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A Cross-Sectional Study Evaluating the Contribution of Systems and Structures to Tackling Antimicrobial Resistance (AMR) in Three Selected University Teaching Hospital Complexes in Sierra Leone: An Analysis of Key Factors

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Abstract

Antimicrobial Resistance (AMR) is a global security threat that poses a significant risk to humanity. Addressing AMR requires effective organizations and processes. This study investigates the systems and structures that may contribute to tackling AMR in three Sierra Leonean University Teaching Hospital Complexes.The hospitals were selected based on their high patient load and availability of laboratory facilities for AMR testing, pharmaceuticals, and infection prevention and control (IPC) programs. Healthcare administrators and unit leaders were interviewed using a standardized questionnaire. The reliability of the questionnaires was assessed using Cronbach's alpha coefficient. The questionnaire was pretested to ensure its validity and reliability. The findings indicate that nurses constitute a significant portion of the health workforce in the three institutions. PCMH Hospital showed the best monitoring system, covering 78% of the essential components, including, IPC guidelines, antibiotic stock verification and waste and antibiotic disposal monitoring. Connaught Hospital also met 56% of these requirements. The study showed a significant correlation between hospital bed capacity and the average patient volume ($p < 0.05$), with higher bed capacities resulting in higher patient volume. In addition, the correlation analysis revealed a significant association between effective monitoring mechanisms and the presence of an antibiotic stewardship program ($p < 0.05$).

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Furthermore, the availability of laboratory departments significantly influenced microbiological culture and sensitivity testing capabilities ($p < 0.05$), with a higher number of departments resulting in more efficient microbiological testing for antibiotic resistance. This study highlights the importance of enhancing the systems and structures of hospitals, to effectively combat AMR.

Keywords : *Antimicrobial, Resistance, Structures, Systems, University Teaching Hospital.*

Introduction

Antimicrobial resistance (AMR) is a critical global health threat, recognized as one of the most significant challenges to public health by the World Health Organization [1, 2]. The spread of resistant bacteria poses a threat to global health. AMR poses à danger to decades of progress in lowering infectious disease morbidity and mortality [3]. According to a recent study, 4.95 millions AMR-related deaths are expected worldwide in 2019, with 27.3 deaths per 100,000 people in Western Sub-Saharan Africa [4]. AMR is characterized by microorganisms, including bacteria, viruses, fungi, and parasites, becoming resistant to antimicrobial drugs that were once effective in treating infections. The overuse and misuse of these drugs, as well as inadequate infection prevention and control practices in healthcare settings, have been identified as key factors contributing to the development and spread of AMR, [5, 6] Although resistant strains are natural, the abuse of drugs has aggravated the problem. Irrational antimicrobial use, such as antibiotic overuse, misuse, and underuse, drives AMR [7, 8]. With several studies confirming that AMR rates are higher in countries where antimicrobial drugs are used more often [8-10]. Kanu and colleagues found increased ciprofloxacin, metronidazole, and benzylpenicillin consumption (11). The prevalence of antibiotic use in the outpatient setting in Sierra Leone is 31.8%. Overall antibiotic consumption was 55.3 defined daily doses (DDDs) per 1000 outpatient-days, access antibiotics accounted for 38.6 DDDs per 1000 outpatient-days (69.8%). Reserve antibiotics were not prescribed, probably because they were not Regions Aantibiotic use and consumedption in Freetown, Sierra Leone : Monitoring antibiotic consumption is crucial to tackling antimicrobial resistance. However, currently there is no system in Sierra Leone for recording and reporting on antibiotic consumption. Several factors have been identified as contributing to the emergence of AMR in Sierra Leone, including inadequate regulation and control of the use of antimicrobial drugs, limited awareness and education among healthcare professionals and patients, and inadequate infection prevention and control practices (IPC) in healthcare facilities [14].

Inadequate laboratory infrastructures, capacities and human resources negatively affect the rational use of antimicrobial agents.

The challenge of AMR is particularly pronounced in low- and middle-income countries (LMICs) such as Sierra Leone, where healthcare resources are often limited, and healthcare systems are weak. The emergence and spread of AMR in these settings may result in increased morbidity, mortality, and healthcare costs. Furthermore, the loss of effective antimicrobial drugs can compromise the management of other infectious diseases, such as malaria, HIV/AIDS, and tuberculosis, which are significant health concerns in LMICs [12]. To address the challenge of AMR, a comprehensive approach is necessary, entailing the improvement of antimicrobial prescribing practices, strengthening of IPC measures and enhancement of laboratory capacity for AMR surveillance. Alongside these efforts, there is a need for heightened awareness and education among healthcare professionals and the public about the implications and risks of AMR. Coordination among all stakeholders, including

policymakers, healthcare providers, patients, and the pharmaceutical industry, is crucial to tackling AMR [15].

This cross-sectional study aims to evaluate the systems and structures that may contribute to the tackling of AMR in three selected University Teaching Hospital Complexes (Connaught Hospital Princess Christiana Maternity Hospital-PCMH, and Ola During Children's Hospital – ODCH) in Sierra Leone. The study seeks to assess the availability of antimicrobial stewardship programs, IPC measures, laboratory capacity for AMR surveillance, and pharmaceutical services towards AMR. The findings of this study will be valuable in identifying the existing gaps in the current systems and structures for tackling AMR in healthcare facilities in Sierra Leone. The results will also inform the development of interventions aimed at improving the management and control of AMR in the country. Ultimately, this study seeks to contribute to the global efforts to combat the threat of AMR and ensure the availability of effective antimicrobial drugs for generations to come.

Materials and Methods

Study Design

This study is a cross-sectional study design, which involved a one-time collection of data from a sample of healthcare workers and hospitals.

Study Population

The study population includes healthcare workers who are involved in the management of patients and healthcare administration in three selected University Teaching Hospital Complexes in Sierra Leone. The healthcare workers included in this study were doctors, nurses, laboratory personnel, and pharmacy professionals.

Study Site

The study was conducted in three University Teaching Hospital Complexes in Sierra Leone, selected based on their high patient load and the availability of laboratory facilities for AMR testing, pharmaceutical services, and the IPC program (Figure 1).

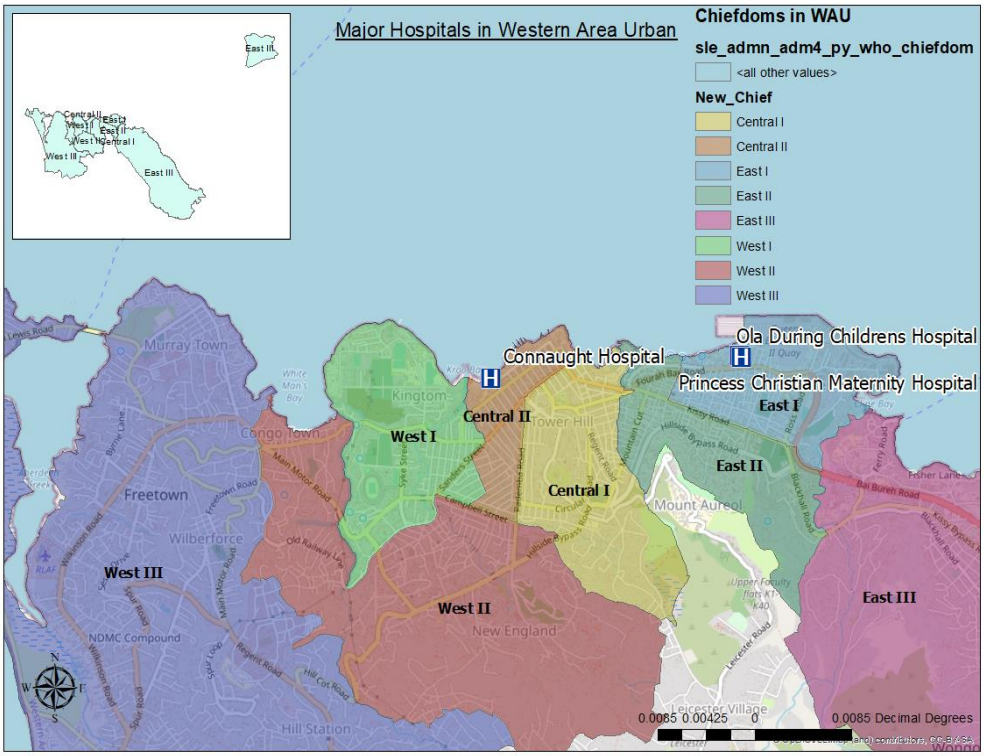

Figure 1. Map of the Study Sites (Connaught Hospital, PCMH and ODCH)

Sample Size Calculation

No specific sample size was calculated as this was an assessment of systems and structures. All the hospital departments and units included in the study were exhaustively assessed using structured data collection tool.

Hospital Selection

Purposive sampling was used to select three hospitals in the University Teaching Hospital Complexes. Respondents who were interviewed in the study included healthcare administrators and heads of the different departments and units.

Study Variables

The variables included the study were information on human resources, hospital capacity, and structures in the different departments and units of the hospitals.

Data Collection and Technique

Data were collected using structured questionnaires administered to respondents. The questionnaires were pretested to ensure their validity and reliability. The questionnaire included questions on hospital systems and procedures/structures, laboratory services, Pharmaceutical Services, and (IPC). The questionnaires were administered by trained research assistants who explained the purpose of the study to the respondents and obtained their informed consent before proceeding with data collection.

Data Validity and Reliability

Validity

1. Internal Validity: This refers to the extent to which the study accurately measures what it intends to measure. To certify internal validity, we employed appropriate research designs, data collection procedures, and statistical analyses. We carefully defined and operationalized the variables of interest, ensuring that the questions asked to assess the systems and structures in the three hospitals are clear and unbiased.
2. External Validity: This refers to the extent to that our findings can be generalized to other populations or settings beyond the three selected University Teaching Hospitals in Sierra Leone. To enhance external validity, the study applied an exhaustive sample of all units and departments and considered factors that might affect the generalizability of the findings, such as hospital size, location, and patient demographics.

Reliability

1. Internal Consistency: This aspect assesses the consistency of responses to the assessment questions.
2. Test-Retest Reliability: This aspect examines the stability of responses over time. We conducted a pilot study with a small group of respondents and then re-administered the survey after a certain period to determine the test-retest reliability.
3. Inter-Rater Reliability: We were cognizance of the fact that multiple research assistants would be involved in data collection or coding. Hence, were able to have an agreement as to what should be done in common. This was ensured through training and standardization of data collection procedures.

To enhance both validity and reliability of the entire process, we carefully applied the following: We used validated and standardized survey instruments to assess the systems and structures. We clearly defined the inclusion and exclusion criteria for selecting respondents.

Data Analysis

Descriptive Analysis

Descriptive statistics were used to summarize the data, including numbers/frequencies, and percentages. The data were entered and analyzed using the Statistical Package for Social Sciences (SPSS) version 25.0. The data were coded and cleaned before analysis.

Ethical Considerations

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the Ethics and Scientific Review Board of Sierra Leone. Permission to conduct the study was sought from the respective hospital administrations. Informed consent was obtained from all respondents, and confidentiality was ensured throughout the study and data used only for this study. Respondents were informed of their right to refuse or withdraw from the study at any time without penalty.

Results

Hospital Profile

An examination of the profile of health professionals in the three hospitals revealed noteworthy patterns. Amongst these hospitals, nurses constituted a significant portion, accounting for 92.92% at Connaught, 76.50% at PCMH, and 74.40% at ODCH, respectively (Table 3.1). Furthermore, medical doctors represent 21.23% at Connaught, 15.90% midwives at PCMH, and 4.81% at ODCH, indicating their prominent presence within the healthcare workforce (Table 1).

Table 1. Demographic Characteristics Health Professional Per Categories

Healthcare Professional	**Hospitals**					
	Connaught		**PCMH**		**ODCH**	
	n	%	n	%	n	%
Medical Doctors	143	21.23	24	6.08	17	4.81
Community Health Officers	0	0.00	2	0.51	2	0.57
Nurses	500	74.40	302	76.50	328	92.92
Midwives	24	3.63	63	15.90	**	**
Pharmacists	5	0.74	4	1.01	6	1.70
Total	672	100	395	100	353	100

** Number of Midwives was not specified for ODCH (all included in the number of Nurses), PCMH= Princess Christian Maternity Hospital; ODCH = Ola During Children's Hospital

Hospital Capacities

With respect to bed capacity, Connaught hospital exhibits a substantially higher capacity than its two counterparts within the university teaching hospital complex. Specifically, Connaught hospital had a bed capacity that is more than twice that of both PCMH and ODCH combined. Similarly, Connaught hospital accommodates a higher average patient volume, surpassing that of ODCH by more than 2.5 times and PCMH by almost four times (Table 2).

Table 2. Hospitals' Capacities

Capacities	**Hospitals**		
	Connaught	**PCMH**	**ODCH**
Number of Beds	350	140	166
Average Patient Volume	5944	1500	1800

Availability of Structures, Documentation, and Guidelines for the Implementation of Antibiotic Surveillance

Structures

Connaught Hospital is equipped with the essential components, accounting for approximately 83% of the requirements, to effectively address the issue of AMR. These components include an Antimicrobial Stewardship Programme, a Laboratory, IPC measures, a Pharmacy, and Waste Management systems.

However, with the exception of surgical site infection protocols. Similarly, PCMH exhibits the presence of all the essential structures (83%) needed for tackling Antibiotic resistance, with the exception of an antibiotic stewardship program. In contrast, ODCH only possesses 50% of the required structures IPC pharmacy, and waste management. It is worth noting that this hospital shares the same laboratory facilities with PCMH.

Comparison of Documentation and Guidelines between Hospitals

ODCH lacks comprehensive documentation in various areas, including regular drug usage reviews, prospective audits and feedback pertaining to specific antibiotic agents, and the availability of routine data on antibiotic use. This lack of documentation raises concerns regarding the hospital's ability to maintain and communicate essential information effectively. On the other hand, all three hospitals demonstrate a comparable level of compliance with guidelines Laboratory safety manual, Laboratory quality manual, Antibiotic guidelines/ policy, IPC guidelines, Drug Policy, with each possessing 60% of the required guidelines.

Monitoring Mechanisms for Structures and Systems and their Relationship to Antibiotic Surveillance

Connaught hospital ranks first in this regard, as it has established a monitoring mechanism that covers more than half (56%) of the required components. These components include monitoring adherence to IPC guidelines, conducting routine medication use evaluations through the stewardship program, verifying antibiotic stock, ensuring proper disposal and management of antibiotics within the facility, and implementing effective waste management protocols.

Similarly, PCMH hospital demonstrates a commendable commitment to monitoring mechanisms, surpassing three-quarters (78%) of the required components. In addition to monitoring adherence to IPC guidelines, verifying antibiotic stock, and ensuring proper disposal and management of antibiotics and waste, PCMH also monitors alcohol-based sanitizer consumption and conducts audits of device management.

Laboratory Capacity for Antibiotic Resistance

The Laboratory Capacity for Monitoring Antibiotic Resistance at Connaught Hospital is Robust

It encompasses 86% coverage of laboratory departments, with six out of the seven departments operating effectively. The laboratory at Connaught Hospital achieves a remarkable 100% turnaround time, ensuring that results are provided within 48 hours. Adequate availability of reagents is ensured, facilitating the laboratory's ability to perform microbiological culture and sensitivity testing with 100% efficiency.

Furthermore, Connaught Hospital has implemented a comprehensive electronic information system, which is fully operational. This advanced system further enhances the laboratory's capabilities.

In terms of pathogen identification and culturing, Connaught Laboratory excels in handling various pathogens, including enteric bacteria and Staphylococcus species.

The Laboratory Capacity for Monitoring Antibiotic Resistance at PCMH (Private Central Medical Hospital) is Moderately Established

It encompasses 57% coverage of laboratory departments, with four out of the seven departments functioning optimally.

The laboratory at PCMH achieves a 50% turnaround time, ensuring that results are provided within 24 hours. Adequate availability of reagents is maintained to support the laboratory's microbiological culture and sensitivity testing, which is conducted with 100% efficiency. Similar to Connaught Hospital, PCMH has implemented an electronic information system, which is fully operational. In terms of pathogen identification and culturing, PCMH laboratory is capable of handling various pathogens, including Enteric bacteria, Staphylococcus species, E. coli, and Streptococcus species.

ODCH

In terms of laboratory departments, ODCH has a complete absence, constituting 0% of its overall setup, as it operates within the confines of the PCMH laboratory. While ODCH shares a similar laboratory capacity for antibiotic resistance with PCMH, it is important to note that ODCH lacks an electronic information system and the necessary infrastructure for microbiological culture and sensitivity testing, which sets it apart from the aforementioned hospital.

Discussion

The profiles of the staff in the study hospitals were analyzed in three selected university teaching hospitals. Nurses were found to be the largest professional group in all three hospitals, comprising 92.92% in Connaught, 76.50% in PCMH, and 74.40% in ODCH. Medical doctors accounted for 21.23% in Connaught, 4.81% in ODCH, and midwives represented 15.90% in PCMH. These findings indicate the dominance of nurses in the healthcare workforce of the selected hospitals. The study conducted in Sierra Leone, as described in the previous response, reported the demographic characteristics of healthcare professionals in three selected university teaching hospitals. Nurses were found to be the largest professional group in all three hospitals, followed by medical doctors and midwives(16) .

Similarly, in an article by Premji and colleague, 13 million nurses make up the bulk of the world's healthcare workforce, making nurses the single proportion of the health workforce (17). Furthermore, Kurth et al stated in the work that, the overwhelming majority of the professionals working in the global health sector are nurses and midwives (18). These findings are in agreement with the findings of our study.

It is worth noting that addressing AMR requires a multidisciplinary approach involving healthcare professionals, policymakers, and the public.

Hospital Capacities

The results regarding AMR and hospital capacities in Sierra Leone highlight important findings. Specifically, when considering bed capacity, Connaught Hospital stands out as having a significantly higher capacity compared to the other two university teaching hospitals. Having a higher bed capacity at Connaught Hospital implies that it has more available beds for patients and can accommodate a larger number of individuals requiring medical care. This increased capacity can be crucial when dealing with cases of antimicrobial resistance, as these cases often require extended hospital stays and specialized treatment.

Additionally, the average patient volume at Connaught Hospital is substantially higher than that of the other two hospitals. This means that Connaught Hospital sees a greater number of patients on average, indicating a higher demand for healthcare services. The patient volume at Connaught Hospital is more than 2.5 times that of ODCH and almost four times that of PCMH.

The higher patient volume at Connaught Hospital suggests that it may have a greater burden of cases related to antimicrobial resistance. Dealing with antimicrobial-resistant infections requires specialized care, including the appropriate use of antimicrobial agents and infection control measures. The higher patient volume at Connaught Hospital may pose challenges in managing these cases effectively and ensuring optimal treatment outcomes.

Overall, the results indicate that Connaught Hospital in Sierra Leone has a higher bed capacity and patient volume compared to the other two university teaching hospitals. These findings have implications for addressing antimicrobial resistance in the country, as they highlight the need for adequate resources, infrastructure, and staffing to effectively manage patients, particularly cases of infectious illnesses including antimicrobial-resistant infections.

This current study conducted in Sierra Leone on AMR assessing hospital capacity provides specific insights into the situation within the country. On the other hand, the study investigating factors contributing to antimicrobial resistance in Sub-Saharan Africa (SSA) also highlighted broader challenges faced by the region (19). The Sierra Leone study focuses on hospital capacities and their implications for antimicrobial resistance. It specifically highlights the bed capacity and average patient volume at Connaught Hospital, which is considerably higher compared to the other two university teaching hospitals. This information provides a snapshot of the healthcare system's ability to manage cases of antimicrobial resistance within Sierra Leone. In contrast, the study on factors contributing to antimicrobial resistance in SSA provides a broader perspective on the challenges faced by the region (19). It identifies key factors such as antibiotic misuse and overuse, widespread usage in agriculture, and the lack of new antibiotic development by the pharmaceutical industry. These factors are not specific to Sierra Leone but are prevalent across SSA.

The study on SSA also highlights challenges in preventing antimicrobial resistance, including poor AMR surveillance and lack of collaboration, irrational use of antibiotics, weak medicine regulatory systems, lack of infrastructural and institutional capacities, lack of human resources, and inefficient IPC practices. These challenges are not limited to hospital capacities but encompass various aspects of healthcare systems and practices within the region.

When comparing the two studies, both studies contribute valuable insights into the issue of antimicrobial resistance. However, it is evident that the Sierra Leone study provides more localized and specific information about the hospital capacities and patient volumes in relation to antimicrobial resistance. It focuses on a specific hospital and highlights the need for adequate resources and infrastructure to address the issue effectively.

On the other hand, the study on SSA provides a broader understanding of the factors contributing to AMR and the challenges faced by the region. It emphasizes the need for comprehensive strategies involving surveillance, collaboration, regulatory systems, and infection prevention and control practices.

The results of the study on AMR structures in the universities teaching hospitals in Sierra Leone indicate variations in the implementation of AMR measures across different hospitals.

According to the study, Connaught Hospital has established most of the required structures for addressing AMR, accounting for 83% of the recommended measures. This suggests that Connaught Hospital has the necessary infrastructure and protocols to tackle AMR effectively. However, it is worth noting that the hospital lacks documentation in terms of routine evaluation of medication, which is only at 20%. Documentation plays a crucial role in monitoring and evaluating the effectiveness of AMR strategies, so this is an area that Connaught Hospital should address.

Like Connaught Hospital, PCMH has established 83% of the required structures for AMR. This indicates a strong foundation in terms of infrastructure and protocols. However, PCMH lacks an antibiotic stewardship program, which is an essential component of responsible antibiotic use. Antibiotic stewardship programs help optimize antibiotic prescribing practices, reduce unnecessary antibiotic use, and prevent the development of AMR. Therefore, implementing an antibiotic stewardship program should be a priority for PCMH.

The study also revealed that ODCH has established only 50% of the required structures for AMR. This means that the hospital's infrastructure and protocols for addressing AMR are lacking compared to Connaught Hospital and PCMH. ODCH particularly falls short in infection prevention and control, pharmacy, and waste management, which are vital aspects of combating AMR. It is worth noting that ODCH shares the same laboratory with PCMH, indicating a potential need for collaboration and knowledge sharing between the two hospitals to improve AMR strategies and structures.

Moving on to documentation, which is crucial for monitoring and evaluating AMR interventions, the study shows that Connaught Hospital has a documentation rate of 20% for routine evaluation of medication. This suggests that there is room for improvement in documenting and evaluating medication practices to enhance tackling AMR.

PCMH has a higher documentation rate compared to Connaught Hospital, with a documentation rate of 40%. The documentation includes the availability of reports on the third post-operative day wound inspection and follow-up dressing, as well as overall data availability. While PCMH showed better documentation practices, there is still room for improvement to ensure comprehensive documentation across all relevant areas of AMR management.

According to the study, ODCH has a 0% documentation rate, indicating a lack of proper documentation practices. This is a significant concern as documentation plays a crucial role in tracking and evaluating the effectiveness of AMR interventions. ODCH should prioritize implementing documentation protocols to improve their ability to monitor and manage AMR effectively.

According to Pauwels and team, there is substantial variation in the level of antimicrobial stewardship (AMS) implementation across different regions (20). However, despite this variation, the Global Point Prevalence Survey (Global-PPS) has proven to be a valuable tool in informing stewardship activities in many participating hospitals.

The Global-PPS is a standardized survey that provides a snapshot of antimicrobial prescribing practices, the prevalence of healthcare-associated infections, and the appropriateness of antimicrobial use in hospitals worldwide. It allows hospitals to assess their own prescribing practices and compare them to other institutions, providing valuable benchmarking data.

The research [20] suggest that there is still more to be gained from integrating the Global-PPS throughout AMS activities in hospitals. This means using the survey as a tool to guide and inform antimicrobial stewardship efforts on an ongoing basis. By integrating the Global-PPS into existing structures and processes, hospitals can continuously monitor and evaluate their prescribing practices and make evidence-based interventions to improve antimicrobial use.

The report by [20] in 2021 [21] emphasizes the importance of using standardized tools and surveys, such as the Global-PPS, to guide and inform antimicrobial stewardship activities. By doing so, hospitals can identify areas for improvement, implement targeted interventions, and track progress over time. This approach enables hospitals to optimize their antimicrobial use, reduce the development of antimicrobial resistance, and improve patient outcomes.

In the context of the study on AMR structures in Sierra Leone's teaching hospitals, integrating the Global-PPS could be beneficial. It would

provide a standardized framework for assessing antimicrobial prescribing practices and identifying gaps in implementation. By incorporating the Global-PPS into their AMS activities, hospitals in Sierra Leone could gain valuable insights and benchmark their performance against other institutions globally. This would facilitate continuous improvement and the development of evidence-based interventions to combat antimicrobial resistance effectively.

The monitoring mechanisms for the structures and systems, as well as antibiotic surveillance, vary across different healthcare facilities. Connaught has implemented monitoring mechanisms for more than half (56%) of the structures and systems. These mechanisms include monitoring adherence to IPC guidelines, routine medication use evaluations performed by the stewardship program, antibiotic stock verification, disposal, and management of antibiotics in the facility, and proper management of waste. While Connaught has implemented several monitoring mechanisms, there is room for improvement in expanding the coverage of these mechanisms.

PCMH has a higher percentage of monitoring mechanisms for the structures and systems, with more than three-fourths (78%) in place. In addition to monitoring adherence to IPC guidelines and antibiotic stock verification, PCMH also monitors the disposal and management of antibiotics, waste management, alcohol-based sanitizer consumption, audits of device management, and hospital-acquired infections. PCMH's comprehensive monitoring approach indicates a strong commitment to patient safety and antimicrobial stewardship.

Similar to Connaught, ODCH has monitoring mechanisms for more than half (56%) of the structures and systems. These mechanisms include monitoring adherence to IPC guidelines, alcohol-based sanitizer consumption, audits of device management, and antibiotic stock. While ODCH has implemented several monitoring mechanisms, it may benefit from expanding coverage to include additional aspects of antibiotic surveillance and management.

Overall, both PCMH and Connaught have implemented a range of monitoring mechanisms for the structures and systems, indicating a proactive approach to ensure patient safety and antimicrobial stewardship. ODCH has made progress in this area, but there is potential for further enhancement. It is important for healthcare facilities to regularly assess and improve their monitoring mechanisms to effectively prevent and manage infections, optimize antibiotic use, and ensure the overall safety of patients.

The studies emphasize the importance of high-quality surveillance data and concerted efforts to reduce the burden of antimicrobial resistance [22, 23].

The studies highlighted the need for comprehensive and real-time surveillance data to tackle antimicrobial resistance. They argue that improving national surveillance systems for antimicrobial resistance and aligning human and veterinary surveillance systems are scientific and political priorities. These efforts should be coordinated both within Europe and globally [4].

In light of this study, the results discussed earlier demonstrate the progress made by Connaught, PCMH, and ODCH in implementing monitoring mechanisms for the structures and systems. However, there is room for improvement and alignment with national surveillance systems. The findings suggest that these healthcare facilities should work towards integrating their monitoring mechanisms with national and international surveillance initiatives. This integration would enhance the quality and comprehensiveness of the surveillance data and contribute to the broader efforts to combat antimicrobial resistance.

A national survey on early warning systems for Emerging Profiles of Antimicrobial Resistance in Italy [24] highlights the heterogeneity observed in their research, indicating that more efforts are needed to address antimicrobial resistance effectively. While the

specific details of their study are not provided, it is likely that the findings emphasize the need for ongoing monitoring and surveillance of antimicrobial resistance.

Considering the results discussed earlier, the heterogeneity mentioned in the study by [24]. reinforces the importance of expanding and strengthening monitoring mechanisms for the structures and systems. By doing so, healthcare facilities like Connaught, PCMH, and ODCH can contribute to a more comprehensive understanding of antimicrobial resistance patterns. This understanding is crucial for implementing targeted interventions and stewardship programs [8] to combat resistance effectively.

In summary, the studies stress the importance of robust surveillance systems and coordinated efforts to address antimicrobial resistance [4, 11]. The results discussed earlier align with these recommendations and highlight the progress made by the healthcare facilities in implementing monitoring mechanisms. However, there is a need for further improvement, alignment with national surveillance systems, and integration into broader global initiatives to reduce the burden of antimicrobial resistance effectively.

Based on the results of the study on laboratory capacity for antibiotic resistance, the following findings can be observed:

Connaught has a high coverage of laboratory departments, with 86% (6 out of 7) of departments available. The laboratory has a 100% turnaround time of 48 hours, indicating efficient processing of samples. Reagents are readily available, ensuring smooth operations. The hospital has 100% microbiological culture and sensitivity testing, indicating the ability to accurately identify and test for antibiotic resistance. Additionally, Connaught has a 100% electronic information system, which facilitates data management and analysis. The laboratory at Connaught is capable of identifying and culturing various pathogens, including enteric bacteria and staphylococcus species.

PCMH has a lower coverage of laboratory departments, with only 57% (4 out of 7) available. The laboratory has a turnaround time of 50%, indicating a longer processing time of 24 hours compared to Connaught. However, reagents are available, and the hospital has 100% microbiological culture and sensitivity testing, ensuring accurate identification and testing for antibiotic resistance. Like Connaught, PCMH also has a 100% electronic information system. The laboratory at PCMH can identify and culture enteric bacteria, Staphylococcus species, E. coli, and Streptococcus species.

ODCH does not have any laboratory departments, indicating a lack of laboratory capacity for antibiotic resistance. The absence of laboratory departments suggests that ODCH may face challenges in accurately identifying and testing for antibiotic resistance.

Overall, Connaught has the highest laboratory capacity, with a high coverage of departments, efficient turnaround time, availability of reagents, and a comprehensive electronic information system. PCMH has a relatively lower coverage of departments but still possesses essential capabilities for identifying and testing antibiotic resistance. ODCH, on the other hand, lacks laboratory departments, indicating a need for improvements in laboratory capacity to effectively address antibiotic resistance.

The study supports the findings from the previous discussion regarding the importance of laboratory capacity for antibiotic resistance [25]. Kersh and colleagues reported that a network supported laboratory capacity for N. gonorrhoeae antimicrobial susceptibility testing (AST) and the detection of associated genetic markers. The study emphasized the significance of robust AST and genomic capacity in informing national public health monitoring and intervention. This aligns with the results discussed earlier, which highlighted the positive outcomes of having well-equipped laboratories with efficient turnaround times, availability of

reagents, and electronic information systems, as seen in Connaught and PCMH.

On the other hand, the study presents a different perspective, particularly in the context of rural healthcare settings [26]. Umutesi and colleagues found major gaps in equipment and supply availability necessary to conduct basic microbiology assays in rural district hospitals (DHs) in Rwanda (25). Despite these challenges, the study demonstrated the feasibility of establishing microbiological testing capacity in these settings. The findings of this study highlight the importance of building microbiological testing capacity in resource-constrained areas to improve clinical care, inform rational antibiotic use, and contribute to the establishment of robust national antimicrobial stewardship programs. This aligns with the need to address the lack of laboratory departments and capacity observed in ODCH in the previous discussion.

In summary, these additional studies support the importance of laboratory capacity for antibiotic resistance testing and surveillance. While the initial discussion focused on specific hospitals and their laboratory capabilities, the studies [25, 26]. provide broader insights into the significance of robust laboratory capacity at the national level and in resource-constrained settings. They emphasize the need for well-equipped laboratories, AST capabilities, and genomic testing to inform public health monitoring, intervention, and improved clinical care.

Study limitations: Despite the range of issues revealed in this study, it is important to note that this study has some limitations. First, the findings discussed in this study are only the findings from only three hospital, thus the results cannot be generalized to all hospitals in Sierra Leone. Second, we did not verify or ascertain some of the claims made by the respondents with regards the systems and structures to combat AMR. Third, we did not test the functionalities of the systems and structures. We only assessed their availability. Studies investigating the functionalities of the systems and structures with regards addressing AMR in Sierra Leone are needed to complete the story. Notwithstanding these shortcoming, the evidence generated in this study can serve as the bases to address AMR in Sierra Leone.

Conclusion

The following conclusions can be drawn from the present study that Connaught Hospital in Sierra Leone has a higher bed capacity and patient volume compared to the other two university teaching hospitals; both PCMH and Connaught implement a range of monitoring mechanisms for the structures and systems, indicating a proactive approach to ensure patient safety and antimicrobial stewardship; and Connaught has the highest laboratory capacity, with a high coverage of departments, efficient turnaround time, availability of reagents, and a comprehensive electronic information system. This study has thrown up many questions in need of further investigation. The Ministry of Health and Sanitation should continue to strengthen hospital systems and structures to help in the fight against AMR.

Conflict of Interest

The authors declare no conflict of interest.

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