
	Severe preeclampsia	4 (1.4%)
	Multiple gestation	7 (2.4%)
	Failed induction	1 (0.3%)
	Breech presentation	10 (3.4%)
	Cord prolapse	2 (0.7%)
Administration of prophylactic antibiotics	Yes	292 (99%)
	No	3 (1%)
Type and dose of prophylactic antibiotics given	Ampicillin 2g	167 (57.1%)
	Ceftriaxone 2g	118 (40.4%)
	Cefotaxime 2g	7 (2.4%)
Timing of prophylactic antibiotics (in relation to start of surgery)	Less than 30 min	111 (37.6%)
	30–60 minutes	178 (60.3%)
	Midway	3 (1%)
Documentation of prophylactic antibiotics	Yes	177 (60.6%)
	No	115 (39.4%)
Duration of cesarean section	Less than 30 minutes	7 (2.4%)
	30 minutes- 2 hours	284 (96.3%)
	Above 2 hours	4 (1.4%)
Intra-operative complication	Yes	34 (11.5%)
	No	261 (88.5%)
Received post-operative antibiotics	Yes	143 (48.5%)

Variables		n (%)
	No	152 (51.5%)
Reason for post-operative antibiotics	Perceived risk of infection	63 (44.1%)
	Prolonged CS	4 (2.8%)
	Not recorded	76 (53.1%)
Type of post-operative antibiotics received	Ceftriaxone	18 (12.6%)
	Ceftriaxone and Metronidazole	122 (85.3%)
	Ampicillin	1 (0.7%)
	Ampicillin and Metronidazole	1 (0.7%)
	Metronidazole	1 (0.7%)
Duration of post-operative antibiotics	24 hours	9 (6.3%)
	48 hours	113 (79%)
	72 hours	14 (9.8%)
	More than 72 hours	7 (4.9%)

The full adherence to all four criteria combined was 17.6%. Among the four criteria, adherence to the recommended timing of administration (within 30–60 minutes before incision) had the highest adherence of 61%, followed by correct antibiotic type (56.6%) and dosage (56.6%). The use of appropriate postoperative antibiotics had the lowest adherence rate of 51.2% (Table 2).

Table 2
Extent of adherence to WHO guidelines for prophylactic antibiotic use during cesarean sections

Elements of Adherence	Adhered	Not adhered
	n (%)	n (%)
Adherence to antibiotic type	167 (56.6%)	128 (43.4%)
Adherence to antibiotic dose	167 (56.6%)	128 (43.4%)
Adherence to timing of prophylaxis administration	180 (61%)	115 (39%)
Adherence to appropriate postoperative antibiotic use	151 (51.2%)	144 (48.8%)
Full adherence (meeting All 4 criteria above)	52 (17.6%)	243 (84.4%)

Significant differences were observed in the administration of additional antibiotics between the two study sites, with Kirehe Hospital showing adherence in 70.9% of cases ($p = 0.002$). No significant differences were found in other elements of adherence between the two hospitals (Table 3).

Table 3
Adherence to the WHO-caesarian-section prophylactic antibiotic guidelines at two study sites in Rwanda

Elements of Adherence criterion	Kirehe hospital	Ruhengeri hospital	P-value
Adherence to antibiotic type	102 (61.1%)	65 (38.9%)	0.60
Adherence to antibiotic dosage	102 (61.1%)	65 (38.9%)	0.60
Adherence to timing of antibiotic administration	115 (63.9%)	65 (36.1%)	0.50
Adherence to appropriate postoperative antibiotic use	107 (70.9%)	44 (29.1%)	0.002*
Full adherence (meeting all 4 criteria above)	37 (71.2%)	15 (28.8%)	0.15
*Significant at $p < 0.05$ (please include the name of the test here)			

DISCUSSION

This study assessed adherence to WHO guidelines for prophylactic antibiotic use during cesarean sections in Ruhengeri Level II Teaching Hospital and Kirehe District Hospital in Rwanda. Although almost all mothers (99%) received prophylactic antibiotics, only 17.6% of cases achieved full adherence to all four elements of the guideline - correct antibiotic type, correct dose and timing, and avoidance of unnecessary postoperative antibiotics. Overall, no statistical differences in practices were detected across the two sites. These results suggest that the challenge was not necessarily about the provision of antibiotics, but their correct use. Inappropriate selection, dosing, timing, and prolonged postoperative regimens reduced the effectiveness of prophylaxis, which might contribute to adverse consequences such as selection of antimicrobial resistance, longer hospital stays and increased healthcare costs. The inappropriate use of antibiotics in surgical settings is a well-recognized contributor to the global burden of AMR, particularly in low- and middle-income countries where surveillance systems remain weak and stewardship structures are not fully developed (WHO, 2021b). Therefore, as evident in this case, even interventions intended to prevent infection can inadvertently contribute to a broader cycle of resistance and inefficiency within the health system if not carefully implemented.

Regarding antibiotic type and dosage, only 57.1% adhered to the recommended regimen using Ampicillin. According to WHO recommendations, a single preoperative dose of a first-generation cephalosporin or penicillin should be used for cesarean prophylaxis because of their narrow spectrum, low cost, and proven efficacy (WHO, 2021b). The frequent use of ceftriaxone (40% in this study), a broad-spectrum antibiotic classified in the “Watch” category of the WHO AWaRe framework, amounts to misuse which not only increases treatment costs but also accelerates the selection of resistant bacterial strains, most notably extended-spectrum beta-lactamase (ESBL)-producing organisms. Previous study showed an increasing burden of misuse in LMICs (Eddy et al., 2022).

Similar deviations have been reported in other countries. In Ukraine, for example, 40.3% of anesthesiologists used ceftriaxone for prophylaxis instead of first-line options (Tytarenko et al., 2022). Similarly, in Egypt, only 6.1% of cesarean cases adhered to the correct antibiotic type and dosage (Noha et al., 2025). This pattern, which reflected both provider behavior and system constraints, demonstrated a common challenge of improper antibiotic selection across diverse contexts. An ethnographic study in Ethiopia, found that prescribers preferred ceftriaxone because it was widely available and viewed as a “stronger” antibiotic, highlighting how availability and perception can outweigh clinical evidence in influencing practice (Alemkere et al., (2023). Interestingly, prescribers often believe that using broader-spectrum antibiotics offers added protection against infection, although evidence consistently shows that first-line agents such as Ampicillin or Cefazolin are equally effective when administered correctly (WHO, 2021b).

This study also found that the adherence to the correct timing of antibiotic administration was less than optimal as it was observed in only 60.3% of the cases. WHO guidelines recommend administering prophylactic antibiotics within 30 to 60 minutes before skin incision to ensure adequate serum and tissue levels during surgery (WHO, 2021b). This recommendation has a strong evidence base as studies have consistently shown that administration within this window significantly reduces maternal infectious morbidity, such as endometritis and wound infection, compared to later timing (Dlamini et al., 2015; Michal et al., 2021). In our study, however, many women received antibiotics either less than 30 minutes before skin incision (37.6%) or midway during the C-section (1%), reflecting missed opportunities for optimal protection. Timing is one of the simplest yet most frequently overlooked aspects of adherence, often due to workflow issues in busy surgical theaters or miscommunication between surgical and anesthesia teams (Bhattacharjee et al., 2013).

Because most women in this study received antibiotics before incision rather than afterwards, the likelihood of SSI in this population might be low. However, timing deviations still represent suboptimal practice and may expose patients to unnecessary risk of infection if serum drug levels peak too early or too late relative to the surgical incision. More importantly, poor timing also reflects broader gaps in coordination and accountability within the surgical team. In well-performing settings, assigning a specific team member, often the anesthesiologist/anesthetist or theater nurse, the responsibility for antibiotic administration significantly improved adherence (Kaveti et al., 2025). We argue that establishing such similar systems in Rwandan hospitals could ensure consistency in timing and promote collective accountability among operating room personnel.

Our study also revealed that nearly half (48.5%) of the women received additional postoperative antibiotics, primarily a combination of ceftriaxone and metronidazole (85.3%). Moreover, this was often done without a documented or justifiable indication. Only a small proportion of these cases involved valid reasons, such as prolonged surgery or intraoperative complications, and even then, inappropriate antibiotic combinations were used. This mirrors findings from Benin and Jordan, where postoperative antibiotic use was widespread despite a lack of clinical justification (Dohou et al., 2022; Abdel Jalil et al., 2018). Such practices reflect a persistent belief among clinicians that extending antibiotic coverage “just in case” provides extra protection, while on the other hand this might lead to unnecessary costs, increase risk of AMR selection, and potential risk for adverse reactions (Rink et al, 2025). Poor documentation further compounds the issue, as seen in this study, where only 60.6% of antibiotic administrations were properly recorded, making it difficult to monitor and improve adherence.

The Unjustified use of postoperative antibiotics has major implications for antimicrobial resistance and health system costs. Prolonged antibiotic exposure selects for resistant organisms, particularly when broad-spectrum agents are used. This can lead to recurrent infections that are more difficult and expensive to treat, posing serious risks in settings with limited diagnostic and therapeutic options (Huemer et al., 2020). Furthermore, unnecessary antibiotics contribute to extended hospital stays, adding to patient burden and straining limited inpatient capacity like

hospital beds. From a stewardship perspective, these findings emphasize the need to move beyond fear-based prescribing toward rational, evidence-based decision-making. The assumption that more antibiotics mean more safety must be replaced with the understanding that appropriate antibiotics mean better outcomes.

When comparing findings across countries, contextual factors appear to strongly influence adherence. In high-income countries such as Israel, adherence rates above 90% were achieved through assigning clear responsibility for antibiotic administration and incorporating prophylaxis into hospital quality indicators where anesthesiologists were responsible for administration of prophylactic antibiotics (Michal et al., 2021). Experience from India showed that adherence reached 85% due to structured institutional protocols, active antibiotic stewardship programs, and continuous staff training (Kaveti et al., 2025). In contrast, countries such as Egypt and Peru recorded adherence levels below 5%, reflecting weak stewardship, limited supervision, and resource challenges (Noha et al., 2025; Kovy et al., 2023). These differences indicate that beyond resource availability, organizational structure and provider perceptions play a crucial role in shaping antibiotic use. In Rwanda, like other LMICs, systemic factors such as lack of appropriate antibiotics, inadequate training, lack of clear hospital protocols, and inconsistent supervision likely explain the low adherence observed.

Taken together, these findings suggest that while prevention of SSI remains a necessary and valid intervention through prophylactic antibiotic use, inappropriate practice appears to be the more pressing problem in Rwanda. Since nearly all mothers receive antibiotics before C-section, the risk of infection primarily arises among those who receive them outside the optimal window. For the majority in this study, deviations from guidelines amounted to overtreatment rather than under-protection. This distinction is critical, as it reframes the discussion from infection prevention toward proper antibiotic stewardship. The consequences of poor stewardship include the selection and spread of antimicrobial resistance, unnecessary financial burden on health systems and patients, and longer hospital stays, which can expose women to other hospital-acquired infections and delayed recovery (WHO, 2021b ; Eddy et al., 2022).

In conclusion, addressing these challenges requires a multifaceted approach. Developing and disseminating clear national and facility-level protocols aligned with WHO recommendations would provide a common standard for practice. Regular provider training and continuing professional education should emphasize not only what to do but also clarify why adherence to timing matters. Incorporating antibiotic timing into surgical safety checklists can ensure accountability, while consistent documentation will allow for ongoing audit and feedback, which have proven effective in improving adherence in other countries (Michal et al., 2021). Furthermore, strengthening antimicrobial stewardship programs within hospitals would provide structured oversight, while ensuring a reliable supply of first-line antibiotics would minimize inappropriate substitutions and promote adherence.

These interventions must be supported by broader health system strengthening. Many of the barriers to adherence such as stockouts, established wrong habits, lack of supervision, and absence of context-specific guidelines reflect structural weaknesses in health systems. Therefore, interventions should combine clinical education with system-level changes, including supportive monitoring frameworks and integration of antibiotic use indicators into hospital performance evaluations. Collaboration between policymakers, pharmacists, and clinicians will also be essential to ensure that evidence-based practices are not only disseminated but actively implemented.

Limitations

This study has several limitations that should be considered when interpreting the findings. First, data was collected from only two hospital sites, which may limit the generalizability of the findings to other healthcare settings in Rwanda or the region. Secondly, pathogen isolation and antimicrobial sensitivity studies were not done. Given the dynamic nature of AMR, real-time pathogens and sensitivity data would have strengthened the validity of assumptions on which the study was premised. Thirdly, the possibility of observer bias cannot be ignored given that data collectors were employees of the respective hospitals. Unfortunately, we could not prevent this situation as it was the condition set by hospital administrators since they were uncomfortable with non-staff data collectors going into sensitive spaces like operating theatres. In addition, given that data collectors relied on direct observation and chart reviews, awareness of their presence may have positively influenced each provider's behavior- a phenomenon known as social desirability bias. Finally, we did not compare adherence between elective and emergency cesarean sections, which could have provided insights into how urgency affects guideline compliance. Despite these limitations, this study provides critical insight into real-world antibiotic use during cesarean sections and underscores the importance of targeted interventions tailored to Rwanda's healthcare context.

CONCLUSION AND RECOMMENDATIONS

Conclusion:

Although prophylactic antibiotics were administered in nearly all cesarean deliveries (99%), full adherence to WHO guidelines was achieved in only 17.6% of cases. Key elements of non-adherence included frequent use of broad-spectrum agents such as ceftriaxone, inconsistent timing, poor documentation, and unjustified postoperative use, seen in nearly half of cesarean sections. These deviations not only reduce the

effectiveness of infection prevention but also accelerate selection of antimicrobial resistance, increase healthcare costs, and compromise patient safety.

Recommendations:

Based on our findings, several steps can be taken to improve adherence to prophylactic antibiotic guidelines during cesarean sections:

- Strengthen antibiotic stewardship through supervision and monitoring:
Hospitals should reinforce antibiotic stewardship programs by implementing routine supervision, regular audits, and continuous monitoring of prophylactic antibiotic use during cesarean sections. Linking adherence indicators to surgical audits and feedback mechanisms can promote accountability and ensure alignment with evidence-based standards.
- Establish WHO-aligned protocols and checklists through refresher trainings:
Health facilities should adopt and consistently implement standardized protocols aligned with WHO recommendations, supported by regular refresher trainings for surgical teams. Integrating these protocols into surgical safety checklists and clinical workflows can enhance standardization of care and reduce inappropriate antibiotic use.
- Conduct qualitative studies to explore factors affecting adherence:
Future research should include qualitative approaches, such as in-depth interviews or focus group discussions with healthcare providers, to explore behavioral, institutional, and contextual factors influencing adherence to prophylactic antibiotic guidelines. Understanding provider perspectives will inform targeted interventions and support the development of policies that promote rational antibiotic use and reduce maternal morbidity and antimicrobial resistance in Rwanda.

Abbreviations

WHO: World Health Organization

SSI: Surgical Site Infection

LMICs: Low- and Middle-Income Countries

CS: Cesarean Section

SPSS: Statistical Package for the Social Sciences

IRB: Institutional Review Board

UGHE: University of Global Health Equity

AMR: Antimicrobial Resistance

CPD: Cephalopelvic Disproportion

NRFHR: Non-Reassuring Fetal Heart Rate

AWaRe framework: Access, Watch and Reserve framework

ASP: Antibiotic Stewardship Programs

ESBL: Extended-spectrum beta-lactamase

Declarations

Ethical Approval and Consent to Participate

This research was conducted in accordance with the Declaration of Helsinki. The ethical approval was obtained from the University of Global Health Equity Institution Review Board (UGHE IRB). Ref: *UGHE-IRB/2025/366*, the Ministry of Health and both hospitals: Ruhengeri level II teaching hospital and Kirehe district hospital approved the study.

This was a minimal-risk observational study involving non-participatory observation of routine clinical practice without direct intervention. No personally identifiable information from patients or healthcare providers was collected. Healthcare providers working in the study areas were

informed about the presence and role of the data collectors during the study period. Written informed consent to participate was deemed unnecessary for this study, as approved by the UGHE Institutional Review Board.

Consent for Publication

Not applicable

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Disclosure of Interest

The team declares no conflicting interest

Availability of Data

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Consent to Participate

Consent to Participate declaration: not applicable

Authors Contribution

GII and BK conceptualized the study and developed the proposal. BAA and COO reviewed the proposal and provided necessary feedback. GII and BK contributed to the data collection and data analysis. GII, BK, BAA and COO contributed to manuscript development, as well as approved the final manuscript.

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