Society of Medical Education & Research

2024, Volume 4, Issue 1, Page No: 136-146

ISSN: 3108-4850

Annals of Pharmacy Education, Safety, and Public Health Advocacy

Cross-Sectional Facility-Based Study on Knowledge, Attitudes, and Practices Regarding Antibiotic Use and Antibiotic Resistance among Healthcare Workers in Monrovia, Liberia

Hans Müller[1]*, Anna Schmidt[1], Thomas Weber[2]

[1]Department of Infectious Disease Epidemiology and Antimicrobial Stewardship, Faculty of Health Sciences, University of Liberia, Monrovia, Liberia.

[2]Department of Global Health and Clinical Pharmacy, Faculty of Medicine, LMU Munich, Munich, Germany.

***E-mail** ✉ hans.mueller@uni-bonn.de

Abstract

Antibiotic resistance continues to pose a serious threat to healthcare systems worldwide. Healthcare professionals are directly involved in prescribing, dispensing, and administering antibiotics. This study aimed to assess knowledge, attitudes, and practices regarding antibiotic use and antibiotic resistance among healthcare professionals at a major tertiary hospital in Monrovia, Liberia. Researchers performed a cross-sectional hospital-based survey between January and June 2023. A total of 61 healthcare workers at ELWA Hospital participated. Using purposive sampling, professionals from different roles answered a structured questionnaire focused on antibiotic use and resistance. Data analysis was conducted in SPSS version 25, applying descriptive statistics for participant profiles and inferential statistics to identify relationships among variables. Participants' ages ranged from 20 to 60 years, with an average of 40.7 (± 5). Nurses made up the largest proportion of the sample at 59%. A substantial majority (68.9%) correctly rejected the idea that antibiotics work against viral infections (OR = 0.45; P = 0.020). Still, over one-third (36.1%) thought it was fine to discontinue antibiotics after symptoms disappeared, while 24.6% supported reusing leftover antibiotics (OR = 0.33; P = 0.002). Encouragingly, 72.1% and 70.5% stated that they never take antibiotics for body pain or headaches (OR = 3.67; P = 0.001, and OR = 4.78; P < 0.001, respectively). However, 39.3% reported occasionally or regularly keeping leftover antibiotics at home, and a similar proportion (39.3%) viewed early cessation of antibiotic courses as acceptable (OR = 0.36; P = 0.016).Findings indicate that significant deficiencies remain in healthcare workers' knowledge, attitudes, and practices regarding antibiotic use and antibiotic resistance, despite some areas of good understanding. Widespread misconceptions around stopping treatment prematurely and reusing leftover antibiotics persist. The results underscore the urgent need for targeted educational initiatives and enhanced antibiotic stewardship in Liberian healthcare facilities.

Keywords: Healthcare workers, Knowledge, Attitudes, Practices, Antibiotic use, Antibiotic resistance

Introduction

Following their discovery, antibiotics have become a standard tool for managing infectious diseases, greatly reducing illness-related complications and mortality [1]. However, recent evidence highlights a major public health concern due to the increasing prevalence of antibiotic resistance [2, 3]. The World Health Organization (WHO) [4] lists antimicrobial resistance (AMR) as one of the top 10 global public health threats, with around 700,000 annual deaths attributed to infections caused by antibiotic-resistant (ABR) bacteria [5, 6]. The effects of ABR are particularly pronounced in low- and middle-income countries, where inadequate diagnostic tools and weak stewardship practices encourage inappropriate antibiotic consumption [7-10]. These underlying problems underscore the importance of investigating behavioral elements, especially the actions

Access this article online https://smerpub.com/

Received: 08 March 2024; **Accepted:** 02 July 2024

Copyright CC BY-NC-SA 4.0

How to cite this article: Müller H, Schmidt A, Weber T. Cross-Sectional Facility-Based Study on Knowledge, Attitudes, and Practices Regarding Antibiotic Use and Antibiotic Resistance among Healthcare Workers in Monrovia, Liberia. Ann Pharm Educ Saf Public Health Advocacy. 2024;4(1):136-46. https://doi.org/10.51847/iTiBDhrNOw

and habits of healthcare workers that affect antibiotic use and resistance patterns.

Multiple investigations have shown that knowledge, attitudes, and practices (KAP) regarding antibiotic use are often insufficient among healthcare professionals. This leads to unsuitable prescribing and misuse of these medications. In various settings, healthcare workers demonstrate limited awareness of how antimicrobial resistance develops, proper antibiotic selection, and adherence to clinical guidelines. Attitudes influenced by patient demands and false beliefs regarding antibiotic effectiveness worsen the situation [11-13]. Such shortcomings in KAP directly promote irrational antibiotic use, such as self-treatment, excessive prescribing, and unfinished courses of therapy, all of which speed up the emergence and transmission of resistant bacteria [14]. The outcomes of growing antibiotic resistance are serious, including longer recovery periods, elevated medical expenses, fewer available therapies, and higher rates of illness and death, especially in areas with restricted resources [5, 10].

In Liberia, irrational medication practices stem from broader challenges like frequent reliance on expired drugs and shortages of adequately trained healthcare providers. Dispensaries in many health facilities are often poorly managed, and staff may overlook or fail to refer to standard treatment guidelines and essential medicines lists during prescribing [15]. The rising danger of ABR in the nation creates a significant strain on a health system that is still rebuilding after years of civil unrest and major disease outbreaks [16]. These structural shortcomings limit effective antibiotic stewardship and raise the likelihood of resistant infections throughout healthcare environments [17, 18].

Even so, there is a notable shortage of direct evidence on healthcare professionals' knowledge, attitudes, and practices (KAP) regarding antibiotic use and resistance. The majority of prior research on ABR across sub-Saharan Africa has emphasized laboratory monitoring of microbes and patterns of antibiotic consumption, while paying less attention to the behavioral and organizational drivers of improper antibiotic use by healthcare workers. This information gap limits the development of locally relevant strategies to improve antimicrobial stewardship and inform national policies. Accordingly, the current study sought to evaluate healthcare workers' knowledge, attitudes, and practices regarding antibiotic use and resistance at Eternal Love Winning Africa (ELWA) Hospital in Montserrado County, northwestern Liberia. Results are expected to guide customized training approaches, strengthen facility-level stewardship initiatives, and provide data to assist in updating Liberia's National Action Plan on AMR.

Materials and Methods

Study setting and design

This cross-sectional investigation was conducted from January to June 2023 at ELWA Hospital, a leading tertiary care center in Paynesville, Montserrado County, within Monrovia, the capital of Liberia. With a capacity of at least 250 beds, ELWA Hospital functions as an essential provider of both routine and specialized medical services nationwide. It operates under ELWA Ministries and played an important part in responding to previous health crises [19], notably the Ebola epidemic. The facility includes various departments, including internal medicine, surgery, pediatrics, obstetrics and gynecology, and emergency services, supported by active laboratory and pharmacy services. Its staff includes a wide range of healthcare professionals — doctors, nurses, laboratory technicians, pharmacists, and midwives — who deliver care to a large number of patients from urban and surrounding areas. This environment provides a suitable setting for examining healthcare workers' knowledge and practices related to ABR, particularly given Liberia's increasing focus on infection prevention and control (IPC), antibiotic stewardship, and continued health system improvements following the Ebola crisis.

Study population and sample size

Although ELWA Hospital employs a larger group of healthcare professionals across its units, the researchers selected 61 participants (Nurses – 36, Pharmacists – 8, Doctors – 7, Laboratory technicians – 6, Midwives – 4) based on practical considerations including available time, logistics, and resources. Purposive sampling ensured the inclusion of diverse professional groups — nurses, physicians, laboratory staff, midwives, and pharmacists — to represent the roles most involved in antibiotic use and stewardship. The sample size was drawn from comparable facility-based KAP research, in which groups of 50–100 healthcare workers provided adequate diversity for analysis [20, 21]. The study prioritized detailed understanding over large-scale coverage, relying on structured questionnaires and subgroup analysis to uncover trends in knowledge and conduct among practicing staff. Thus, the group of 61

offered a balanced and realistic approach aligned with the study's goals and setting.

Data collection

The researchers adapted a structured questionnaire from earlier validated tools used to measure KAP on antibiotic use and ABR [22, 23]. Adjustments were made to suit local conditions, and the content was independently evaluated by two experts in pharmacy and public health for appropriateness, clarity, and completeness. Refinements continued until the content validity index (CVI) reached ≥0.70, with the finished version achieving a CVI of 0.79, confirming good content validity [24]. A pilot study with 10 healthcare workers (excluded from the final results) further improved the instrument. Reliability was assessed using Cronbach's alpha, yielding a value of 0.79, indicating acceptable internal consistency.

The completed questionnaire contained 35 items organized into four parts. Section I gathered background details such as age, sex, education level, and job category. Section II featured 12 true/false questions evaluating knowledge of antibiotic use and resistance, with correct answers earning 1 point and incorrect ones earning 0. Some knowledge items were crafted to reveal common misunderstandings about antibiotic use, even when they may contain partial truths in limited medical situations. Respondents were directed to consider the statements in terms of general, non-prescribed, or self-initiated use. For instance, the item "Antibiotics are effective in preventing infectious diseases" was meant to be answered as "False," since antibiotics are not suitable for routine prevention of common infections by individuals and are only recommended for prophylaxis under specific medical oversight (e.g., before certain surgeries). Section III presented 9 statements exploring attitudes toward antibiotic use and ABR, scored on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree) for positive statements, with reverse coding for negative ones. Section IV examined self-reported practices using 10 items, scoring appropriate behaviors from 0 ("never") to 2 ("always") and reverse-scoring inappropriate actions.

Statistical analysis

Data entry occurred in Microsoft Excel 2016, followed by cleaning and checks for accuracy and completeness. Analysis was performed using the Statistical Package for Social Sciences (SPSS) version 25 (IBM, USA). Descriptive statistics summarized frequencies and percentages for categorical data, including participant demographics. Individual KAP items were scored, and overall mean scores were computed and handled as continuous variables in preliminary evaluations. Multivariable logistic regression was applied to investigate the relationships between selected independent factors and higher KAP scores, yielding Odds Ratios (ORs). Responses were converted into binary categories ("Positive Attitude" versus "Negative/Neutral Attitude") based on the preferred direction supported by evidence. For favorable statements (e.g., "Antibiotics should be taken only when prescribed"), "Strongly Agree" or "Agree" indicated a positive attitude. For unfavorable ones (e.g., "It is okay to share leftover antibiotics"), "Strongly Disagree" or "Disagree" counted as positive. The resulting ORs reflected the likelihood that participants would adopt a positive stance toward correct antibiotic use. Statistical significance was determined at $P < 0.05$.

Results and Discussion

Demographic characteristics of study participants

Sixty-one healthcare workers took part in the study. The average age was 40.7 years, with an interquartile range (IQR) of 32–45. Males represented 19 participants (31.1%), while females accounted for 42 (68.9%). Nurses formed the largest group with 36 individuals (59%), followed by pharmacists with 8 (13.1%), doctors with 7 (11.4%), laboratory technicians with 6 (9.8%), and midwives with 4 (6.5%). In terms of education, 28 participants (45.9%) held high school diplomas, 22 (36%) had Bachelor's degrees, and 11 (18%) possessed Master's degrees (**Table 1**).

Table 1. Demographic characteristics of study participants (n = 61)

Variable	Categories	Frequency	Percent
Age (years)	Mean = 40.7 (±5.31); Range: 20–60	—	—
	20–30	9	14.7
	31–40	23	37.7
	41–50	17	27.8

	51–60	12	19.6
Sex	Male	19	31.1
	Female	42	68.9
Highest academic qualification	High school diploma	28	45.9
	Bachelor's degree	22	36.2
	Master's degree	11	18.0
Field of discipline	Nurses	36	59.3
	Pharmacists	8	13.1
	Doctors	7	11.4
	Laboratory technicians	6	9.8
	Midwives	4	6.5

Note: Statistically significant associations are indicated by bold P-values where P < 0.05.

Knowledge of ABR among study participants

When it came to recognizing appropriate antibiotic use, more than two-thirds (70.5%) of the surveyed healthcare workers correctly rejected the claim that antibiotics can prevent infectious diseases. This accurate view was notably associated with higher overall knowledge scores (Odds Ratio [OR] = 0.42; 95% Confidence Interval [CI]: 0.21–0.83; p = 0.012). Similarly, 68.9% opposed the idea that antibiotics can treat viral infections (P = 0.020). On the other hand, more than a third (36.1%) wrongly assumed treatment could safely end once symptoms eased, while an identical share thought antibiotics were useful for lowering fever or handling allergies. Roughly one-quarter of the group (24.6%) endorsed reusing leftover antibiotics, and holding this view was clearly associated with lower knowledge scores (OR = 0.33; P = 0.002) (**Table 2**).

Table 2. Participants' knowledge regarding antibiotic use and antimicrobial resistance (n = 61)

Statement	"True" response n (%)	"False" response n (%)	Correct response
Antibiotics can help prevent infectious diseases.	18 (29.5%)	43 (70.5%)	False
Antibiotics are useful for treating fever and allergic reactions.	22 (36.1%)	39 (63.9%)	False
Antibiotics are effective against infections caused by viruses.	19 (31.1%)	42 (68.9%)	False
Antibiotics are appropriate for treating bacterial infections.	55 (90.2%)	6 (9.8%)	True
Antibiotic therapy can be stopped once symptoms resolve.	22 (36.1%)	39 (63.9%)	False
Antibiotics may be taken for extended periods without harmful effects.	7 (11.5%)	54 (88.5%)	False
Lower doses of antibiotics require more time to achieve recovery.	31 (50.8%)	30 (49.2%)	True
Previously used antibiotics can be saved for future similar illnesses.	15 (24.6%)	46 (75.4%)	False
Not completing a prescribed antibiotic course can lead to antibiotic resistance.	47 (77.0%)	14 (23.0%)	True
Resistant bacteria can be transmitted between individuals.	52 (85.2%)	9 (14.8%)	True
Antibiotic resistance only affects individuals who consume antibiotics.	6 (9.8%)	55 (90.2%)	False
When bacteria become resistant, treating the resulting infections becomes challenging.	56 (91.8%)	5 (8.2%)	True

Attitude towards antibiotic use and ABR

Roughly 18% of the healthcare workers surveyed (11.5% agreeing and 6.6% strongly agreeing) felt it was acceptable to pass leftover antibiotics to others. Meanwhile, 39.3% agreed or strongly agreed that ending antibiotic treatment early when symptoms subside is harmless. This particular view was significantly associated with less favorable attitudes toward antibiotic use (OR = 0.36; P = 0.016). Only a small fraction (8.2%) showed skepticism toward how healthcare workers decide on prescriptions. Most participants opposed allowing pharmacists to dispense antibiotics without a doctor's order, with 68.8% disagreeing or strongly disagreeing with that practice (OR = 0.20; 95% CI: 0.07–0.54; P = 0.002). Fewer than one in four (14.7%) endorsed the incorrect belief that antibiotic resistance

mainly harms only those who misuse the drugs (**Table 3**).

Table 3. Attitudes regarding antibiotic consumption and antibiotic resistance among respondents (n = 61)

Statement	Strongly agree	Agree	Unsure	Disagree	Strongly disagree	OR (positive attitude)	95% CI	P-value
Antibiotics should be used only when prescribed by a medical doctor.	35 (57.4%)	20 (32.8%)	3 (4.9%)	2 (3.3%)	1 (1.6%)	27.50	6.21–121.8	**< 0.001**
Sharing unused antibiotics with relatives or friends who have similar symptoms is acceptable.	2 (3.3%)	5 (8.2%)	4 (6.6%)	25 (41.0%)	25 (41.0%)	0.14	0.04–0.45	0.061
Discontinuing antibiotic therapy once symptoms improve is considered safe practice.	4 (6.6%)	12 (19.7%)	8 (13.1%)	22 (36.1%)	15 (24.6%)	0.36	0.16–0.83	**0.016**
Patients should be counseled on completing their antibiotic course whenever antibiotics are prescribed or dispensed.	5 (8.2%)	14 (23.0%)	10 (16.4%)	20 (32.8%)	12 (19.7%)	0.66	0.30–1.19	0.087
Antibiotic resistance represents a major threat to public health.	40 (65.6%)	15 (24.6%)	3 (4.9%)	2 (3.3%)	1 (1.6%)	55.00	11.3–267.9	<0.501
I believe healthcare professionals prescribe antibiotics appropriately.	25 (41.0%)	26 (42.6%)	5 (8.2%)	3 (4.9%)	2 (3.3%)	17.33	5.02–59.8	<0.056
Antibiotics should be available over the counter for easy access without a prescription.	3 (4.9%)	7 (11.5%)	9 (14.8%)	24 (39.3%)	18 (29.5%)	0.20	0.07–0.54	**0.002**
Antibiotic resistance occurs only in individuals who misuse antibiotics.	4 (6.6%)	9 (14.8%)	12 (19.7%)	22 (36.1%)	14 (23.0%)	0.30	0.12–0.74	0.082
Training of healthcare workers on antibiotic resistance and proper antibiotic use is necessary.	28 (45.9%)	22 (36.1%)	6 (9.8%)	3 (4.9%)	2 (3.3%)	0.31	0.16–0.83	**0.076**

Note: Bolded p-values indicate statistically significant associations (P < 0.05).

Practices regarding antibiotic use and antimicrobial resistance (ABR)

Most participants reported never taking antibiotics to treat body aches (72.1%) or headaches (70.5%). These habits were strongly linked to safer overall antibiotic behaviors (odds ratios of 3.67 and 4.78; P = 0.001 and P < 0.001, respectively). Although these are positive results, nearly 39.3% reported sometimes or often saving leftover antibiotics. In addition, 77.0% regularly followed infection prevention and control measures (P < 0.001). Nevertheless, 16.4% said they always throw antibiotics away in the ordinary household trash, revealing a continuing shortfall in proper medication disposal (**Table 4**).

Table 4. Antibiotic use practices and behaviors related to antibiotic resistance among participants (n = 61)

Practice statement	Always	Sometimes	Never	OR (Safe practice)	95% CI	P-value
Use of antibiotics for relieving general body aches	5 (8.2%)	12 (19.7%)	44 (72.1%)	3.67	1.72–7.82	**0.001**

Consumption of antibiotics for treating headaches	3 (4.9%)	15 (24.6%)	43 (70.5%)	4.78	2.12–10.78	**< 0.001**
Premature discontinuation of antibiotics once symptoms improve	8 (13.1%)	20 (32.8%)	33 (54.1%)	1.65	0.86–3.17	0.132
Retaining unused antibiotics for possible later use	6 (9.8%)	18 (29.5%)	37 (60.7%)	2.06	1.03–4.10	**0.040**
Obtaining antibiotics without a medical prescription	5 (8.2%)	14 (23.0%)	42 (68.9%)	3.00	1.42–6.33	0.124
Following physician/pharmacist instructions when taking antibiotics	50 (82.0%)	8 (13.1%)	3 (4.9%)	0.06	0.02–0.20	0.153
Reviewing antibiotic instructions on labels before consumption	35 (57.4%)	20 (32.8%)	6 (9.8%)	0.30	0.12–0.75	0.061
Disposal of leftover antibiotics along with household waste	10 (16.4%)	23 (37.7%)	28 (45.9%)	0.57	0.28–1.15	0.116
Compliance with infection prevention protocols in healthcare settings	47 (77.0%)	10 (16.4%)	4 (6.5%)	0.04	0.01–0.15	**< 0.001**
Adherence to standard therapeutic guidelines during antibiotic use or administration	41 (67.2%)	9 (14.7%)	11 (18.0%)	0.38	0.18–0.81	**0.012**

Association between demographic factors and knowledge of antibiotic use and ABR

The examination of variables linked to a thorough understanding of antibiotic use and resistance identified multiple notable relationships. Individuals with a Bachelor's degree had markedly higher odds of demonstrating accurate knowledge relative to those with only a high school education. Likewise, doctors were significantly more likely to possess correct knowledge than nurses. Age also played a role, with respondents aged 31–40 years showing higher odds of good knowledge than those in the younger 20–30 age group. In contrast, female participants had significantly lower odds of achieving high knowledge scores than males. No statistically significant associations were found in other educational levels, age brackets, or professional disciplines (**Table 5**).

Table 5. Relationship between socio-demographic factors and level of correct knowledge on antibiotic use and antibiotic resistance

Variable	Category	Odds ratio (OR)	95% confidence interval	P-value
Age (years)	20–30 (Reference group)	1.00	—	—
	31–40	2.45	1.12–5.78	**0.032**
	41–50	1.32	0.85–2.91	0.214
	51–60	1.05	0.61–2.34	0.887
Sex	Male (Reference group)	1.00	—	—
	Female	0.42	0.21–0.79	**0.005**
Educational level	High school diploma (Reference group)	1.00	—	—
	Bachelor's degree	3.10	1.65–6.12	**0.001**
	Master's degree	1.85	0.92–3.98	0.083
Professional category	Nurses (Reference group)	1.00	—	—
	Pharmacists	1.90	0.78–4.12	0.156
	Physicians	3.55	1.52–7.89	**0.018**
	Laboratory technicians	1.22	0.55–2.98	0.674
	Midwives	0.85	0.31–2.11	0.721

Note: Bolded P-values indicate statistically significant associations (P < 0.05).

Healthcare professionals play a central role in limiting the emergence and spread of antimicrobial resistance by educating patients, preventing infections in clinical environments, and ensuring appropriate prescribing, dispensing, and administration of antibiotics [24, 25]. This study aimed to evaluate healthcare workers' knowledge of antimicrobial resistance and related issues. The findings are outlined below.

The average age of respondents was 40.7 years, indicating a relatively experienced workforce. Most

participants were female (68.9%), and nurses represented the largest professional group (59%). These demographic patterns are consistent with findings from other sub-Saharan African studies, in which nursing staff and female workers dominate the healthcare workforce [11, 26]. Educational attainment varied considerably, with nearly half of the participants reporting only a high school qualification. This is an important observation, as previous research has demonstrated that higher educational levels are strongly associated with a better understanding and more appropriate antibiotic use [27, 28].

A large proportion of participants (70.5%) correctly rejected the idea that antibiotics prevent infectious diseases, and 68.9% understood that antibiotics are ineffective against viral infections, indicating a generally solid baseline knowledge of appropriate antibiotic use. These results compare favorably with a WHO multi-country survey in which 64% of respondents incorrectly believed antibiotics were effective against viral illnesses such as colds and influenza [29]. Similarly, research among university students in Saudi Arabia found substantial misconceptions, including the belief that antibiotics work against viral infections and that viruses can become resistant to antibiotics [30]. Despite this, some misconceptions persisted in the present study, as 36.1% of participants still believed that antibiotics could reduce fever and allergic symptoms, or that antibiotics could be stopped once symptoms improve. Comparable misunderstandings have been reported in European studies, even among healthcare professionals [31]. Such incorrect beliefs are concerning because they may contribute to early discontinuation of therapy and inappropriate prescribing practices, both of which drive antimicrobial resistance [29, 32]. The coexistence of accurate knowledge and persistent misconceptions highlights the need for targeted educational strategies that address not only facts but also entrenched beliefs and behaviors.

In addition, 24.6% of respondents believed leftover antibiotics could be reused, while 18% considered sharing antibiotics with others acceptable. Furthermore, 39.3% agreed that stopping antibiotics once symptoms improve is safe, and this perception was significantly linked to poorer attitudes toward appropriate antibiotic use. Similar patterns have been documented globally. For example, a United States survey found that 26% of adults used leftover antibiotics, and many intended to do so again for convenience [33]. In Canada, 73% of parents who stored leftover antibiotics reported sharing them [34]. In the United Kingdom, premature discontinuation of antibiotic therapy has also been widely observed despite clinical recommendations [35]. Although recent evidence suggests shorter antibiotic courses may be appropriate for certain conditions, treatment decisions should remain clinically guided and aligned with WHO recommendations [36]. These findings emphasize the continued importance of antimicrobial stewardship education, even among healthcare professionals.

Notably, 91.8% of participants recognized that antibiotic-resistant infections are more difficult to treat and agreed that antimicrobial resistance can affect all individuals, not only those who misuse antibiotics. This demonstrates a strong foundational understanding. In contrast, global studies still report widespread misconceptions, such as the belief that antibiotics treat viral infections or that resistance is limited to those who misuse antibiotics [31]. For instance, a Saudi Arabian study found that over half of respondents held incorrect views about viral resistance mechanisms [30]. In the current study, only 14.7% believed antimicrobial resistance affects only antibiotic misusers, reflecting a comparatively accurate understanding. This aligns with WHO explanations that resistance spreads broadly through healthcare systems, food chains, and the environment [7]. The relatively high awareness observed here may reflect prior training or stewardship initiatives, underscoring the importance of continued education.

Regarding self-medication practices, 72.1% of participants reported not using antibiotics for body pain, and 70.5% avoided using them for headaches. This reflects generally appropriate practice. These findings contrast with research among healthcare students in Rwanda, where half believed antibiotics were suitable for pain management [37]. Similarly, studies in Kenya and across African hospitals have reported frequent empirical antibiotic use, including for non-bacterial conditions [38, 39]. Compared with these reports, the present findings suggest more cautious antibiotic use, possibly due to professional experience or institutional stewardship efforts.

The study also found that 39.3% of participants stored leftover antibiotics, while 16.4% disposed of them in household waste. Similar unsafe disposal practices have been documented in low- and middle-income countries. In Kenya, more than half of respondents kept antibiotics for future use, and many disposed of them through environmentally unsafe methods [40]. In Tanzania, most

households discarded unused medicines in domestic waste or latrines [41]. Such practices contribute to environmental contamination and the spread of resistant organisms [42, 43]. In contrast, countries with structured drug return systems, such as the United Kingdom, have reported improved disposal behaviors following pharmacy-led interventions [44]. These findings highlight the need for strengthened public education and formal medication disposal systems.

The study further revealed that 77% of participants adhered consistently to infection prevention and control (IPC) measures. This is encouraging and consistent with global evidence showing that strong IPC compliance reduces hospital-acquired infections and antimicrobial resistance transmission. However, this rate is higher than that reported in The Gambia, where compliance was below 50% [45], and in a multi-country African study, where average compliance ranged from 56.8% to 62.3% [46]. Nevertheless, improvement initiatives in East Africa have demonstrated that IPC adherence can exceed 90% with structured training and quality improvement programs [47]. These comparisons indicate that while current performance is positive, further improvements remain achievable. Continued reinforcement of IPC training and institutional support is therefore essential.

Overall, this study contributes important evidence on antimicrobial use and resistance among healthcare workers in Liberia, a context where data are limited. It highlights both strengths—such as strong IPC adherence and good awareness of antimicrobial resistance—and weaknesses, including persistent misconceptions and inappropriate antibiotic practices. These findings provide a foundation for designing targeted interventions to improve stewardship.

Regression analysis showed that doctors had significantly higher knowledge than nurses (OR: 3.55), consistent with findings from Nigeria and India, where prescribing responsibilities and pharmacological training contribute to greater knowledge [48-50]. Similarly, higher education level (Bachelor's degree) was strongly associated with better knowledge (OR: 3.10), in line with studies from Saudi Arabia [51, 52]. However, the finding that female healthcare workers had lower knowledge (OR: 0.42) contrasts with studies from Egypt and Nepal, which reported no difference or higher female knowledge [53, 54]. This suggests that gender-related disparities may depend on contextual and institutional factors. The highest knowledge levels observed among the 31–40 years age group align with evidence that professional experience strengthens applied knowledge over time [55]. Overall, these findings indicate that educational interventions should be tailored rather than generalized.

Although the study was conducted at a single facility with a relatively small sample, efforts were made to include participants from diverse professional backgrounds to improve representativeness. Nevertheless, selection bias cannot be excluded. Additionally, self-reported responses may be influenced by social desirability bias, although confidentiality measures were implemented to reduce this effect.

Conclusion

In conclusion, while healthcare workers generally demonstrated good knowledge and positive attitudes toward antibiotic use, important gaps persist in practice, particularly regarding leftover antibiotics, premature discontinuation of therapy, and unsafe disposal. The study fills a key evidence gap in Liberia and emphasizes the need for continuous professional development, stronger antimicrobial stewardship training, and improved institutional and national policies. It also provides baseline data that can support future interventions aimed at strengthening healthcare workers' knowledge and practices regarding antimicrobial resistance.

Acknowledgments: None

Conflict of Interest: None

Financial Support: None

Ethics Statement: None

References

1. Sakeena MHF, Bennett AA, Jamshed S, Mohamed F, Fathima F, Azhar S, et al. Investigating knowledge regarding antibiotics and antimicrobial resistance among pharmacy students in Sri Lankan universities. BMC Infect Dis. 2018;18:209.
2. Chukwu EE, Oladele DA, Awoderu OB, Afocha EE, Lawal RF, Olorunfemi O, et al. A national survey of public awareness of antimicrobial resistance in Nigeria. Antimicrob Resist Infect Control. 2020;9(1):72.

3. Marston BJ, Dokubo EK, van Steelandt A, Martel L, Williams D, Hersey S, et al. Ebola response impact on public health programs, West Africa, 2014–2017. Emerg Infect Dis. 2017;23(Suppl 1):S25-32.
4. World Health Organization. 10 global health issues to track in 2021. Available from: https://www.who.int/news-room/spotlight/10-global-health-issues-to-track-in-2021. Accessed October 1, 2023.
5. O'Neill J. Tackling drug-resistant infections globally: final report and recommendations. Government of the United Kingdom; 2016. Available from: https://apo.org.au/node/63983. Accessed September 25, 2023.
6. European Commission. EU action on antimicrobial resistance. 2023. Available from: https://health.ec.europa.eu/antimicrobial-resistance/eu-action-antimicrobial-resistance_en. Accessed September 25, 2023.
7. Ahmed SK, Hussein S, Qurbani K, Ibrahim RH, Fareed A, Ali YM, et al. Antimicrobial resistance: impacts, challenges, and future prospects. J Med Surg Public Health. 2024;2:100081.
8. World Bank. Drug-resistant infections: a threat to our economic future. Available from: https://www.worldbank.org/en/topic/health/publication/drug-resistant-infections-a-threat-to-our-economic-future. Accessed July 14, 2025.
9. Serra-Burriel M, Keys M, Campillo-Artero C, Agodi A, Barchitta M, Gikas A, et al. Impact of multi-drug resistant bacteria on economic and clinical outcomes of healthcare-associated infections in adults: systematic review and meta-analysis. PLoS One. 2020;15(1):e0227139.
10. Murray CJ, Ikuta KS, Sharara F, Swetschinski L, Robles Aguilar G, Gray A, et al. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. Lancet. 2022;399(10325):629-55.
11. Auta A, Hadi MA, Oga E, Adewuyi EO, Abdu-Aguye SN, Adeloye D, et al. Global access to antibiotics without prescription in community pharmacies: a systematic review and meta-analysis. J Infect. 2019;78(1):8-18.
12. Ayukekbong JA, Ntemgwa M, Atabe AN. The threat of antimicrobial resistance in developing countries: causes and control strategies. Antimicrob Resist Infect Control. 2017;6(1):47.
13. Gebre M, Uddin MF, Duke T, Hailu T, Mulugeta A, Worku B, et al. Perception and experience of clinicians and caregivers in treating childhood severe pneumonia and hypoxemia using bubble continuous positive airway pressure in Ethiopian tertiary and general hospitals. PLoS One. 2022;17(10):e0275952.
14. Khan MS, Hutchison C, Coker RJ, Aung ST, Kyaw KW, Myint T, et al. Preventing emergence of drug resistant tuberculosis in Myanmar's transitioning health system. Health Policy Plan. 2017;32(suppl_2):i43-50.
15. Harris JT. Assessing the Rational Use of Essential Medicines in Public Health Facilities Montserrado County, Liberia [Thesis]. Muhimbili University of Health and Allied Sciences; 2012.
16. World Health Organization Regional Office for Africa. Guarding against antimicrobial resistance in Liberia. 2025. Available from: https://www.afro.who.int/news/guarding-against-antimicrobial-resistance-liberia. Accessed July 6, 2025.
17. Liberia Medicines & Health Products Regulatory Authority (LMHRA). Pharmacovigilance Regulations. Available from: https://www.lmhra.gov.lr/new/pg_img/25_05_28_PV%20Regulations_LMHRA_JG.pdf. Accessed July 6, 2025.
18. Ministry of Health, Liberia. National Standard Therapeutic Guidelines and Essential Medicines List (lbr-mn-78-02-guideline-2017-eng). 2017.
19. Beaubien J. Startling Statistic: only 8 Patients In Largest Ebola Hospital. TPR; 2014. Available from: https://www.tpr.org/2014-12-03/startling-statistic-only-8-patients-in-largest-ebola-hospital. Accessed July 6, 2025.
20. Anargh V, Singh H, Kulkarni A, Kotwal A, Mahen A. Hand hygiene practices among health care workers (HCWs) in a tertiary care facility in Pune. Med J Armed Forces India. 2013;69(1):54-6.
21. ActivityInfo. Sample size calculator for needs assessments and KAP surveys. Available from: https://www.activityinfo.org/support/docs/sampling/snapshot.html. Accessed July 6, 2025.
22. Lawshe CH. A quantitative approach to content validity. Personnel Psychol. 1975;28(4):563-75.
23. Mudenda S, Bumbangi FN, Yamba K, Munyeme M, Mwila C, Mukonka V, et al. Drivers of antimicrobial resistance in layer poultry farming: evidence from

high prevalence of multidrug-resistant Escherichia coli and enterococci in Zambia. Vet World. 2023;16(9):1803-14.
24. Cane J, O'Connor D, Michie S. Validation of the theoretical domains framework for use in behaviour change and implementation research. Implement Sci. 2012;7(1):37.
25. Umscheid CA, Mitchell MD, Doshi JA, Agarwal R, Williams K, Brennan PJ. Estimating the proportion of healthcare-associated infections that are reasonably preventable and the related mortality and costs. Infect Control Hosp Epidemiol. 2011;32(2):101-14.
26. Precha N, Sukmai S, Hengbaru M, Waleewong O, Sringernyuang L, Thavorn K, et al. Knowledge, attitudes, and practices regarding antibiotic use and resistance among health science and non-health science university students in Thailand. PLoS One. 2024;19(1):e0296822.
27. Abbo LM, Cosgrove SE, Pottinger PS, Pereyra M, Khandelwal A, Braun B, et al. Medical students' perceptions and knowledge about antimicrobial stewardship: how are we educating our future prescribers? Clin Infect Dis. 2013;57(5):631-8.
28. Li P, Hayat K, Shi L, Chang J, Yang C, Liu M, et al. Knowledge, attitude, and practices of antibiotics and antibiotic resistance among Chinese pharmacy customers: a multicenter survey study. Antibiotics. 2020;9(4):184.
29. Estany-Gestal A, Salgado-Barreira A, Vazquez-Lago JM. Antibiotic use and antimicrobial resistance: a global public health crisis. Antibiotics. 2024;13(9):900.
30. Albadrani RK, Alyenbawi AH, Albalawi M, Alsubhi A, Alharbi B, Alharbi R, et al. Assessment of knowledge, attitudes, and practices of antibiotic resistance among university students in Saudi Arabia. BMC Res Notes. 2025;18(1):161.
31. Jones ASK, Chan AHY, Beyene K, Mehta R, Saeed B, Ahmed A, et al. Beliefs about antibiotics, perceptions of antimicrobial resistance, and antibiotic use: initial findings from a multi-country survey. Int J Pharm Pract. 2024;32(1):21-8.
32. Chalkidou A, Lambert M, Cordoba G, Taxis K, Hansen MP, Bjerrum L. Misconceptions and knowledge gaps on antibiotic use and resistance in four healthcare settings and five European countries—a modified Delphi study. Antibiotics. 2023;12(9):1435.
33. Shah J, Trautner BW, Olmeda K, Perez A, Patel S, Martinez N, et al. A survey of patient practices regarding leftover antibiotics reveals a potential source of antibiotic overuse. Antimicrob Agents Chemother. 2024;68(8):e0046924.
34. Russell Publishing Ltd. Many families share leftover antibacterial drugs. PharmacoEcon Outcomes News. 2018;816(1):19.
35. Borek A, Ledda A, Pouwels K, Butler CC, Tonkin-Crine S, Walker AS, et al. Stop antibiotics when you feel better? Opportunities, challenges and research directions. JAC Antimicrob Resist. 2024;6(5):dlae147.
36. World Health Organization. Antimicrobial resistance. Available from: https://www.who.int/health-topics/antimicrobial-resistance. Accessed July 6, 2025.
37. Nisabwe L, Brice H, Umuhire MC, Niyonzima C, Niyonsenga J, Mbarusha I, et al. Knowledge and attitudes towards antibiotic use and resistance among undergraduate healthcare students at University of Rwanda. J Pharm Policy Pract. 2020;13:7.
38. Kiener M, Ichura C, Ndenga BA, Mutuku FM, Bisanzio D, Kitron U, et al. Antibiotic prescribing patterns at outpatient clinics in Western and Coastal Kenya. PLOS Glob Public Health. 2025;5(1):e0004109.
39. Abubakar U, Salman M. Antibiotic use among hospitalized patients in Africa: a systematic review of point prevalence studies. J Racial Ethn Health Disparities. 2024;11(3):1308-29.
40. Karimi KJ, Ngumba E, Ahmad A, Gachanja A, Kariuki S, Ojwang P, et al. Contamination of groundwater with sulfamethoxazole and antibiotic resistant Escherichia coli in informal settlements in Kisumu, Kenya. PLoS Water. 2023;2(4):e0000076.
41. Marwa KJ, Mcharo G, Mwita S, Katabalo D, Ruganuza D, Kapesa A. Disposal practices of expired and unused medications among households in Mwanza, Tanzania. PLoS One. 2021;16(2):e0246418.
42. Apreja M, Sharma A, Balda S, Kataria K, Capalash N, Sharma P. Antibiotic residues in environment: antimicrobial resistance development, ecological risks, and bioremediation. Environ Sci Pollut Res. 2022;29(3):3355-71.

43. EBSCO Research Starters. Antibiotics as environmental waste. Available from: https://www.ebsco.com/research-starters/environmental-sciences/antibiotics-environmental-waste. Accessed July 6, 2025.
44. Hamilton RA, Ercolani MG, Aggarwal R, Brown C, Smith A, Taylor D, et al. Evaluation of antibiotics returned for safe disposal during and after a community pharmacy antibiotic amnesty campaign. JAC Antimicrob Resist. 2024;6(5):dlae172.
45. Darboe SMK, Darfour-Oduro SA, Kpene GE, Jallow S, Bah A, Touray K, et al. Factors influencing healthcare workers' perceived compliance with infection prevention and control standards, North Bank East region, The Gambia, a cross-sectional study. BMC Res Notes. 2025;18(1):43.
46. Kabego L, Balde T, Barasa D, Mwangi J, Ndaye A, Ochieng M, et al. Analysing the implementation of infection prevention and control measures in health care facilities during the COVID-19 pandemic in the African Region. BMC Infect Dis. 2023;23(1):824.
47. Kassa G, Ogongo I, Rabkin M, Mwangi P, Kariuki S, Ouma D, et al. The East Africa Infection Prevention and Control (IPC) learning network: an approach to improving IPC competencies and practices during the COVID-19 pandemic, 2020–2023. Clin Infect Dis. 2025;81(1):41-8.
48. Abubakar B, Sárváry A. Knowledge, attitude, and practice on antibiotics use among healthcare workers: a cross-sectional study in Niger state, Nigeria. J Infect Prev. 2023;24(5):206-15.
49. Manga MM, Mohammed Y, Suleiman S, Bello A, Ibrahim H, Abubakar I, et al. Antibiotic prescribing habits among primary healthcare workers in Northern Nigeria: a concern for patient safety in the era of global antimicrobial resistance. PAMJ One Health. 2021;5:19.
50. Trikha S, Dalpath SK, Sharma M, Shafiq N. Antibiotic prescribing patterns and knowledge of antibiotic resistance amongst the doctors working at public health facilities of a state in northern India: a cross sectional study. J Family Med Prim Care. 2020;9(8):3937-43.
51. Nukaly HY, Aljuhani RA, Alhartani MM, Althubaiti AA, Alharbi NS, Alghamdi A, et al. Knowledge of antibiotic use and resistance among medical students in Saudi Arabia. Adv Med Educ Pract. 2024;15:501-12.
52. Alshehri AA, Khawagi WY. Knowledge, awareness, and perceptions towards antibiotic use, resistance, and antimicrobial stewardship among final-year medical and pharmacy students in Saudi Arabia. Antibiotics. 2025;14(2):116.
53. Maarouf L, Amin M, Evans BA, Abouelfetouh A. Knowledge, attitudes and behaviour of Egyptians towards antibiotic use in the community: can we do better? Antimicrob Resist Infect Control. 2023;12:50.
54. Yunita SL, Yang HW, Chen YC, Hsu YC, Li CY, Hsu CH, et al. Knowledge and practices related to antibiotic use among women in Malang, Indonesia. Front Pharmacol. 2022;13:1019303.
55. Baillie EJ, Merlo G, Van Driel ML, Magin PJ, Hall L. Early-career general practitioners' antibiotic prescribing for acute infections: a systematic review. J Antimicrob Chemother. 2024;79(3):512-25.