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Antibiotic Procurement Trends and ABC Analysis: Insights from a Three-Year Retrospective Descriptive Study at Benjamin Mkapa Zonal Referral Hospital

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ABSTRACT

Background: The lower middle income countries (LMICs) are experiencing exponential procurement expenditure and consumption of antibiotics yearly in primary to tertiary healthcare facilities. The menace of antimicrobial resistance (AMR) is a significant burden on the world economy, leading to financial losses due to reduced productivity from illness (in humans and animals) and increased treatment costs.

Objective: We analysed antibiotic procurement data at a Tanzanian hospital using an ABC analysis method. This could help fight Antimicrobial Resistance by providing insights into consumption patterns and expenditure.

Methodology: A retrospective descriptive study was employed to analyse quantities of antibiotics procured for three years (from 2020 to 2022). Antibiotic total purchasing costs were analysed using the ABC analysis at Benjamin Mkapa Hospital (BMH).

Results: A steady increase in antibiotic procurement was observed, with expenditures rising by 35.83% in 2021 and 59.35% in 2022 compared to 2020. ABC analysis revealed that Category A antibiotics—primarily ceftriaxone, amoxicillin/clavulanic acid, and flucloxacillin/amoxicillin—comprised 12.20% of all antibiotics purchased in 2020 but accounted for over 68% of the total antibiotic expenditure (TZS 116,197,700.00). In 2021, Category A antibiotics represented 15.2% of purchases and 64% of total expenditure (TZS 148,318,885.80), with ceftriaxone, meropenem, and azithromycin being the most frequently procured. By 2022, Category A antibiotics expanded to 23.26% of stocked items and contributed to more than 78% of the total antibiotic spending (TZS 213,033,376.50), with amoxicillin/clavulanic acid, ceftriaxone, and metronidazole being the leading agents.

Conclusion: A steady increase in antibiotic expenditures has been observed. However, the procurement, expenditure, and consumption of Access antibiotics are below the recommended threshold resulting in increased spending and consumption of Watch and Reserve antibiotics. Decreasing the consumption of Reserve antibiotics may help in avoidance or prevention of antimicrobial resistance.

BACKGROUND

Health expenditures are expected to rise significantly by 2050, with projections showing increases of 25% in low-income countries (LICs), 15% in middle-income countries (MICs), and 6% in high-income countries (HICs). On a global scale, this translates to an annual spending surge of 8%.[1] The challenge of antimicrobial resistance (AMR) poses a serious threat to the global economy. It results in significant financial losses due to decreased productivity caused by illness both in humans and animals as well as soaring treatment costs. The rise and spread of drug-resistant pathogens, which have developed various new resistance mechanisms, jeopardise our ability to manage common infections effectively.[2] Second and third line antibiotics are preferred over first-line options, which tend to be more expensive due to antibiotic resistance (AMR). The immediate effects of AMR include prolonged illnesses, increased mortality rates, and longer hospital stays.[3] Even mild infections that once seemed trivial, such as wounds, could escalate into untreatable conditions. This progression may result in further illnesses, disabilities, and even early death, causing devastating consequences for individuals, communities, and economies alike.[1] The link between antibacterial consumption and bacterial resistance has been established.[4] Antibiotics rank among the top drug classes by expenditure, surpassed only by antineoplastic agents and haemostatic modifiers.[5,6]

The World Health Organisation (WHO) and the Tanzanian Ministry of Health have developed the Global Action Plan and the National Action Plan on Antimicrobial Resistance (NAP-AMR) to address the issues arising from antibiotic resistance. These plans are designed to offer a comprehensive framework for the responsible use and consumption of antibiotics. As a result of these efforts, both global and national Essential Medicines Lists (EML) have been revised to include three distinct categories of antibiotics: 'Access', 'Watch', and 'Reserve' (AWaRe).[3,7,8] The World Health Organisation (WHO) suggests a framework involving the Access, Watch, and Reserve categories, with recommended proportions of over 90%, under 10%, and less than 1%, respectively. This guideline aims to enhance treatment outcomes, curb the development of resistance, and maintain the effectiveness of antibiotics that are considered a 'last resort'.[9,10,11]

Encouraging the proper use of antibiotics is one of the most vital measures we can take. By doing so, we can lower healthcare costs by cutting back on unnecessary prescriptions and reducing the occurrence of drug resistant infections.[6] Effective control over the selection, quantification, procurement, consumption, and use of antibiotics is crucial for managing the pharmaceutical budgets of healthcare facilities. It also plays a key role in ensuring rational prescribing practices. To help a health facility understand the total annual expenditure on antibiotics, conducting an ABC analysis (also known as Pareto analysis) proves to be a valuable tool.[12,13] ABC analysis is a valuable tool for pinpointing which items need more focused management. In this method, the top 10% of items account for approximately 70% of the budget (Group A). The next 20% of inventory items consume about 20% of the financial resources (Group B), while the remaining 70% of items only represent a mere 10% of the budget (Group C).[12,14] The Benjamin Mkapa Hospital (BMH) is one of Tanzania's key zonal referral hospitals and has seen a significant rise in both antibiotic procurement and expenditure over the years. This trend underscores the need to thoroughly examine how antibiotics are purchased and spent at BMH. Our study focused on analyzing antibiotic procurement data from 2020 to 2022 using an ABC analysis approach. The objective of this research was to assess the efficiency of antibiotic procurement and inventory management in making the best use of available resources. Additionally, the study aimed to estimate the use and prescription of Watch and Reserve antibiotics. This information is crucial to inform interventions which will help lower health care costs and enhance treatment outcomes in the fight against antimicrobial resistance (AMR).

MATERIAL AND METHODS

Study Site

The study was conducted at BMH, a tertiary and zonal referral hospital located in the central zone of Tanzania. The hospital is situated within the University of Dodoma (UDOM) and can accommodate up to 400 beds at maximum capacity. As a university training hospital, it offers specialised services, including attending to severe medical cases, conducting advanced surgical procedures, performing kidney and bone marrow transplants, and providing medical oncology services.

Study Designs

A retrospective descriptive study was conducted to analyse the quantities and costs of antibiotics procured over three years (from 2020 to 2022) at BMH. The procurement costs were analysed using the ABC method and categorised based on the antibiotics' AWaRe classification.

Inclusion and Exclusion Criteria of Selected Antibiotics

An ABC analysis of antimicrobials (antibiotics) was conducted to evaluate the trends in procurement and expenditures. The procurement and expenditure of antibiotics are influenced by their use in the treatment of infectious diseases, which is linked to antimicrobial resistance (AMR). This relationship constitutes part of the pharmacoeconomic framework for understanding AMR. The analysis focused specifically on oral and parenteral antibiotics, as their therapeutic and pharmacological effects have systemic impacts that are more likely to contribute to AMR. Topical antibiotic preparations were excluded from the analysis, as they are generally not included in antimicrobial stewardship programs.[15,16]

Sampling Process

The procurement data for antibiotics at BMH was systematically recorded using a Microsoft Excel spreadsheet. This dataset encompasses annual totals of quantities and purchase prices for each antibiotic. Detailed entries include descriptions of the antibiotics encompassing the generic name, strength, and administration route alongside the basic units of measurement (such as tablets, ampules, bottles, capsules, and vials).

Data Management and Analysis

The main pharmacy store of BMH collected antibiotics procurement data over a three-year period, from January 2020 to December 2022. This information was gathered and analysed using a Microsoft Excel spreadsheet. All of the antibiotics included in the analysis were selected from a comprehensive list, and the data was examined based on the total quantity purchased each year and the unit tender price. To facilitate understanding and analysis, the antibiotic expenditure data was presented in both tables and charts. The analysis encompassed all antibiotics acquired during this time frame, considering factors such as quantity, total expenditure, route of administration, and spectrum of activity.

We computed the total expenditure on antibiotics within the year, the percentage representation of each antibiotic's value relative to the overall expenditure, and the cumulative percentage of total costs. The antibiotics were subsequently classified into the Access, Watch, and Reserve (AWaRe) categories in accordance with the Tanzania Standard Treatment Guidelines and the 2021 Tanzania Essential Medicines List.[17]

Ethics Approval

The National Institute for Medical Research and the National Health Research Ethics Review Committee (NatHREC) granted the study an ethical clearance certificate with reference number NIMR/HQ/R. 8a/Vol. IX/4260 and BMH authority permitted the study in the hospital.

ABC Analysis

ABC analysis is a method used to classify the total annual expenditure or usage of antibiotics into three categories: A, B, and C. Category A antibiotics include the top 10 to 20% of items that consume 75 to 80% of the annual pharmaceutical budget. Category B antibiotics have an intermediate rate of usage (10 to 20% of all antibiotics) and account for 15 to 20% of the yearly expenditure on antibiotics procurement from the total budget. Category C antibiotics are the vast majority, with low individual usage, accounting for 5 to 10% of the pharmaceutical budget allocated.[12,13,18]

Steps for Performing ABC Analysis of Antibiotics Expenditure at BMH

The steps that were performed in ABC analysis included[12]

1. Recording all antibiotics in a Microsoft Excel spreadsheet along with their unit buying cost.
2. Recorded quantity of each antibiotics that was purchased/procured using a Microsoft Excel spreadsheet.
3. Calculated the amount spent on antibiotics using equations 1 and 2, as shown below.

$$Value\ of\ antibiotics\ procured\ = unit\ of\ each\ antibiotics \times quantity\ procured \ldots\ldots (1)$$

Then;

$$Total\ value\ of\ all\ antibioti\ procured = \sum_{i=1}^{n} Value\ of\ antibiotics\ procured \ldots (2)$$

4. calculated the percentage of the total value of each antibiotic procured, as shown in Equation Three below

$$\text{Percentage of the total value of each antibiotic procured} = \text{Value of antibiotics procured/Total value of all antibiotics} \times 100 \ldots\ldots (3)$$

5. Arranged the list of antibiotics in descending order, starting from the antibiotic with the highest consumption values to the lowest.
6. Calculated the cumulative percentages by beginning with the first item percent as it is and then obtaining the cumulative percentage of the second; the percentage of the first item was added by the second. Then, for the third item, the cumulative percentage of the second was added to the percentage of the third, and the same was done for the other.
7. The cut-off point/ boundaries for A, B, and C class antibiotics were selected and used to categorise purchased antibiotics.

a. "A" antibiotics class has the highest annual usage, with 10 to 20% of all procured antibiotics and usually accounting for 75 to 80% of pharmaceutical yearly budget expenditure

b. "B" antibiotics class represented 10 to 20% of all antibiotics with 15 to 20% of pharmaceutical budget expenditure

c. The "C" antibiotics class were 60 to 80% of all antibiotics consumed and contributes 5 to 10% of the allocated pharmaceutical budget's annual value.

8. Graphically presented the findings of ABC analysis

a. A plot of the annual purchasing cost of antibiotics for 2020, 2021, and 2022 vs the yearly allocated budget for pharmaceuticals

b. A plot of the total cumulative value (vertical axis) against antibiotics rank number (horizontal axis). Several antibiotic items influence the slope of a graph. The steeper the curve, the higher the proportion of the total value in class "A".

c. A combined plot of three years based on proportions of ABC classes against proportions of the number of antibiotics in each class

Selected boundaries are flexible; they depend on the number of antibiotics items (pharmaceutical available), volume, and value of items available. Also, their selection is more affected by how ABC analysis results are applied.

RESULTS

Over the past three years, the antibiotics' purchasing cost trend at BMH for 2020, 2021, and 2022 was TZS 170 million (8%), TZS 230 million (9%), and TZS 270 million (9%), respectively. The hospital's annual budget allocations were TZS 2.2 billion for 2020, TZS 2.6 billion for 2021, and TZS 3 billion for 2022 (Figure 1).

Table 1 reveals that between 2020 and 2022, 46 to 56% of the antibiotics procured fell into the Access category, while up to 43% were classified as Watch and nearly 9% of the antibiotics purchased during this period were Reserve. Notably, oral antibiotics comprised over 70% of the total antibiotics acquired in this timeframe.

The findings from the ABC analysis reveal that the "A" category consists of ceftriaxone (P), amoxicillin/clavulanic acid 375mg (O, A), flucloxacillin/amoxicillin 500mg (O, A), cefuroxime 500mg (O, W), and meropenem (P, R). Together, these antibiotics represent 12.20% of all purchases and accounted for more than 68% of the total expenditure on antibiotic procurement in 2020 (Table 2, and Figures 2 and 5).

In 2021, category A antibiotics accounted for 15.22% of total purchases, making up over 64.24% of all antibiotics acquired. The most commonly used antibiotics in this category included ceftriaxone 1gm (P, W), meropenem (P, R), azithromycin 500mg (O, W), metronidazole (P, A), amoxicillin/clavulanic acid 625mg (O, A), flucloxacillin/amoxicillin 500mg (O, A), and ampicillin/cloxacillin 500mg (P, A) (Table 2 and Figures 3 and 5).

In 2022, the category A antibiotics included Amoxicillin/clavulanic acid 625mg (O, A), ceftriaxone 1gm (P, W), metronidazole (P, A), flucloxacillin/amoxicillin 500mg (O, A), piperacillin/tazobactam (P, W), ampicillin/cloxacillin 500mg (O, A), ampicillin/cloxacillin 500mg (P, A), azithromycin 500mg (O, W), meropenem (P, R), and clarithromycin 500mg (O, W). These antibiotics accounted for 23.26% of the total antibiotics in stock and represented over 78% of all antibiotics purchased during that year (Table 2 and Figures 4 and 5).

FIGURE 1: Illustration of the Annual Purchasing Cost Of Antibiotics for 2020, 2021, and 2022

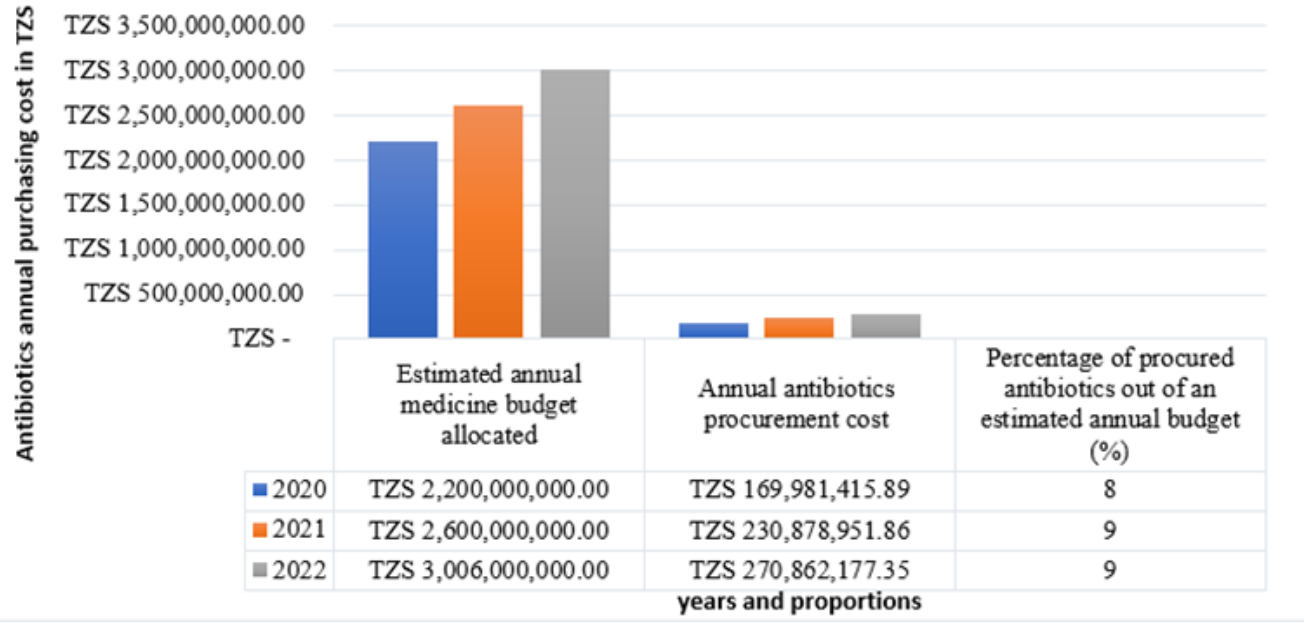


TABLE 1: Antibiotics Procurement Distribution Based on AWaRe Classification and Route of Administration From 2020 To 2022

Criteria	2020 (N=41)	2021(N=46)	2022(N=43)
AWaRe			
Access	19(46.34%)	26(56.52%)	21(48.84%)
Watch	18(43.90%)	15(32.61%)	18(41.86%)
Reserve	3(7.32%)	4(8.70%)	3(6.98%)
Unclassified	1(2.44%)	1(2.17%)	1(2.33%)
Route of administration			
Oral	30(73.17%)	31(67.39%)	31(72.09%)
Systemic	11(26.83%)	15(32.61%)	12(27.91%)

TABLE 2: Comparative Three Year (2020-2022) ABC Analysis of Procured Antibiotics at BMH

Variables / Years	ABC category	Number of antibiotics (n)	Percentage of all antibiotics (%)	Value of annual expenditure (TZS)	Percentage of total annual expenditure (%)
2020	A	5	12.20	116,197,700.00	68.36
	B	17	41.46	47,300,064.00	27.83
	C	19	46.34	6,483,652.00	3.81
	Total	41	100.00	169,981,416.00	100.00

Continue

TABLE 2: Continued

Variables / Years	ABC category	Number of antibiotics (n)	Percentage of all antibiotics (%)	Value of annual expenditure (TZS)	Percentage of total annual expenditure (%)
2021	A	7	15.22	148318885.80	64.24
	B	18	39.13	73218878.00	31.71
	C	21	45.65	9341188.10	4.05
	Total	46	100.00	230878951.90	100.00
2022	A	10	23.26	213033376.50	78.65
	B	19	44.19	52217565.30	19.28
	C	14	32.56	5611235.56	2.07
	Total	43	100.00	270862177.40	100.00

TZS, Tanzania Shilling

FIGURE 2: BMH's ABC Value Analysis in Year 2020

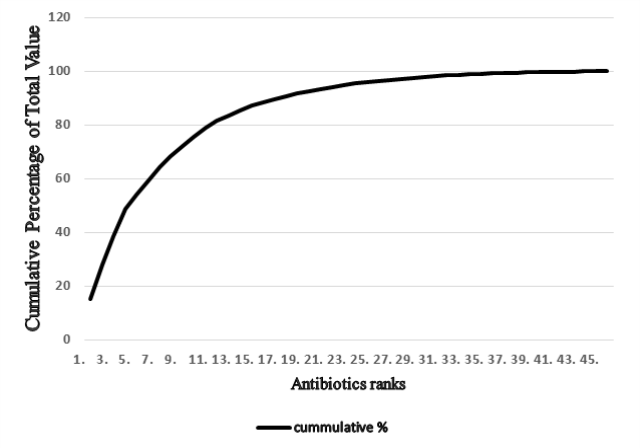


FIGURE 3: BMH's ABC Value Analysis In Year 2021

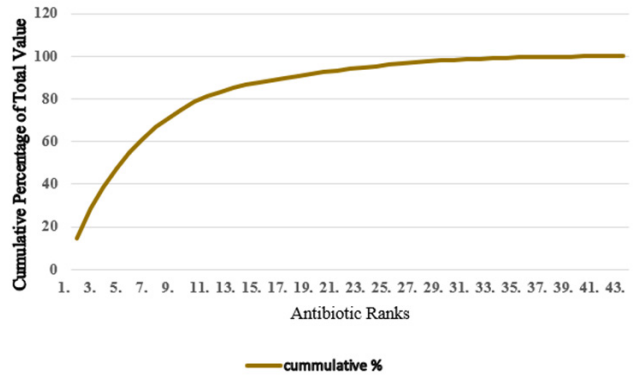


FIGURE 4: BMH's ABC Value Analysis In Year 2022

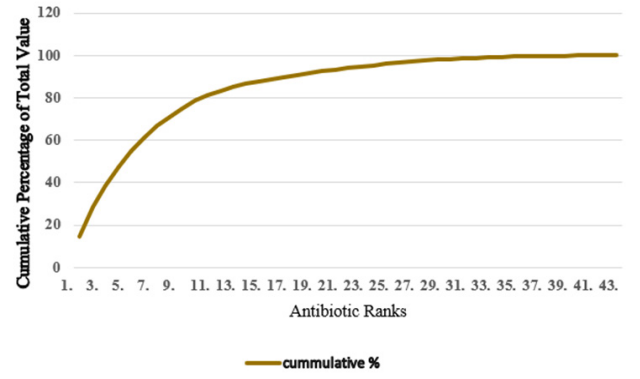
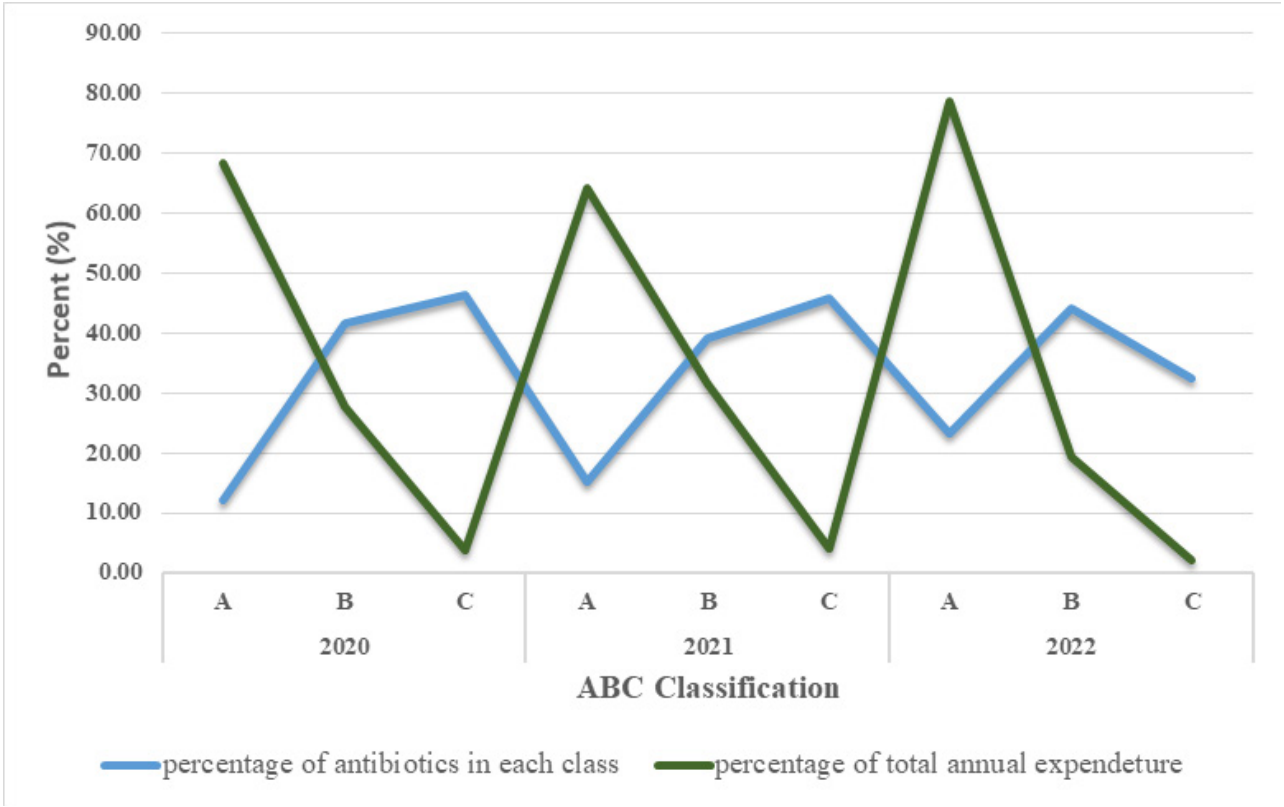


FIGURE 5: Comparative Three Year (2020-2022) ABC Analysis of Procured Antibiotics at BMH



DISCUSSION

Healthcare facilities allocate a significant portion of their budget to the procurement of pharmaceuticals.[18] According to surveillance data from 2010 to 2015, the United States spent 10 billion USD on antibiotics.[19] As reported, one third of the hospital's budget is spent on purchasing supplies, including medicines.[18] At BMH, antibiotic procurement represents a substantial portion of the annual pharmaceutical budget. In 2021 and 2022, the purchasing costs for antibiotics saw a significant rise compared to the budget allocated for 2020. A study conducted in Rwanda in 2023 highlighted the considerable spending on antibiotics relative to other medications, underscoring the critical need for effective inventory management.[18] In South Africa, around 7% of the total yearly spending on pharmaceuticals goes toward antibiotics.[13] Vietnam spends almost three times as much on antibiotics in its health facilities as BMH does in Tanzania.[4] Effective inventory management and timely AMS interventions play a vital role in curbing antibiotic use and associated costs.[19,20]

Our survey found that oral antibiotics made up over 70% of the antibiotics acquired during the specified period. In South Africa alone, 89% of the antibiotics obtained in 2020 were oral, while only 8% were administered parenterally.[13] Our findings were lower than a study in LMIC, where 91.2% of antibiotics procured from 82 health facilities surveyed were oral antibiotics.[4] Recent research indicates a notable difference in the use of injectable antibiotics compared to our findings, as data collected from primary healthcare facilities reveal a lower prevalence of these medications. Our analysis shows that cutting back on injectable antibiotics could significantly reduce healthcare costs. Additionally, a nationwide antimicrobial surveillance study conducted across three African countries found a staggering 98% increase in the purchasing of injectable antibiotics.[9,21,22] The level of the healthcare facility can influence antibiotic usage, particularly in tertiary hospitals that offer specialised services. This often results in a higher reliance on parenteral second and third line antibiotics.

Between 2020 and 2022, 46 to 56% of antibiotics sourced were categorised as Access, while up to 43% fell under Watch. Additionally, almost 9% of the Reserve category antibiotics were purchased at BMH. According to WHO guidelines, the use of these categories should ideally be over 90% for Access, under 10% for Watch, and below 1% for Reserve antibiotics.[9] Previous findings reported that 55% of antibiotics were for Access and 2% for the Watch category, while no Reserve antibiotics were procured.[13] Research on triplet studies conducted in sub-Saharan Africa revealed that Access class antibiotics were

utilised at the rates ranging from 65% to 90%. In comparison, Watch class antibiotics were consumed at a rate of 10% to 31%, while the consumption of Reserve antibiotics remained very low, typically at or below 10%.[9,21,22] Recent research supports our findings, showing a rise in the purchase of Reserve and Watch antibiotics among the less accessible groups. This decline in the procurement, prescribing, and use of these antibiotics may stem from successful Antimicrobial Stewardship (AMS) initiatives. Alternatively, it could be linked to factors such as inaccessibility, unavailability, and high cost of these medications. It's worth mentioning that Reserve and Watch antibiotics are typically pricey and necessitate hospitalisation for their prescription and administration.

Between 2020 and 2022, the antibiotics that saw the highest sales were ceftriaxone, amoxicillin combined with a beta-lactamase inhibitor, and meropenem. On the other hand, nitrofurantoin, benzylpenicillin injection, and benzathine penicillin injection were the least purchased. The variation in antibiotic procurement at BMH was influenced by patterns in prescribing, usage, and consumption. According to national treatment guidelines, hospitals need to be equipped to test, prescribe, and stock antibiotics appropriate to their level, which greatly affects their antibiotic expenses.[8,17] The procurement trends seem to be shaped by specialised services, particularly in areas such as major surgical procedures, complex infection management, cancer patient care, solid organ transplants, and hematopoietic stem cell procedures. In contrast, the antibiotics that are prescribed less often tend to be used for mild cases and are deemed essential for primary and secondary healthcare facilities, including dispensaries, health centres, and district hospitals.[19] Over the span of six years in the United States, expenditures on miscellaneous antibiotics topped the list at 21.1%. Following closely were tetracyclines at 20.9%, penicillins at 16.4%, and cephalosporins at 10.6%. Macrolides accounted for 9.6%, while quinolones made up 9.1%. Notably, spending on quinolones dropped significantly over the study period, whereas expenditures for cephalosporins and sulphonamides saw an upward trend.[19] Most expenses for tetracyclines, sulfamethoxazole/trimethoprim, macrolides, aminoglycosides, quinolones, and cephalosporins were in the outpatient setting. Penicillin had almost equivalent expenditures in the outpatient (45.0%) and inpatient (51.8%) settings.[6] There is a notable difference in expenditures between community settings and hospitals. Recent updates to the National Treatment Guidelines have resulted in a decreased reliance on quinolone antibiotics, which had previously been overprescribed and misused. This misuse accounted for as much as 25% of the antibiotics purchased by facilities.[6,19] Macrolide antibiotics such as azithromycin, erythromycin, and clarithromycin are commonly prescribed due to their affordability and the availability of generic options. By shifting the treatment strategy, we can decrease inappropriate prescribing and usage, ultimately leading to significant cost savings for healthcare facilities. In Sub-Saharan countries, the most frequently procured antibiotics include isoniazid (21 to 27%), flucloxacillin (10 to 13%), amoxicillin (7 to 9%), azithromycin (6 to 9%), and a combination of rifampicin, isoniazid, pyrazinamide, and ethambutol (6 to 7%).[6] In South Africa and Tanzania, the protocols for administering antibiotics for the treatment of tuberculosis (TB) exhibit notable differences. In Tanzania, the majority of antibiotics are acquired for specific programs and are distributed through primary health facilities. The government facilitates accessibility to these medications, thereby eliminating the need for these facilities to undertake procurement independently.[19] Syrup-formulated antibiotics are the most economical and frequently purchased medications in Tanzania, largely due to their widespread use in primary healthcare settings for the management of common pediatric infections. Consequently, their inventory levels are comparatively low in tertiary healthcare facilities when compared to other pharmaceuticals, such as ceftriaxone, azithromycin, and metronidazole, which are stocked in greater quantities.[19]

Based on our ABC analysis, less than 25% of procured antibiotics at BMH account for high expenditures, yet they represent over two thirds of the total costs. In 2020, only 5 out of 41 antibiotics (12.20%) fell into Category A, but these accounted for more than 68% of the total expenses. By 2021, Category A antibiotics made up 15.22% of all purchases while contributing over 64.24% to the total expenditure. In 2022, the top 10 antibiotics alone accounted for over 78% of the antibiotic spending.

Over the last three years, the three most frequently procured antibiotics at BMH have been ceftriaxone, amoxicillin/clavulanic acid, and meropenem. Together, these three antibiotics represent roughly half of the annual budget dedicated to antibiotic procurement, also driving a significant portion of the annual revenue from antibiotic sales. The increase in the annual budget for antibiotics may stem from the hospital's expansion of services between 2020 and 2022. With the introduction of new services, such as oncology, bone marrow transplants, open-heart surgeries, orthopaedics, and neurosurgery, it's likely that there was a corresponding rise in the consumption and purchasing costs of antibiotics. Additionally, the COVID-19 pandemic in 2021 and 2022 spurred heightened demand, supply challenges, and increased use of antibiotics.[23] This may have contributed to the overall rise in pharmaceutical spending. During the pandemic, ceftriaxone, meropenem, and azithromycin emerged as the most frequently prescribed antibiotics for managing bacterial infections that developed secondary to viral pneumonia in hospitalised patients.

Limitation

The ABC analysis conducted in this study did not encompass the procurement costs associated with vertical program antimicrobials, such as anti-tuberculosis medications provided free of charge by the Tanzanian government. Consequently, the role of low-cost antibiotics in contributing to antimicrobial resistance (AMR) may have been underappreciated, leading to potentially misleading conclusions based on procurement expenditures. To our knowledge, this represents the inaugural ABC analysis focusing on antibiotic procurement expenditures within a zonal referral hospital in Tanzania, leaving a gap in comparative local data. It is essential to note that this study is limited to a single healthcare facility; therefore, the findings may not be generalised to other healthcare institutions across Tanzania.

CONCLUSION AND RECOMMENDATION

A steady increase in antibiotic expenditures has been observed. However, the procurement, expenditure, and consumption of Access antibiotics are below the recommended threshold of 60%, resulting in increased spending and consumption of Watch and Reserve antibiotics. It is recommended to decrease the consumption and prescribing of Reserve antibiotics to avoid or prevent antimicrobial resistance. Regular analysis of antibiotic expenditures and consumption using the ABC-AWaRe classification may assist in guiding advanced AMS programs.

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