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Antibiotic Usage Patterns for Surgical Prophylaxis at the Tamale Teaching Hospital

Cynthia Akumanue[1], Cordelia Kumah Daniella[2], Anita Amofa Benewaa[3], Peter Nana Addo Danquah[4], Martin Mumuni Danaah Malick[5]
Department of Pharmacy Practice, School of Pharmacy and Pharmaceutical Sciences, University for Development Studies.
Email address: mdanaah@uds.edu.gh

***Abstract—Background**: Surgical Site Infections (SSIs) are one of the most common and frequent hospital-acquired infections among surgical patients in Low- and Middle-Income Countries, presenting significant challenges for healthcare systems. SSIs can be mitigated through Surgical Antibiotic Prophylaxis (SAP), which has been shown to reduce infection rates, enhance patient outcomes, and lower healthcare costs. Antibiotic usage patterns for surgical prophylaxis at the Tamale Teaching Hospital (TTH) has not yet been well studied and documented. **Aim**: To identify the antibiotic usage patterns for surgical prophylaxis and determine adherence to Infectious Diseases Society of America (IDSA) Treatment Guidelines on SAP at the TTH. **Method**: A quota sampling technique was used to select 361 surgical patients whose electronic medical records from October 2023 to March 2024 were reviewed. An abstraction format was used to collect data on patient demographics, surgery details and (SAP) usage patterns. We also evaluated the impact of SAP parameters on adherence to IDSA Guidelines on SAP and Data was analysed using SPSS Version 29.0. **Results**: Pre-surgical antibiotic usage pattern: Ceftriaxone + Metronidazole: 86 (23.82%); Cefuroxime: 74 (17.73%); Ceftriaxone: 33 (9.14%); No antibiotics: 61 (16.90%). Post-surgical antibiotic usage patterns: Ceftriaxone + Metronidazole: 87 (24.09%); Cefuroxime: 58 (16.07%); Ceftriaxone: 21 (5.82%); No antibiotics: 45 (12.47%). Impact of SAP Parameters on Adherence: Antibiotic choice: 220 (60.10%); Timing of Administration: 250 (68.50%); Dosage: 210 (57.50%); Duration of Prophylaxis: 200 (54.80%). Overall Adherence to IDSA Guidelines: Pre-surgical: 46 (12.74%); Post-surgical: 28 (7.48%). **Conclusion**: Ceftriaxone plus Metronidazole Combination and Cefuroxime monotherapy are the most common antibiotics used for SAP at the TTH. Antibiotic choice and Timing of administration had the most impact on SAP Adherence while overall adherence was low.*

***Keywords**— Pre-surgical, Post-Surgical, Adherence, SAP, IDSA, Guidelines.*

I. INTRODUCTION

Surgical Site Infections (SSIs) are notably the most prevalent Healthcare-Associated Diseases (HADs) in surgical patients (1), and remain a significant concern in the field of surgery, contributing to patient morbidity, prolonged hospital stays, and increased healthcare costs (2). SSIs occur at the incision site or deep tissue space within 30 days of surgery (3). In the local phase of surgical site infection, macrophages usually fail to completely engulf and phagocytise all dead cells, which may result in the potential proliferation and spread of bacteria in the surrounding region. Moreover, in the systemic phase of infection, the microorganisms finally penetrate the bloodstream and begin to migrate to distant organs. The poisons secreted by the bacterium infiltrate the host and cause damage to the host's tissue (4). The process of wound healing in SSIs occurs through a sequence of cascades comprising the inflammatory phase, fibroblastic phase, and remodelling phase (5). The predominant organisms causing SSIs after clean procedures are skin flora, including S. aureus and coagulase-negative staphylococci (e.g., S. epidermidis) (6).The clinical manifestations of SSIs can be observed as superficial infections involving the skin and subcutaneous tissue, deep infections affecting the fascial and muscle layers, or organ/space infections involving any body part rather than the incision site. These infections are characterized by localized signs and symptoms of inflammation, such as redness, swelling, warmth, and purulent discharge, and are mostly aligned with systemic manifestations, including fever and leucocytosis (7). As a way to treat SSIs, these infections may require additional surgical procedures, such as debridement or implant removal to effectively manage the infection (8). SSIs pose substantial suffering and decrease the quality of life of patients. It affects their cognitive and emotional well-being leading to an elongation in the healing process, numerous health facility visitations, and persistent dependence on healthcare costs (9).

Antibiotic prophylaxis, that is the administration of antibiotics before surgery, has been a cornerstone in preventing SSIs for decades. Antibiotic prophylaxis in this regard decreases the bacterial count in wounds to aid in the prevention of surgical site infections via the body's defences. The incorrect use of pre-operative antibiotic prophylaxis can increase the mortality rate, adverse drug reactions, resistant bacterial infection, treatment costs, and the length of hospital stay (10). The primary objectives of employing antimicrobial agents in surgical prophylaxis are to lower the chance of SSIs, avoid or minimize ISS-related morbidity and mortality, shorten the length and cost of treatment (the cost-effectiveness of prophylaxis becomes apparent when the expenses associated with the management of SSIs are taken into account) (11), cause no negative effects, and have no negative impact on the patient's or the hospital's microbial flora. For the aforementioned goals to be achieved, the selected pathogens must be effectively combated by the antimicrobial agent which is most probably to colonize and affect the site used for surgery, administered in the right amount and time when guarantees adequate concentration of serum and tissue throughout incision and potential contamination. The prophylactic regimen should be safe and administered for the

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shortest effective period to optimize therapeutic outcomes while minimizing possible adverse effects and the development of resistance as well as costs [12]. The appropriate selection of an antibacterial medication for a particular patient ought to consider the parameters of the optimal agent, the relative effectiveness of the antibacterial agent during the entire procedure, the profile of safety, The patient's drug allergies, cost, ease of administration, pharmacokinetic profile, and bactericidal efficacy [13]. The selected agent should be active against the most prevalent pathogens in surgical locations. In most surgical procedures, a single prophylactic antibiotic dose administered shortly before the surgical incision is typically adequate. The monotherapy model conforms to the standard of reducing antibiotic exposure while ensuring that sufficient antibiotic concentrations are available at the incision site during the critical first stages of the procedure. Commonly known and approved agents frequently used in surgical antimicrobial prophylaxis include cefazolin, cefuroxime, cefoxitin, cefotetan, ertapenem, vancomycin, or the combination of metronidazole and cefazolin, particularly during periods in colorectal surgery when it is vital to cover bacteria anaerobes [14]. Since cefazolin is the most thoroughly researched antibacterial agent with proven efficacy, it is preferred for prophylaxis in the majority of surgeries. Its benefits include its low cost, acceptable safety profile, favored course of action, and range of activity against microorganisms frequently seen in surgery [15].

We have seen a tremendous development in the historical evolution of antibiotic prophylaxis such as examining the early practices to modern guidelines and exploring the various classes of antibiotics frequently used, their dosing regimens, and the importance of timing in optimizing prophylactic interventions. It is however imperative to say that, the future of SAP is very promising as it proves to unleash many emerging innovative strategies such as antimicrobial coatings, probiotics, and immunomodulatory agents [2,16]. One strategic innovation that possesses the potential to enhance antibiotic delivery in surgical prophylaxis is the conception of Nanotechnology. This transformational tool is noted for its precision and versatility. It makes use of a programmable array of nanoparticles that are intended to encapsulate antibiotics and release them gradually at the surgical site. This localized drug delivery model aids in reducing systemic exposure reducing the risk of adverse reactions while maintaining therapeutic levels at the areas where they are most needed. This innovation enhances the efficacy of antibiotics and contributes to patient safety by minimizing the impact on the body's microbiome [2,16,17]. The primary goal of nanotechnology is to facilitate more accurate medication delivery and targeting, reduce toxicities while maintaining therapeutic efficacy, and guarantee improved safety and biocompatibility as well as enhance faster development of new safe regimens [18]. The area of personalized medicine is also a potentially innovative strategy that has found its bearings in the field of antimicrobial therapy. This specialized procedure makes use of pharmacogenomics, thus, tailoring drug choices based on an individual's genetic profile. Healthcare professionals may pinpoint genetic indicators that affect how a patient's body metabolizes and reacts to antibiotics by targeting and analyzing their genetic composition. This information makes it possible to choose the most effective antibiotics against the most likely pathogens and maximize therapeutic results for the patient's specific physiology. By ensuring that patients receive the most effective antibiotic, personalized antibiotic prophylaxis lowers the chance of negative side effects and improves overall effectiveness [19]. Current research efforts are exploring the complex network of host factors that affect a person's vulnerability to SSIs. These host variables include a number of patient-specific features, such as the microbiome's makeup, immunological profiles, and genetics. According to genetic differences, some people are more susceptible to infections, while others may have innate immunity that provides superior defense. By identifying and targeting these host factors, clinicians can tailor prophylactic regimens to match a patient's unique vulnerabilities and strengths in order to maximize therapeutic outcomes [20]. With the widespread use of surgical devices during surgery, medical device-associated biofilms continue to pose a huge threat to human health, and these biofilms have become a major source and a contributing factor to the occurrence of nosocomial infections. An American study has shown that up to 80% of microbial infections in the human body involve biofilm formation, especially in hospital settings, which greatly increases the incidence rate and mortality [21].

The establishment and implementation of antibiotic prophylaxis guidelines have resulted in a coordinated, multidisciplinary approach within the healthcare team. A crucial strategy for optimizing antibiotic administration is collaboration between surgeons, anesthesiologists, nurses, and pharmacists. To guarantee that surgical schedules align with the timing of antibiotic administration and that antibiotics are administered within the recommended timeframe prior to incision, surgeons and anesthesiologists must work together. Nurses play a critical role in administering antibiotics and monitoring patients for side effects or problems. Pharmacists are essential for making sure that antibiotics are chosen, administered, and prepared at the right dosage and also for performing medication reconciliation to prevent any possible drug interactions [22]. Previous research on the prophylactic use of antibiotics has demonstrated notable differences in adherence to the standard recommendations [23]. The indication and dose of selected antibiotic regimens were relatively satisfactory in compliance but the choice, timing, and length of antibacterial prophylactic usage showed significant nonadherence to guidelines [24]. The diversity in the administration and practice of SAP across various health settings may be caused by variations in published guidelines, surgeons' disregard for these standards, and practitioners' or service providers' ignorance of or inability to obtain these guidelines. Researchers from different countries had reported a gross noncompliance to guidelines and the inappropriate use of SAP across the length and breadth of the countries' medical settings [25].

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II. Materials and Methods

A quota sampling technique was used to retrospectively select who underwent surgery at the General surgery, urology, orthopaedics, ENT, and neurosurgery wards of the Tamale Teaching Hospital from October 2023 to March 2024. A well-structured and scientifically validated data abstraction format was used. The format was pretested on 15 patients, modified accordingly, and used to abstract details concerning surgical data, surgical antibiotic provider data, and SAP usage data as well appropriate SAP usage assessment data of all study participants. The data was electronically validated for completeness and clarity as well as coded for entry into SPSS version 29.0 SPSS for analysis. Simple frequencies, mean, median, and standard deviation were employed to describe the data while various summary statistics were calculated to assess the adherence to SAP usage according to the recommendations of standard guidelines. Logistic regression model was used to find out the association and possible causalities that might have significantly resulted in the study outcome.

III. Results

TABLE 1: Gender distribution of Study Participants

	Frequency	Percent
Female	133	36.8
Male	228	63.2
Total	361	100.0

TABLE 2: Age distribution of Study participants

Age groups (Years)	Frequencies	Percentages
18-30	71	19.7
31-45	108	29.9
46-60	109	30.2
>60	73	20.2
Total	361	100.0

TABLE 3: The Distribution of Antibiotics Used Before and After Surgical Incision.

Antibiotics used	Pre-surgical		Post-surgical	
	Frequency	Percentage	Frequency	Percentage
Cefuroxime	64	17.73	58	16.07
Ceftriaxone	33	9.14	21	5.82
Metronidazole	8	2.22	0	0.00
Co-amoxiclav	25	6.93	37	10.25
Levofloxacin	6	1.66	5	1.39
Ceftriaxone + Metronidazole	86	23.82	87	24.09
Cefuroxime + Metronidazole	9	2.49	13	3.60
Co-amoxiclav + Metronidazole	16	4.43	16	4.43
Co-amoxiclav + Gentamycin	9	2.49	6	1.66
Ceftriaxone + clindamycin	10	2.77	8	2.22
Others	34	9.42	65	18.00
No antibiotics	61	16.90	45	12.47
Total	**361**	**100.00**	**361**	**100.00**

TABLE 4: Cross-tabulation of the Number of Antibiotics used before and after the Surgical Incision

Number of Antibiotics used before Incision	Number of Antibiotics used after Incision			
	0	1	2	Total
0	24 (6.65)	27 (7.48)	10 (2.77)	61 (16.90)
1	10 (2.77)	105 (29.09)	38 (10.53)	153 (42.38)
2	11 (3.05)	23 (6.36)	113 (31.30)	147 (40.72)
Total	45 (12.47)	155 (42.93)	161 (44.60)	361 (100)

TABLE 5. Distribution of Surgeries and Corresponding common Antibiotic Prophylaxis Used during the Study Period

Type of Surgery	Frequency	Percentage (%)	Common Antibiotic Used
General Surgery	149	41	Ceftriaxone
Urology	84	23	Ceftriaxone
Orthopaedics	69	19	Cefuroxime
ENT	39	11	Co-amoxiclav
Neurosurgery	20	6	Cefuroxime
Total	361	100	

TABLE 6: Adherence to IDSA Surgical Antibiotic Prophylaxis (SAP) Guidelines

Variable	Compliance		Non-compliance	
	Frequency	Percentage	Frequency	Percentage
Antibiotics Choice	220	60.10	141	39.90
Timing of Administration	250	68.50	111	31.50
Dosage	210	57.50	151	42.50
Duration of Prophylaxis	200	54.80	161	45.20

Overall Compliance

Pre-Surgical Prophylaxis	Frequency	Percentage
No	315	87.26%
Yes	46	12.74%
Total	361	100%

Post-Surgical Prophylaxis	Frequency	Percentage
No	333	92.52%
Yes	28	7.48%
Total	361	100%

TABLE 7: Parameter Estimates for Logistic Regression Model for Presurgical Prophylaxis

Variable	Estimate	Std. Error	Z Value	Pr(>|Z|)	OR	95% Conf. Int. 2.5	97.5
Intercept	0.134	1.319	0.101	0.919	1.143	0.075	14.216
Sex	-0.041	0.361	-0.114	0.910	0.960	0.476	1.977
Age	0.018	0.140	0.129	0.897	1.018	0.777	1.348
Religion	0.658	0.360S	1.828	0.068	1.930	0.983	4.064
Comorbidity	-0.102	0.489	-0.209	0.835	0.903	0.360	2.509
Surgery	0.175	0.136	1.284	0.199	1.191	0.917	1.571
Ward	0.023	0.210	0.107	0.914	1.023	0.686	1.571
Wound	-0.854	0.329	-2.598	0.009	0.426	0.225	0.825
Length	0.259	0.123	2.102	0.036	1.296	1.029	1.673
Antibiotics1	1.678	0.307	5.472	0.000	5.353	3.021	10.100
SSI	-0.641	0.857	-0.747	0.455	0.527	0.113	3.814

TABLE 8: Parameter Estimates for Logistic Regression Model for Post-surgical prophylaxis

Variable	Estimate	Std. Error	Z Value	Pr(>|Z|)	OR	95% Conf. Int. 2.5	97.5
Intercept	-1.113	1.689	-0.659	0.510	0.329	0.014	13.362
Sex	0.220	0.439	0.501	0.616	1.246	0.515	2.920
Age	0.309	0.160	1.936	0.053	1.362	0.993	1.865
Religion	-0.235	0.416	-0.563	0.573	0.791	0.326	1.702
Comorbidity	-0.379	0.609	-0.621	0.534	0.685	0.180	2.062
Surgery	-0.083	0.195	-0.426	0.671	0.920	0.618	1.344
Ward	-0.520	0.361	-1.438	0.150	0.595	0.273	1.141
Wound	0.716	0.363	1.971	0.049	2.046	0.969	4.116
Length	-0.255	0.161	-1.583	0.114	0.775	0.550	1.042
Antibiotics2	-0.751	0.317	-2.366	0.018	0.472	0.250	0.877
SSI	0.147	1.145	0.128	0.898	1.159	0.057	7.836

IV. Discussions

Majority of respondents were male, representing 63.2% of the total sample size, with females making up the remaining 36.8 % (Table1). This finding is different from similar studies

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conducted by a group of researchers at Jimma University Teaching Hospital in southwest Ethiopia (JUTH) (Hospital et al., 2016b) and another study by Acheampong et al conducted in Ghana who reported a higher number of females (Mensah et al., 2018b). The age and gender distributions are important for understanding the potential risks associated with different demographics, as some age groups are more susceptible to infections or complications post-surgery (Table.2). According to the IDSA 2020 guidelines on SAP, frequently used antibiotics for surgical prophylaxis were Ampicillin–sulbactam, Ampicillin, Aztreonam, Cefazolin, Cefuroxime, Cefotaxime Cefoxitin, Cefotetan, Ceftriaxone, Ciprofloxacin, Clindamycin, Ertapenem, Fluconazole Gentamicin, Levofloxacin, and Metronidazole (Reference guidelines here). Comparatively, our study showed cefuroxime (17.73%) and ceftriaxone (9.14%) as the commonly used monotherapy antibiotics for presurgical prophylaxis and cefuroxime (16.07%) and Co-amoxiclav (10.25%) as monotherapy for post-surgical prophylaxis; whereas Ceftriaxone plus metronidazole was the most commonly used combination antibiotic therapy for both pre-surgical (23.82%) and post-surgical (24.09%) prophylaxis (Table. 3). Additionally, our study further revealed varied patterns in the use of antibiotics before and after surgical incisions. 83.1% of patients received antibiotics before incision. While 42.38% of patients received one antibiotic before incision, a significant proportion (40.72%) were administered two antibiotics. For post-incision, 44.60% of patients received two antibiotics. ((Table.4). A similar research in southwest Ethiopia revealed that 79.9% of respondents received antibiotics before incision while 20.1% received antibiotics after the incision (Hospital et al., 2016b). The combination of two antibiotics both before and after incision was common, occurring in 31.30% of cases (Table. 4). A comparable study indicates a higher percentage (68.8%) of combination antibiotics before and after incision (Mensah et al., 2018b). The frequent use of multiple antibiotics, particularly the high proportion of patients receiving two antibiotics post-incision, reflects an overly aggressive approach to infection prevention (Sefah, Denoo, Bangalee, Kurdi, Sneddon, et al., 2022b). While this has the possibility of reducing the risk of SSIs, it also raises concerns about the potential for antibiotic resistance (Agyare et al., 2024b). The IDSA guidelines recommend no antibiotics for orthopaedic surgery involving knee, foot, and hand surgery and cefazolin for spinal procedures, no antibiotic medication for ENT, cefazoline for neurosurgery, fluoroquinolones, cefazolin, clindamycin, aminoglycosides and trimethoprim-sulfamethoxazole for urology. However, findings from our study revealed that, the types of surgeries performed, including general surgery, urology, orthopaedics, ENT, and neurosurgery, showed varying adherence to the IDSA guidelines. The most common type of surgery was general surgery, where ceftriaxone was the antibiotic of choice; urology was the second most common type, with ceftriaxone being the antibiotic of choice. In Orthopaedics, ENT, and Neurosurgery, Cefuroxime, Amoxiclav, and Cefuroxime were preferred respectively (Table. 5). Adherence to guidelines varied significantly, with the timing of administration being the most adhered to (68.5% adherence), but the duration of prophylaxis was the least (54.8% adherence) (Table. 6). These adherence rates are higher than those reported by Y.M Alahmadi which showed 18.2% adherence to the duration of antibiotic administration and an overall adherence rate of 19.5% (Alahmadi et al., 2020b). Adherence to IDSA SAP guidelines were notably low, with only 12.74% of patients adhering to the pre-surgical prophylaxis guidelines and 7.48% adhering to post-surgical guidelines (Table.6). On the factors influencing non-compliance with SAP guidelines, there was a statistically significant association between adherence and the occurrence of SSI ($p = 0.02$) (Table.7). The logistic regression analysis identified that the use of antibiotics before incision significantly increased the likelihood of non-adherence. Again, the length of hospital stays in days also influenced adherence, with longer stays associated with higher non-adherence (Table.8). This suggests that the longer the length of stay in the hospital, the lesser the probability of adhering to the recommended guidelines for surgical antibiotic prophylaxis (SAP) similar to a study conducted in a Congolese Teaching Hospital which showed an association between adherence and the occurrence of SSIs (Bunduki et al., 2020).

Limitations of the Study

Details on the academic qualifications and practice experiences of surgical antibiotics prophylaxis providers were not readily available. This data would have helped us establish a possible an association between the providers' years of experiences and their antibiotics choices. We could not also establish a possible relationship between the types of wounds and the choice of SAP due to incomplete data entry. Finally, the retrospective nature of our study did not provide an opportunity for us to assess the impact of the choice of SAP on treatment outcomes.

V. CONCLUSIONS

Majority of the study participants were males with an average age of 51 years. Generally, second and third generation cephalosporin were prescribed for most of the different types of surgery. The most common prescribed SAP for both pre and post-surgery were Ceftriaxone plus Metronidazole combination and Cefuroxime monotherapy. The combination of two antibiotics both before and after incision was common. Antibiotic choice and Timing of administration had the most impact on SAP Adherence while overall adherence was low.

Recommendations

The clinical management team of the Tamale Teaching Hospital should revise their SAP guidelines and make them congruent with internationally established standard SAP guidelines. Implementing Antimicrobial Stewardship Programs (ASPs), which include educating and training front-line clinical teams to ensure adherence to Standard Antimicrobial Protocols (SAP) and local guidelines, along with conducting regular clinical audits and holding feedback meetings, will enhance future antimicrobial practices and help address increasing antimicrobial resistance rates. Finally, the

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department of health information services of the TTH should work on improving their data entry strategies in order to capture research usable data.

Conflict of interest declaration

All the researchers have no conflict of interest situations to declare

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Authors Contributions

CA conceived the research idea and CKD, AMB, PNAD collected all the relevant data including the literature review under the supervision of CA. CA performed the data analysis. MMDM wrote the manuscript with the help of CA. All the authors thoroughly reviewed the manuscript and approved its content for publication

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Data Availability Statement

All the quantitative and qualitative data used in writing the article are included in this manuscript

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