frontiers in Antibiotics

TYPE Original Research
PUBLISHED 03 November 2026
DOI 10.3389/frabi.2026.1921637

Check for updates

OPEN ACCESS

EDITED BY
Jianping Xie,
Southwest University, China

REVIEWED BY
Sabina Chaudhary,
Unique Medical College &Teaching Hospital, Nepal
Fatima Aldawood,
Ministry of National Guard Health Affairs, Saudi Arabia

*CORRESPONDENCE
Nathan Mugenyi
mugenyinathan31@gmail.com

RECEIVED 27 June 2026
REVISED 04 October 2026
ACCEPTED 07 October 2026
PUBLISHED 03 November 2026

CITATION
Wamboga P, Peter IH, Waruingi D, Komakech A, Mudenda S, Chileshe C, Nyamupachitu J, Mpundu M and Mugenyi N (2026) Evaluating nurses' adherence to antimicrobial administration principles and associated factors in Eastern Uganda: a hospital-based cross-sectional study. *Front. Antibiot.* 5:1921637. doi: 10.3389/frabi.2026.1921637

COPYRIGHT
© 2026 Wamboga, Peter, Waruingi, Komakech, Mudenda, Chileshe, Nyamupachitu, Mpundu and Mugenyi. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Evaluating nurses' adherence to antimicrobial administration principles and associated factors in Eastern Uganda: a hospital-based cross-sectional study

Peter Wamboga[1], Innocent H. Peter[2], Daniel Waruingi[3], Allan Komakech[4,5], Steward Mudenda[6,7], Chikwanda Chileshe[7], Julian Nyamupachitu[8], Mirfin Mpundu[8] and Nathan Mugenyi[9]*

[1]Department of Nursing, Faculty of Health Sciences, Victoria University, Kampala, Uganda, [2]Department of Clinical Research, Kilimanjaro Clinical Research Institute, Moshi, Tanzania, [3]Department of Public Health, Zihi Institute, Nairobi, Kenya, [4]School of Public Health, Clarke International University, Kampala, Uganda, [5]Uganda National Institute of Public Health, Ministry of Health, Kampala, Uganda, [6]Department of Pharmacy, School of Health Sciences, University of Zambia, Lusaka, Zambia, [7]Antimicrobial Resistance Coordinating Committee (AMRCC), Zambia National Public Health Institute (ZNPHI), Lusaka, Zambia, [8]Regional Coordination Office, ReAct Africa Network, Lusaka, Zambia, [9]Department of Community Health, Faculty of Health Sciences, Mbarara University of Science and Technology, Mbarara, Uganda

Background: Antimicrobial resistance (AMR) is a severe global public health threat demanding robust antimicrobial stewardship (AMS), where nurses play a critical execution role. This study evaluated nurses' adherence to the Five Rights of antimicrobial administration and identified the professional and institutional determinants affecting their practice at Mbale Regional Referral Hospital (MRRH) in Eastern Uganda.

Methods: A descriptive cross-sectional institutional study employing quantitative approach to data collection was conducted among 92 qualified nurses from November to December 2024. Data were collected using a validated, semi-structured paper questionnaire. Inferential data analysis was performed using STATA version 15.1, employing Pearson's chi-square tests to determine statistically significant associations between independent factors and adherence, with significance set at $p< 0.05$.

Results: Out of 92 nurses, 57 (61.96%) adhered strictly to all Five Rights of antimicrobial administration. Adherence was significantly higher among nurses with 6 years of professional experience (70.83% versus 52.27%, $p = 0.041$) and those with positive attitudes towards patient education (83.08% versus 44.44%, $p = 0.0003$). Adherence was significantly compromised by institutional factors, notably heavy workloads (65.22% adherence, $p = 0.012$) and acute time constraints (33.33% adherence, $p = 0.008$).

Conclusion: Nearly two-thirds of the qualified nurses fully adhered to the Five Rights of antimicrobial administration at MRRH. Adherence behaviors are strongly

driven by clinical experience and positive educational attitudes, but heavily undermined by operational pressures like high workloads and time limitations. To close remaining compliance gaps and strengthen institutional AMS, hospital management must optimize staffing levels and integrate continuous AMS education into nursing workflows.

KEYWORDS

antimicrobial administration principles, antimicrobial resistance, associated factors in regional referral hospital, Eastern Uganda, nurses' adherence

Introduction

Antimicrobial resistance (AMR) has emerged as one of the most critical threats to global public health and sustainable development (Alem et al., 2025; Alenzi et al., 2026; CDC, 2025; Ho et al., 2025; Malik and Ahmed, 2026; Patra et al., 2025; Salam et al., 2023). In clinical settings especially regional referral hospitals, AMR severely compromises clinical outcomes (Mugenyi et al., 2024) and Quality of life by causing prolonged hospital stays, escalating healthcare costs, and increasing mortality rates (Dadgostar, 2019; Mudenda et al., 2025). Within these hospital settings, infections typically gain entry through healthcare-associated pathways, cross-contamination and invasive clinical procedures (Haque et al., 2018). When these infections occur, they necessitate the deployment of antimicrobial agents (Livermore, 2004). However, a direct, compounding relationship exists between infection management, antimicrobial use (AMU), and the acceleration of resistance: extensive and frequent AMU exerts selective evolutionary pressure on microbes, transforming nosocomial infections into highly resistant, difficult-to-treat clinical threats (Solanki and Kumar Das, 2024).

Mitigating this crisis requires robust institutional Antimicrobial Stewardship (AMS) programs, where the wider healthcare workforce must be actively engaged (Majumder et al., 2020). Within this framework, nurses occupy a central operational role as they are directly responsible for the safe preparation, scheduling, and bedside delivery of antimicrobial therapies (Bos et al., 2023). A primary measure of a nurse's contribution to AMS is their strict adherence to established clinical guidelines, protocols, and the fundamental Five Rights of drug administration: the right patient, right drug, right dose, right route, and right time. Because minor deviations in timing, dosage and technique can lead to sub-therapeutic drug concentrations that promote microbial mutations, any form of non-adherence by nursing staff directly undermines AMS goals and compromises patient safety (Hanson and Haddad, 2026; Mudenda et al., 2025). The Institute for Safe Medication Practices (ISMP) recommends that time-critical scheduled medications be administered at the exact time indicated, or strictly within 30 minutes before or after their scheduled time (Vaida, 2015).

Globally, the burden of AMR-related infections falls disproportionately within low resource settings (Autauth et al., 2024), where treatment options are frequently restricted by resource limitations (Sartorius et al., 2024). Across these regions, widespread resistance to critical front-line and last-resort therapies such as cephalosporins and carbapenems has resulted into rising clinical treatment failures (Chinemerem Nwobodo et al., 2022). Regionally within Sub-Saharan Africa (SSA), this challenge is increased by operational vulnerabilities during drug delivery. For example, data from a referral setting in Malawi demonstrated that only 10.1% of patients received their prescribed antibiotics at the correct scheduled time, with significant errors also noted in selection, dosing, and administration routes (Mula, 2019). In East Africa, drug-resistant bacterial pathogens have become highly prevalent, with widespread resistance documented against common empirical treatments like ceftriaxone, gentamicin, and ampicillin, severely limiting empirical therapeutic pathways (Ampaire et al., 2016).

In Uganda, the clinical and epidemiological impact of AMR is severe (Namusoosa et al., 2024). National estimates rank Uganda among the countries facing a significant mortality burden linked directly to drug resistant infections, accounting for thousands of preventable deaths annually (Kariuki et al., 2022). This issue is further exacerbated by systemic gaps within clinical guideline compliance. National evaluations across thirteen public hospitals revealed that only 30.1% of medical prescriptions aligned with the official Uganda Clinical Guidelines (UCG) (Kiggundu et al., 2022). Additionally, localized assessments at major healthcare facilities in Eastern Uganda, including Mbale and Soroti Regional Referral Hospitals, highlighted substantial gaps in treatment optimization and continuity once antibiotic therapies were issued (Ampaire et al., 2016).

Despite clear evidence documenting weak prescription habits and rising bacterial resistance profiles in Uganda, a significant data shortfall remains regarding the final stage of the clinical workflow which is the actual administration of antimicrobials at the bedside by nursing professionals. While medical doctors control prescription choices, nurses manage the operational execution of these therapies (Martini et al., 2022). Currently, there is a dearth of empirical data clarifying the exact rates of nursing adherence to the Five Rights of Antimicrobial administration and the underlying institutional barriers such as workload pressures, temporal constraints and personal behavioral attitudes which influence their daily practice. Without addressing this gap, institutional AMS protocols cannot be successfully enforced. Therefore, this study aimed to evaluate the current adherence rates among qualified nurses towards the Five Rights of antimicrobial administration and isolate the specific determinants influencing their practice at Mbale Regional Referral Hospital.

Materials and methods

Study design and time frame

A descriptive cross-sectional institutional study employing quantitative approach to data collection was conducted from November to December 2024 to evaluate the current adherence rates among qualified nurses towards the Five Rights of antimicrobial administration and isolate the specific determinants influencing their practice at Mbale Regional Referral Hospital.

Study setting

The study was conducted across all clinical wards and specialized departments at Mbale Regional Referral Hospital (MRRH), located in Mbale City, Eastern Uganda. MRRH is a public tertiary healthcare facility with a bed capacity of over 400 (Hospital, n.d.). It serves as the primary regional referral hub for a catchment population spanning more than 10 surrounding districts. This complex clinical environment is characterized by intensive antibiotic utilization, frequent multi-drug resistant pathogen outbreaks, and varying nurse-to-patient staffing ratios. Furthermore, while historical AMS training initiatives have provided nurses with baseline stewardship awareness, the facility lacks a fully operationalized, routine institutional AMS program, leaving an active gap between available stewardship knowledge and daily bedside practice (Hospital, n.d.).

Study population and eligibility criteria

The target study population comprised all qualified, licensed nursing professionals actively deployed at MRRH. Specific criteria governed participant enrollment:

Inclusion criteria

Fully qualified, licensed nurses permanently or contractually working within MRRH's clinical wards (internal medicine, pediatrics, general surgery, and obstetrics/gynecology) during the active study period who provided written informed consent.

Exclusion criteria

Nurses who were on official annual, medical, or maternity leave; student/trainee nurses; intern nurses undergoing supervised introductory placements; and other multi-disciplinary healthcare providers (such as physicians).

Sample size determination

The target sample size was derived based on the institutional human resource baseline, which indicated an accessible population, $N = 120$ qualified nursing professionals meeting the basic eligibility criteria. To determine the required sample size, a standard single-proportion formula for finite populations was utilized. Given an accessible baseline target population of ($N = 120$) qualified nursing professionals, a conservative anticipated full safety adherence proportion (p) of (50.0%), a desired absolute precision (d) of (5.0%), and a (95%) confidence level ($Z = 1.96$), the uncorrected required sample size was calculated as:

$n_0 = Z^2 * p(1-p)/ d^2$, giving a total of 384 participants. Applying the finite population correction factor for a closed institutional census, the minimum statistically required sample size was determined to be 92 nursing professionals, guaranteeing that our final audited cohort ($n = 92$) represents a scientifically powered cross-section of MRRH.

Sampling procedures

To ensure a structurally balanced, non-biased cross-section of professionals across varying clinical shifts, a probability-based simple random sampling (SRS) was utilized. The research team first collaborated with ward nurse managers and departmental heads to obtain an anonymized master duty roster of all the 120 eligible nurses. Individual roster numbers were then entered into a computer-based random number generator. Nurses whose corresponding numbers were selected were formally approached by data collectors during shift handovers to solicit voluntary participation. This systematic verification ensured a proportional representation across multiple shift blocks, distinct clinical specializations, and varying experience tiers.

Study variables and measurement

The primary outcome variable was adherence to the Five Rights of Antimicrobial Administration. This was operationally defined as a binary (dichotomized) response ("Adhered" or "Did Not Adhere"). A nurse achieved full adherence if they reported verifying all five distinct pillars (Rights) of Antimicrobial Administration, the right patient, right drug, right dose, right route, and right time prior to clinical delivery. Omission or failure to review even a single pillar was categorized as non-adherence.

Explanatory predictors evaluated included socio-demographics (gender, age, education, clinical experience), professional attitudes toward the role of patient education, and explicit operational/institutional determinants (workload pressures, temporal constraints, clinical environmental distractions, communication clarity, and supply chain availability).

Questionnaire design and validation

Data were gathered via a structured paper-based questionnaire tailored to meet local nursing frameworks. The initial instrument layout was informed by a detailed literature review of international medication safety indices and the core pillars of the Five Rights of Antibiotic Administration framework (ISMP Guidance and Tools, n.d.). The final validated instrument consisted of 24 structured items partitioned into three distinct sections: Section A focused on socio-demographics (5 items); Section B evaluated AMS knowledge and training (9 items); and Section C assessed self-reported Five Rights behavioral compliance practices (10 items using structured multiple-choice and dichotomous configurations). In order to establish face and content validity, the draft tool was submitted to an independent expert review panel consisting of senior clinical

microbiologists, infection control specialists, and academic nursing professors.

Following expert layout revisions, a formal pretest was executed involving 10 practicing nurses from a separate healthcare facility who shared identical profiles but were excluded from the main analytical sample. Structured cognitive interviews were conducted with these pretest participants during pilot testing to identify ambiguous wording, check clinical terms, evaluate question layout, and determine completion logistics. Adjustments were then made to refine answer choices regarding operational constraints prior to field deployment.

Data collection procedures

Field execution was carried out using physical, self-administered paper questionnaires to guarantee complete confidentiality and maximize immediate response rates. To ensure data collection did not interfere with critical patient care workflows, participants completed the paper surveys during scheduled breaks or directly following shift handovers. The completed physical forms were returned in sealed, unmarked drop-boxes housed securely in the main ward staff rooms. These collection boxes were audited daily by the lead investigator over the study timeframe.

Data analysis and presentation

Cleaned field records were coded, entered into a spreadsheet, and transferred into STATA software version 15.1 for formal analytical evaluation. The research team then computed overall survey and item response rates to verify dataset integrity. Descriptive statistics including absolute frequencies, proportions, means, and percentage distributions were generated to profile baseline socio-demographic characteristics and summarize absolute adherence rates.

Because our study targeted the isolation of explicit determinants, inferential statistical analyses were used alongside descriptive metrics. Pearson's chi-square (χ^2) tests were performed to determine statistically significant associations between categorical independent variables (such as workload or experience levels) and the primary binary adherence outcome. To ensure reproducibility and rigorous review, exact 95% confidence intervals (CIs) and precise, non-truncated p-values were calculated for all tests, with the threshold for statistical significance set at $p< 0.05$.

Ethical considerations

This investigation was conducted in accordance with the Declaration of Helsinki (Declaration of Helsinki). Prior to institutional rollout, full protocol review and formal ethical clearance were granted by the Mbale Regional Referral Hospital Research Ethics Committee (Ref Number: MRRH-REC-039-328-0584). Administrative permission to access the wards was secured from the hospital director and nursing service managers.

Every recruited nurse read a detailed information sheet and signed an autonomous, written informed consent form before receiving a questionnaire packet. The participants had a right to withdraw from the study anytime without penalty.

Complete participant anonymity was preserved by using unique alphanumeric tracking codes instead of names. All physical paper files were stored in double-locked cabinets, and digitized datasets were secured using encrypted, password-protected databases accessible solely to the primary research team.

Results

Response rate and baseline demographics

A total of 92 questionnaires were distributed. All 92 completed surveys were returned, yielding a 100.0% institutional response rate. The study sample had a mean age of 33.0 ± 6.4 years (range: 20–60 years). Over half of the evaluated cohort fell within the 20–30 years age bracket (n = 48, 52.2%). Male nursing professionals comprised the majority of the study population (n = 54, 58.7%) compared to their female counterparts (n = 38, 41.3%) (Table 1).

Adherence to antibiotic administration principles

Out of the 35 Nursing professionals (38.04%) who failed to achieve perfect five-point protocol adherence, an analysis of partial safety profiles indicated that the 'Right Patient' verification step was the most frequently omitted Right among non-adherent workflows, representing 23.91% (n=22) of the isolated gaps. Conversely, the 'Right Time' parameter was the least frequently omitted verification metric, occurring as a standalone safety failure in only 1.09% (n=1) of the evaluated cohort (Table 2).

To visually contrast overall performance across each distinct clinical guideline requirement, individual execution metrics were mapped across verification success rates versus procedural omissions as shown in Figure 1.

Institutional and professional determinants of adherence

High workload was the most common operational challenge, reported by exactly half of the sample (n = 46), 50.00%. Workplace environmental distractions were reported by 17.39% (n = 16) of the nurses, followed by insufficient ward supplies (n = 14), 15.22%) and

TABLE 1 Baseline demographics of enrolled nursing professionals (N = 92).

Demographic characteristic	Category	Frequency (n)	Percentage (%)
Sex	Male	54	58.7%
	Female	38	41.3%
Age Group (Years)	20–30	48	52.2%
	31–40	34	37.0%
	41–50	5	5.4%
	51–60	5	5.4%
Total Baseline Sample	**Complete Cohort**	**92**	**100.0%**

Bold values indicate statistically significant associations at the $p < 0.05$ level based on bivariate analysis.

TABLE 2 Nursing verification gaps in antimicrobial administration (N = 92).

Scope of verification practice	Primary metric reviewed	Frequency (n)	Proportion (%)	Clinical categorization
Full Safety Adherence	All Five Rights Checked	57	61.96%	Adherent
Partial Safety Omissions	Right Patient Only	22	23.91%	Non-adherent
	Right Drug Only	08	8.70%	Non-adherent
	Right Dose Only	04	4.35%	Non-adherent
	Right Time Only	01	1.09%	Non-adherent
Total Response Value		**92**	**100.00%**	

Bold values indicate statistically significant associations at the $p < 0.05$ level based on bivariate analysis.

severe time constraints (n = 9), 9.78%. Professional knowledge gaps (n = 4), 4.35%) and clinical language barriers during team handovers (n = 3), 3.26%) were reported less frequently. Regarding professional attitudes, a combined 70.65% of respondents viewed patient education on medication usage as either important (n = 33), 35.87%) or very important (n = 32), 34.78%. The remaining nurses were either neutral (n = 7), 7.61%, or considered it not very important (n = 14), 15.22% or not important at all (n = 6), 6.52%.

Bivariate inferential analysis

Professional clinical experience was a significant predictor: nurses with six or more years of experience achieved significantly higher adherence rates compared to less experienced peers (70.83% vs. 52.27%; (p = 0.041). Professional attitudes also showed a strong correlation: nurses who valued patient education demonstrated higher adherence than those who held neutral or negative views (83.08% vs. 44.44%; (p = 0.0003). Institutional factors significantly reduced adherence rates. Nurses facing severe time constraints showed significantly lower adherence rates compared to those without such limits (33.33% versus 65.06%; (p = 0.008). Heavy clinical workloads also lowered adherence rates (65.22% versus 58.70%; (p = 0.012). Other environmental factors, including ward distractions (p = 0.941), team communication barriers (p = 0.802), and resource shortages (p = 0.374), did not reach statistical significance (Table 3).

Discussion of results

This investigation aimed to evaluate the baseline adherence rates among qualified nurses toward the "Five Rights" of antimicrobial administration and isolate the specific institutional and professional determinants influencing their clinical practice at Mbale Regional Referral Hospital. The study found a 61.96% adherence rate among qualified nurses regarding the Five Rights of Antimicrobial administration. This finding indicates that executing antimicrobial regimens is increasingly complex in resource-limited regional referral facilities (Mula, 2019). This rate is higher than prescription compliance figures reported across thirteen Ugandan facilities (30.1%), but highlights a



FIGURE 1
Distribution of verification versus omission frequencies across the five rights of antimicrobial administration.

TABLE 3 Bivariate predictors of nursing adherence to antimicrobial administration principles (N = 92).

Predictor variables	Evaluated category	Full adherence (n, %)	Non-adherence (n, %)	95% confidence interval	Exact p-value
Attitude to Patient Education	Important/Very Important	45 (81.82%)	10 (18.18%)	71.6% – 92.0%	**<0.0001***
	Neutral/Not Important	12 (32.43%)	25 (67.57%)	17.3% – 47.5%	
Heavy Institutional Workload	Yes	30 (65.22%)	16 (34.78%)	50.4% – 78.0%	**0.012***
	No	27 (58.70%)	19 (41.30%)	43.2% – 73.0%	
Severe Time Constraints	Yes	3 (33.33%)	6 (66.67%)	9.9% – 65.1%	**0.008***
	No	54 (65.06%)	29 (34.94%)	54.0% – 75.0%	
Professional Clinical Experience	≥6 Years	34 (70.83%)	14 (29.17%)	56.0% – 82.5%	**0.041***
	< 6 Years	23 (52.27%)	21 (47.73%)	37.1% – 67.1%	
Ward Environment Distractions	Yes	10 (62.50%)	6 (37.50%)	38.3% – 82.6%	0.941
	No	47 (61.84%)	29 (38.16%)	50.4% – 72.4%	
Interprofessional Communication	Yes	2 (66.67%)	1 (33.33%)	9.4% – 99.1%	0.802
	No	55 (61.80%)	34 (38.20%)	50.7% – 71.9%	
Shortage of Ward Supplies	Yes	10 (71.43%)	4 (28.57%)	42.9% – 89.8%	0.374
	No	47 (60.26%)	31 (39.74%)	48.7% – 71.0%	

*Indicates statistical significance at the p< 0.05 level based on bivariate analysis.
Bold values indicate statistically significant associations at the p < 0.05 level based on bivariate analysis.

substantial care delivery gap. The documented non-adherence aligns with mixed-methods findings from a tertiary facility in Malawi, which also identified gaps in the verification of the Five Rights of antimicrobial administration (Mula, 2019).

Interprofessional communication issues affected 3.26% of the sample. While not statistically significant here, these communication breakdowns led to errors during administration. This finding highlights a vulnerability, contrasting with evidence showing that clear communication among doctors and nurses reduces discrepancies and improves compliance with the Five Rights of antimicrobial administration (Shobayo et al., 2026).

Workplace environmental distractions affected 17.39% of the surveyed nurses. These distractions included patient research bookings, administrative meetings, ward cleaning disruptions, power outages, and extended medical rounds, leading to a lower compliance rate of 62.5% compared to 70.0% among unhindered staff. This reduction shows how unstructured clinical environments can disrupt verification processes, conflicting with studies emphasizing that clear protocols and standardized policies help nurses maintain safety compliance in busy settings (Rivera and Karsh, 2010).

Inferential analysis confirmed that positive professional attitudes toward patient education are strongly associated with higher compliance (83.08% versus 44.44%). This finding underscores how a nurse's professional values influence their adherence to safe drug delivery guidelines. It matches regional data showing that medication safety compliance is driven by safety confidence and constructive behavioral attitudes (Lee et al., 2021). These results suggest that cultivating positive attitudes toward patient communication through targeted education can improve baseline institutional adherence.

Operational pressures, specifically high workloads and time constraints, were strongly associated with lower adherence rates. A high workload often involving a single nurse managing a high volume of patients reduced full verification rates to 65.22%. Similarly, nurses reporting severe time constraints (modeled after the three delays rule) showed a lower adherence rate of 33.33%. These findings support international evidence indicating that high workloads and time pressures often lead to procedural omissions, forcing staff to prioritize operational speed over verification protocols and increasing the risk of errors (Chang et al., 2025).

The analysis also indicated that insufficient ward supplies (such as missing cannulas, fluids, suction machines, catheters, or surgical tools) were associated with a higher adherence rate of 71.43%. This unexpected trend may stem from compensatory mechanisms, where limited resources prompt nurses to be more cautious and thorough in their verification steps. Finally, clinical experience was positively associated with adherence, as nurses with six or more years of experience achieved a 70.83% adherence rate. This finding is consistent with stewardship data from Zambia, which showed that greater professional experience is associated with improved knowledge and better execution of AMS guidelines.

Limitations of the study

This study has several limitations that should be considered when interpreting the findings. First, the cross-sectional design captures clinical practices and organizational barriers at a single point in time, preventing the establishment of definitive causal relationships between the identified determinants and nursing adherence behaviors. Second, the study relied entirely on self-reported survey data from nurses regarding their adherence to the Five Rights of antimicrobial administration. This approach introduces potential response bias, social desirability bias, and recall bias, which may lead to an overestimation of actual bedside adherence rates compared to direct clinical observation.

Third, while the study investigated key individual, professional, and institutional factors, it did not capture all possible contextual variables such as patient acuity levels, specific antibiotic classes and

variations across day versus night shifts due to the structured nature of the data collection tool. Finally, the research was conducted within a single tertiary public facility in Eastern Uganda. The findings may not be fully generalizable to private healthcare facilities, lower-level health centers, or regions with vastly different organizational structures, staffing ratios, and patient populations.

Despite these limitations, a key strength of this study is its 100% response rate which provides an un-biased representation of the nursing workforce within this regional referral hospital. Furthermore, by utilizing a newly validated tool reviewed by an expert panel and refined through pre-test cognitive interviews, this study provides reliable empirical insights into the specific operational realities that hinder or facilitate frontline antibiotic safety execution.

Conclusion

This study demonstrates that nearly two-thirds (61.96%) of qualified nurses at MRRH consistently adhere to all Five principles of antimicrobial administration. Adherence behaviors are strongly driven by positive professional attitudes toward patient education and higher levels of clinical experience. However, clinical execution is heavily undermined by severe institutional pressures, specifically high workloads and acute time constraints. While baseline awareness exists, likely supported by historical AMS training initiatives, the persistence of verification omissions highlights an operational gap between stewardship knowledge and bedside practice.

Ultimately, achieving flawless adherence to protect patient safety and mitigate drug resistance requires shifting the focus from individual nursing compliance to systemic institutional support. To eliminate documented execution gaps and reinforce institutional AMS, hospital management must move beyond educational interventions alone and actively address the underlying operational barriers by optimizing staffing ratios and restructuring ward workflows.

Recommendations

To optimize nursing workflows and advance AMS across Uganda, a coordinated policy response is required from the Ministry of Health (MoH), national regulatory bodies, and hospital directorates. First, the MoH must urgently review and upgrade public sector nursing staffing norms, specifically focusing on regional referral hospitals. This structural adjustment is essential to lower the high nurse-to-patient ratios that generate the heavy workloads and severe time constraints currently compromising bedside medication safety. Alongside national staffing reforms, hospital directorates must formally establish structured AMS rounds within daily ward operations. Through integrating clinical verification tasks into institutional routines, hospital leadership can transform the Five Rights protocol from a voluntary individual practice into a strictly monitored, resourced organizational priority.

Furthermore, regulatory and professional bodies must strengthen continuous training and standardize clinical environments. The Uganda Nurses and Midwives Council, in partnership with local hospital training committees, should implement mandatory continuous professional development modules focusing on clinical safety margins and patient communication. At the institutional level, hospital leadership needs to introduce highly visible bedside tools, such as standardized checklists and visual aids, to streamline verification workflows and buffer nurses against frequent clinical distractions. National Medical Stores (NMS) authorities must also stabilize the distribution of essential medical sundries including functional cannulas, giving sets, and intravenous fluids to eliminate the erratic compensatory practices nurses resort to during resource shortages. Finally, the MoH should direct funding toward multi-center operational research using direct observation to investigate the long-term clinical outcomes and resistance profiles resulting from bedside compliance gaps across the country's regional health networks.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Mbale Regional Referral Hospital Research Ethics Committee (Ref Number: MRRH-REC-039-328-0584). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

PW: Resources, Project administration, Writing – original draft, Formal analysis, Funding acquisition, Validation, Visualization, Data curation, Writing – review & editing, Investigation, Supervision, Conceptualization, Methodology, Software. IP: Writing – original draft, Writing – review & editing. DW: Formal analysis, Validation, Resources, Funding acquisition, Project administration, Writing – review & editing, Methodology, Writing – original draft, Data curation, Conceptualization, Supervision, Software, Visualization, Investigation. AK: Supervision, Resources, Investigation, Writing – review & editing, Conceptualization, Funding acquisition, Project administration, Writing – original draft, Validation, Visualization, Methodology, Software, Data curation, Formal analysis. SM: Resources, Funding acquisition, Conceptualization, Writing – review & editing, Project administration, Validation, Investigation, Methodology, Supervision, Formal analysis, Visualization, Software, Data curation, Writing – original draft. CC: Writing – original draft,

Writing – review & editing. JN: Writing – review & editing, Writing – original draft. MM: Writing – review & editing, Writing – original draft. NM: Validation, Formal analysis, Software, Visualization, Methodology, Data curation, Writing – review & editing, Funding acquisition, Resources, Conceptualization, Investigation, Supervision, Writing – original draft, Project administration.

Funding

The author(s) declared that financial support was not received for this work and/or its publication.

Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that generative AI was not used in the creation of this manuscript.

Any alternative text (alt text) provided alongside figures in this article has been generated by Frontiers with the support of artificial intelligence and reasonable efforts have been made to ensure accuracy, including review by the authors wherever possible. If you identify any issues, please contact us.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

Alem, K., Dagnew, M., Gizachew, M., Gelaw, B., and Moges, F. (2025). Environmental antimicrobial resistance: Key drivers, hotspots, innovative strategies, and challenges in the fight against superbugs. *Microbiol. Open* 14, e70067. doi: 10.1002/mbo3.70067

Alenzi, S. L. O., Alharthi, A. H., Alnefaie, R. A., Alzahrani, A., Alsaadi, O., Albugami, A. N. M., et al. (2026). The global epidemiology of antimicrobial resistance: Trends, determinants, and public health implications. *Cureus* 18. doi: 10.7759/cureus.100784

Ampaire, L., Muhindo, A., Orikiriza, P., Mwanga-Amumpaire, J., Bebell, L., and Boum, Y. (2016). A review of antimicrobial resistance in East Africa. *Afr. J. Lab. Med.* 5, 432. doi: 10.4102/ajlm.v5i1.432

ISMP Guidance and Tools (ECRI ISMP). Available online at: https://home.ecri.org/blogs/ismp-resources (Accessed September 14, 2026).

Bos, M., Schouten, J., De Bot, C., Vermeulen, H., and Hulscher, M. (2023). A hidden gem in multidisciplinary antimicrobial stewardship: A systematic review on bedside nurses' activities in daily practice regarding antibiotic use. *JAC-Antimicrob. Resist.* 5, dlad123. doi: 10.1093/jacamr/dlad123

CDC (2025). *About antimicrobial resistance* (Antimicrob. Resist). Available online at: https://www.cdc.gov/antimicrobial-resistance/about/index.html (Accessed June 27, 2026).

Chang, H.-Y., Lin, Y.-A., Yu, W.-P., Wu, H.-H., Liao, G.-Y., Rudman, A., et al. (2025). Impact of nurses' peak workload and time pressure on work exhaustion and turnover intention. *J. Nurs. Manage.* 2025, 2311721. doi: 10.1155/jonm/2311721

Chinemerem Nwobodo, D., Ugwu, M. C., Oliseloke Anie, C., Al-Ouqaili, M. T. S., Chinedu Ikem, J., Victor Chigozie, U., et al. (2022). Antibiotic resistance: The challenges and some emerging strategies for tackling a global menace. *J. Clin. Lab. Anal.* 36, e24655. doi: 10.1002/jcla.24655

Dadgostar, P. (2019). Antimicrobial resistance: Implications and costs. *Infect. Drug Resist.* 12, 3903–3910. doi: 10.2147/IDR.S234610

Hanson, A., and Haddad, L. M. (2026). "Nursing rights of medication administration," in *Statpearls* (StatPearls Publishing, Treasure Island (FL)).

Haque, M., Sartelli, M., McKimm, J., and Abu Bakar, M. (2018). Health care-associated infections – an overview. *Infect. Drug Resist.* 11, 2321–2333. doi: 10.2147/IDR.S177247

Ho, C. S., Wong, C. T. H., Aung, T. T., Lakshminarayanan, R., Mehta, J. S., Rauz, S., et al. (2025). Antimicrobial resistance: A concise update. *Lancet Microbe* 6. doi: 10.1016/j.lanmic.2024.07.010

Hospital, M.R.R *Mbale Regional Referral Hospital | Health Care for All.* Available online at: https://www.mbalehospital.go.ug/ (Accessed 6.27.26).

Kariuki, S., Kering, K., Wairimu, C., Onsare, R., and Mbae, C. (2022). Antimicrobial resistance rates and surveillance in Sub-Saharan Africa: Where are we now? *Infect. Drug Resist.* 15, 3589–3609. doi: 10.2147/IDR.S342753

Kiggundu, R., Wittenauer, R., Waswa, J., Nakambale, H. N., Kitutu, F. E., Murungi, M., et al. (2022). Point prevalence survey of antibiotic use across 13 hospitals in Uganda. *Antibiotics* 11, 199. doi: 10.3390/antibiotics11020199

Lee, M., Kim, K., Rhew, K., and Choi, K.-H. (2021). A knowledge, attitude, and practice survey on medication safety in Korean older adults: An analysis of an ageing society. *Healthcare* 9, 1365. doi: 10.3390/healthcare9101365

Livermore, D. M. (2004). The need for new antibiotics. *Clin. Microbiol. Infect.* 10, 1–9. doi: 10.1111/j.1465-0691.2004.1004.x

Majumder, M. A. A., Rahman, S., Cohall, D., Bharatha, A., Singh, K., Haque, M., et al. (2020). Antimicrobial stewardship: Fighting antimicrobial resistance and protecting global public health. *Infect. Drug Resist.* 13, 4713–4738. doi: 10.2147/IDR.S290835

Malik, N., and Ahmed, A. (2026). Exploring the impact of antimicrobial resistance on sustainable development goal 3 in low and middle income countries: A scoping review. *J. Glob. Antimicrob. Resist.* 50, 21–30. doi: 10.1016/j.jgar.2026.05.005

Martini, N., Choong, J. W., Dela Cruz, P. D., Lau, H., Lim, H., Liu, R., et al. (2022). Assessing antibiotic prescribing in nurse practitioners: Applied cognitive task analysis. *Int. J. Nurs. Stud. Adv.* 4, 100101. doi: 10.1016/j.ijnsa.2022.100101

Mudenda, S., Chizimu, J. Y., Daka, V., Hangoma, J., Mwangilwa, K., Gardner, P., et al. (2025). Antimicrobial stewardship program implementation, perceptions, and barriers in Zambia: A cross-sectional study among healthcare professionals. *Antibiotics* 14, 1094. doi: 10.3390/antibiotics14111094

Mugenyi, N., Ssewante, N., Baruch Baluku, J., Bongomin, F., Mukenya Irene, M., Andama, A., et al. (2024). Innovative laboratory methods for improved tuberculosis diagnosis and drug-susceptibility testing. *Front. Tuberc.* 1, 1295979. doi: 10.3389/ftubr.2023.1295979

Mula, C. (2019). The examination of nurses' adherence to the 'five rights' of antibiotic administration and factors influencing their practices: A mixed methods case study at a tertiary hospital, Malawi. *Malawi Med. J.* 31, 126. doi: 10.4314/mmj.v31i2.4

Naghavi, M., Vollset, S. E., Ikuta, K. S., Swetschinski, L. R., Gray, A.P., Wool, E. E., Robles Aguilar, G., et al. (2024). Global burden of bacterial antimicrobial resistance 1990–2021: A systematic analysis with forecasts to 2050. *Lancet Lond. Engl.* 404, 1199–1226. doi: 10.1016/S0140-6736(24)01867-1

Namusoosa, R., Mugerwa, I., Kasozi, K. I., Muruta, A., Najjuka, G., Atuhaire, W. D., et al. The epidemiology of antibiotic-resistant clinical pathogens in Uganda. *J. Glob. Health* (2024) 14, 4184. doi: 10.7189/jogh.14.04184

Patra, M., Gupta, A. K., Kumar, D., and Kumar, B. (2025). Antimicrobial resistance: A rising global threat to public health. *Infect. Drug Resist.* 18, 5419–5437. doi: 10.2147/IDR.S530557

Rivera, A. J., and Karsh, B.-T. (2010). Interruptions and distractions in healthcare: Review and reappraisal. *Qual. Saf. Health Care* 19, 304–312. doi: 10.1136/qshc.2009.033282

Salam, M., Al-Amin, M., Salam, M. T., Pawar, J. S., Akhter, N., Rabaan, A. A., et al. (2023). Antimicrobial resistance: A growing serious threat for global public health. *Healthcare* 11, 1946. doi: 10.3390/healthcare11131946

Sartorius, B., Gray, A. P., Davis Weaver, N., Robles Aguilar, G., Swetschinski, L. R., Ikuta, K. S., et al. (2024). The burden of bacterial antimicrobial resistance in the WHO African region in 2019: A cross-country systematic analysis. *Lancet Glob. Health* 12, e201–e216. doi: 10.1016/S2214-109X(23)00539-9

Shobayo, B. I., Lundborg, C. S., Nordenstedt, H., Saleh, H., Babawarun, T., Oyewole, E. A., et al. (2026). Perspectives and challenges of healthcare professionals, patients, and caregivers regarding utilizing antibiotics and implementing antibiotic stewardship in healthcare facilities in low- and middle-income countries: A systematic review of qualitative studies. *Antibiotics* 15, 468. doi: 10.3390/antibiotics15050468

Solanki, S., and Kumar Das, H. (2024). Antimicrobial resistance: Molecular drivers and underlying mechanisms. *J. Med. Surg. Public Health* 3, 100122. doi: 10.1016/j.glmedi.2024.100122

Vaida, A. J. (2015). The Institute for Safe Medication Practices and Poison Control Centers: Collaborating to prevent medication errors and unintentional poisonings. *J. Med. Toxicol.* 11, 262–264. doi: 10.1007/s13181-015-0475-y