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# Antimicrobial use across six referral hospitals in Tanzania: a point prevalence survey

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## ABSTRACT

**Objective** To delineate the prevalence and factors associated with antimicrobial use across six referral hospitals in Tanzania using WHO point prevalence survey (PPS) methodology to inform hospital-specific antimicrobial stewardship programmes.

**Design** Cross-sectional analytical study.

**Setting** Six referral hospitals in Tanzania.

**Participants** Patients irrespective of age and gender (n=948) admitted in the six referral hospital wards before 8:00 hours on each day of the survey were included in December 2019. Using the WHO PPS methodology, data on hospitals, wards, patients, antibiotics, and indications for antibiotics were collected.

**Outcome measures** We analysed the prevalence of antibiotic use by referral hospital, ward, indication and patient characteristics as the main outcomes. We also described adherence to the Tanzania Standard Treatment Guidelines (STG) and WHO's AWaRe categorisation of antibiotics.

**Results** Approximately 62.3% of inpatients were prescribed antibiotics, predominantly from the Access group of antibiotics (ceftriaxone, metronidazole or ampicillin–cloxacillin). The overall adherence of antibiotic prescriptions to the Tanzania STG was high (84.0%), with the exception of Sekou Toure Regional Referral Hospital (68.0%) and Maweni Regional Referral Hospital (57.8%). The most common indication for antibiotic prescriptions was community-acquired infections (39.8%). Children less than 2 years of age (OR 1.73, 95% CI 1.02 to 2.92, p=0.039); admission to surgical wards (OR 4.90, 95% CI 2.87 to 8.36, p <0.001); and admission to paediatric wards (OR 3.93, 95% CI 2.16 to 7.15, p <0.001) were associated with increased odds of antibiotic use. Only 2 of 591 patients were prescribed antibiotics based on culture and antimicrobial susceptibility testing results.

**Conclusions** Empirical use of antibiotics is common, and the Access group of antibiotics is predominantly prescribed in children less than 2 years and patients admitted to surgical and paediatric wards. Lack of utilisation of antimicrobial susceptibility testing services in these hospitals requires urgent interventions. Routine monitoring of antibiotic use is recommended to be part of antibiotic stewardship programmes in Tanzania.

## Strengths and limitations of this study

► This Point Prevalence Survey has addressed one of the five strategic objectives of the Tanzania National Action Plan on Antimicrobial resistance (2017–2022) and has created benchmarking information to guide antimicrobial stewardship programmes.

► Data were collected from six referral hospitals in Tanzania connoting regional-wide representation of antibiotic use with a large sample size (n=948).

► This survey was based on the standardised WHO methodology and involvement of staff in these referral hospitals will enable them to conduct similar surveys to monitor temporal antibiotic use.

► We could not depict seasonal variations in antibiotics use as this was a point prevalence survey.

► It was not possible to delineate the contribution of prescribers' professional ranks to antibiotic prescription because some patients were prescribed multiple antibiotics by different prescribers.

## INTRODUCTION

Antimicrobial resistance (AMR) is an escalating threat to global health, endangering the ability to prevent and cure a wide range of infectious diseases.[1] The current AMR global crisis is the result of a number of factors, with inappropriate use of antibiotics and lack of antimicrobial use surveillance systems being core factors contributing to the spread of AMR.[2 3] The 2016 Global Health Security Agenda assessment concluded that AMR is a major problem in Tanzania and that there are high levels of inappropriate use of antimicrobials in the human and animal sectors.[4] Inappropriate antimicrobial use is likely accelerating the spread of AMR, which has clinical and cost implications for patients, communities and the healthcare system.[5 6] The development of national monitoring systems is an essential part of national action plans for AMR, as clearly stipulated in the Global Action Plan and the Tanzanian National Action Plan on AMR.[7–9] Hospitals

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are excellent settings for gaining understanding of antibiotic prescribing patterns.[10–12] Collecting hospital data on antimicrobial use and subsequently implementing informed interventions to optimise antibiotic use has significant potential to lower antibiotic resistance rates at local levels.

The WHO Methodology for Point Prevalence Survey (PPS) on antibiotic use in hospitals[13] is a standardised tool that allows for comparison of results within and among countries.[14–16] A large study involving 53 countries reported a lower proportion of antibiotic use in North American and European countries (<40.0%), whereas the overall proportion of antibiotic use in African countries was 50.0%.[17] Because there is limited information on antibiotic use that used WHO's PPS methodology in the East African Region and Tanzania in particular,[18] the primary objective of the present study was to collect information on antibiotic prescriptions in selected referral hospitals to estimate the prevalence of antibiotic use in these hospitals. A secondary objective was to use this information to inform interventions at the local and national levels aimed at improving antibiotic prescribing, antibiotic use and antimicrobial stewardship (AMS) programmes.

## METHODS

### Study design, settings and duration

This PPS on antibiotic use was conducted in December 2019 at six referral hospitals in the United Republic of Tanzania. Mbeya Zonal Referral Hospital (ZRH) is located in the Southern Highlands with 553 total bed capacity and 323 536 total hospital annual admissions, and 346 hospital beds were included in the survey. The respective values for the other five referral hospitals were Benjamin Mkapa ZRH (Central area): 400, 5934 and 67; Sekou Toure Regional Referral Hospital (RRH) (Lake Victoria area): 315, 22 068 and 226; Temeke RRH (Costal area): 309, 11 792 and 224; Bukoba RRH (Northern area): 308, 11 009 and 163; and Maweni RRH (Western area): 168, 9121 and 54. These hospitals provide services to patients referred from lower tiers of healthcare facilities (ie, district hospitals, health centres and dispensaries). However, a ZRH serves as a tertiary hospital with more specialty services and also provide services to patients referred from RRHs.

### Study population, inclusion and exclusion criteria

In accordance with the WHO methodology for PPS, all patients (irrespective of age and gender) admitted in the referral hospital wards before 8:00 hours on the day of the survey were included.[13] Only antibiotics administered through oral, parenteral, rectal or inhalation routes were included. The WHO PPS methodology recommends that for hospitals with <500 total inpatient beds, all patients meeting the inclusion criteria must be surveyed. Since hospital bed size in all six surveyed hospitals did not exceed 500 beds, no sample size estimation was needed, and all patients on the day of survey were enrolled.[13]

Inpatients with incomplete data in their medical files were excluded from the PPS.

### Sampling methods and sample size

The six prioritised referral hospitals were chosen based on multiple criteria for ongoing, cross-cutting interventions on infection prevention and control (IPC) measures and AMS. These included: (1) country's zonal/regional representation; (2) presence of hospital staff recently trained on the new IPC guidelines; (3) presence of any other implementing partner performing AMR surveillance-related work and (4) hospitals that were not involved in a previously conducted PPS by WHO and the Ministry of Health, Community Development, Gender, Elderly and Children in Tanzania. These six hospitals were approved as intervention sites by the National AMR Multi-sectoral Coordination Committee. Data collection was completed in each hospital within a week after the first day of data collection. To minimise the impact of patients moving between wards, each ward was completely surveyed in 1 day. Of the 2053 total beds in the six referral hospitals surveyed, 1080 patients were eligible (the remaining beds were unoccupied). Of these, a total 948 (87.8%) were included for data analysis. The remaining patients were not enrolled because of incomplete and/or mismatching of information in the medical files/records.

### Data collection

A comprehensive training on the protocol for PPS for participating hospital staff involving doctors, pharmacists and nurses and staff from the Ministry of Health, Community Development, Gender, Elderly and Children (deemed research assistants in this paper) was conducted by the coinvestigators in Dar es Salaam, Tanzania, 10 December 2019–13 December 2019, prior to data collection 16 December 2019–21 December 2019. One component of the training was a session on the protection of study participants, with an emphasis on data confidentiality, patient privacy, and hospital staff privacy. The training sessions included practising with and pilot testing the data collection forms and methods.

Antimicrobial drug regimens prescribed to patients hospitalised at or before 08:00 hours on the days of the PPS were abstracted from patient files and other medical records. The records of all patients meeting the eligibility criteria were included in the PPS irrespective of whether they received antibiotic treatment. Antibiotics were classified according to the Anatomical Therapeutic Chemical Classification (ATC) methodology developed by the WHO Collaborating Centre for Drug Statistics Methodology in Oslo, Norway,[19] and by the 2019 WHO AWaRe (Access, Watch and Reserve) classification of antibiotics.[20]

Study endpoints were the prevalence of antibiotic use, WHO's AWaRe categorisation of antibiotics, ward, indication and patient characteristics. No patient interviews and no clinician or health facility staff interviews were performed. Any engagement with health facility staff was only for the purpose of retrieval of medical records.

## Data management

Data were entered in a standardised MS Excel template. The data were subjected to a quality check process and were subsequently analysed using STATA (software V.13.0) in accordance with the objectives of the PPS. Each spreadsheet was uploaded to a secure, password-protected Microsoft One-Drive that could only be accessed by the investigators. Only deidentified patient and provider data were recorded. Core variables collected were specified in the WHO PPS methodology for each of the following categories: hospital variables, ward variables, patient variables (anonymised), prescribers' professional ranks, indication of antibiotic treatment variables and prescribed antibiotics variables. Antimicrobial use was defined as types and quantities of antimicrobials used by a patient in a hospital during a specific period of time. Continuous variables were described as mean±SD or median (plus IQR), depending on the distribution of data. Categorical variables were described and presented in frequencies and percentages (proportions). These data allowed disaggregation of outcome variable (ie, antibiotic use) by patient characteristics (ie, gender and age), wards, hospitals and antibiotic treatment indication. Univariate and multivariate logistic regression analyses were done to ascertain the independent predictor variables for antibiotic use using OR, 95% CI. Any factor with a $p \leq 0.05$ in univariate analysis was subjected to multivariate analysis. A $p \leq 0.05$ was considered to be statistically significant.

Permission to conduct this PPS was provided by the respective regional and hospital authorities. As this PPS did not directly involve patients but rather their information in medical files/records, a waiver of consent was requested from the authorities of the participating hospitals. Trained research assistants from the national level and local referral hospitals' health personnel were involved to help build a foundation for continuous monitoring of antibiotic prescription and use in the context of strengthening AMS programmes.

## Patients and public involvement statement

This PPS was conducted as part and parcel of the implementation of the Tanzania National Action Plan on AMR (2017–2022).

## RESULTS

### Baseline demographic and clinical information of patients enrolled

Data from 948 patients were included in this study, with female patients accounting for 58.3%. The overall median age (IQR) among patients ≥2 years of age was 32 (22–47.5) years, whereas the median age for patients<2 years was 3 (1–10) months. Most of the patients were enrolled from Mbeya ZRH (36.2%), and the majority had indwelling peripheral vascular catheters (73.5%)

**Table 1** Demographic and clinical characteristics of enrolled patients at Tanzanian zonal hospitals, n=948

| Variable | No (%) |
| --- | --- |
| Gender | |
| Male | 395 (41.7) |
| Female | 553 (58.3) |
| Hospital | |
| Mbeya ZRH | 343 (36.2) |
| Temeke RRH | 176 (18.6) |
| Sekou Toure RRH | 171 (18.0) |
| Bukoba RRH | 140 (14.8) |
| Benjamin Mkapa ZRH | 64 (6.8) |
| Maweni RRH | 54 (5.7) |
| Wards | |
| Adult medical | 267 (28.2) |
| Adult surgical | 119 (12.6) |
| Paediatrics | 140 (14.8) |
| Intensive care unit | 45 (4.8) |
| Mixed | 377 (39.8) |
| McCabe score | |
| Non-fatal | 817 (86.2) |
| Rapidly fatal | 24 (2.5) |
| Ultimately fatal | 73 (7.7) |
| Not reported | 34 (3.6) |
| Presence of central vascular catheter | 14 (1.5) |
| Presence of peripheral vascular catheter | 697 (73.5) |
| Indwelling urinary catheter | 282 (29.7) |
| Patients intubated | 20 (2.1) |
| Patients with malaria during current hospitalisation | 79 (8.3) |
| Patients with tuberculosis during current hospitalisation | 22 (2.3) |
| Patients with HIV infections | 61 (6.4) |
| Previous history of hospitalisation (within 90 days) | 84 (8.9) |

RRH, regional referral hospital; ZRH, zonal referral hospital.

(table 1). Approximately one-quarter of patients were referred from other hospitals (26.4%, n=250).

### Antibiotic use

A total of 591 (62.3%) patients were receiving antibiotic treatment during the PPS. Hospital-specific proportions of patients receiving antibiotics ranged from 51.3% in Mbeya ZRH to 74.3% in Sekou Toure RRH (figure 1). The majority of patients on antibiotics were given one (37.1%, n=219) or two agents (54.8%, n=324). Three, four and five antibiotics were prescribed in 6.9% (n=41), 0.9% (n=5) and 0.3% (n=2) of cases, respectively. Only two patients were specifically treated based on antimicrobial susceptibility test (AST) laboratory results.
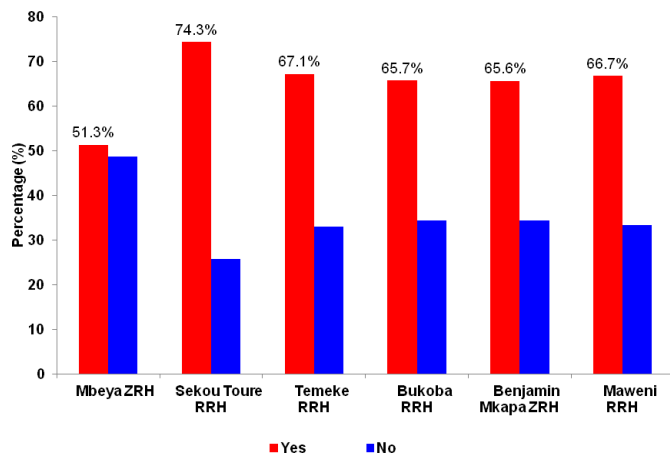
**Figure 1** Proportions of antibiotic use across six referral hospitals. RRH, regional referral hospital; ZRH, zonal referral hospital.

### Distribution of antibiotic prescriptions by referral hospital and ward

A total of 1013 antibiotics were prescribed to patients during the PPS. The most commonly used antibiotics were ceftriaxone (30.9%), metronidazole (22.9%), ampicillin–cloxacillin (17.0%) and gentamicin (11.0%). Ceftriaxone, metronidazole and gentamicin were prescribed in all hospitals, whereas vancomycin, moxifloxacin and meropenem were prescribed only at ZRHs. Antibiotic prescriptions were predominantly in the mixed ward (n=389, 38.4%), followed by adult medical wards (n=205, 20.2%) and paediatric wards (n=194, 19.2%) (table 2).

### Diagnoses underlying the indication for antibiotic therapies

Most antibiotics were used for community-associated infections (36.7%), followed by surgical prophylaxis (30.2%) and medical prophylaxis (24.0%). Ceftriaxone and metronidazole were predominant antibiotics regardless of the indications (table 3).

A total of 670 diagnoses underlying the indication for antibiotic therapies were recorded. The most common diagnoses was skin, soft tissue, bone and joint infections (17.2%, n=115) and gastrointestinal tract infections (12.7%, n=85). Other diagnoses were obstetric and gynaecological infections (10.9%, n=73); cardiovascular system infections (10.7%, n=72); respiratory tract infections (10.4%, n=70); central nervous system infections (4.6%, n=31); urinary tract infections (3.0%, n=20) and other infections (6.7%, n=45). However, antibiotic use for a purpose other than treatment was reported in 127 (19.0%) patients and in 32 diagnoses (4.8%) where there was a completely undefined site with no systemic inflammation.

### Adherence to the Tanzania standard treatment guidelines

Of the 1013 antibiotics assessed, information on adherence was reported in 998 antibiotics, and the overall compliance was 84.0%. The highest compliance rates were observed in Temeke RRH (99.5%), Mbeya ZRH (94.0%) and Bukoba RRH (90.2%). Adherence rates

at the remaining hospitals were Benjamin Mkapa ZRH (72.4%), Sekou Toure RRH (68.0%) and Maweni RRH (57.8%).

### Aware classification of antibiotics

A total of 991 (97.9%), 18 (1.8%) and 3 (0.3%) antibiotics were classified as Access, Watch and Reserve, respectively. Interestingly, all three antibiotics in the Reserve group were prescribed in the ZRH (see online supplemental table 1).

### Factors associated with antibiotic use

Factors associated with increased odds of antibiotic use were age less than 2 years, male gender and type of hospital ward. Admission to Mbeya ZRH and patients with no previous admission within 90 days were associated with decreased odds of antibiotic use. The multivariate logistic regression analysis showed that independent predictors for antibiotic use were children less than 2 years of age (OR 1.73, 95% CI 1.02 to 2.92, p=0.039); admission to surgical wards (OR 4.90, 95% CI 2.87 to 8.36, p<0.001); and admission to paediatric wards (OR 3.93, 95% CI 2.16 to 7.15, p<0.001) (table 4).

### DISCUSSION

Monitoring of antibiotic use in hospitals is a pivotal component of AMS programmes and is crucial to informing national and hospital policies and practices aimed at improving antibiotic use and guiding procurement of these agents. In this PPS, empirical use of antibiotics was high (62.3%), with subtle variations across hospitals. Similarly, high proportions of antibiotic use have been previously reported in Kenya (67.7%), Botswana (70.6%), Nigeria (69.7%) and Jordan (78.2%).[18 21–23] In contrast to these findings, low proportions of antibiotics use have been reported in South Africa (37.7%), Brazil (42.5%), UK (40.9%), Northern Ireland (46.2%) and Belgium (27.1%).[14 23–26] The differences can be accounted for by varying stringency pertaining to antimicrobial use guidelines/policies across countries, differences in patients' characteristics, and the need to administer antibiotics in patients referred to tertiary and specialised hospitals. In Tanzania, previous studies (each based on one centre) that used a non-PPS methodology also reported a high proportion of antibiotic use (42.6%–84.9%).[5 11 27 28]

The most common antimicrobial agents reported in this PPS were ceftriaxone and metronidazole, regardless of the hospitals or wards/units where the patients were admitted and the indications for antibiotic prescriptions. These agents are relatively inexpensive and widely available in Tanzania and are used routinely for surgical prophylaxis and treatment of invasive infections. They are also Access antibiotics listed in the Standard Treatment Guidelines.[29] This is consistent with findings from two other studies in Tanzania.[27 28] On the other hand, vancomycin (Watch antibiotic) and moxifloxacin and meropenem (Reserve antibiotics in the Standard Treatment Guidelines) were

**Table 2** Distribution of antibiotic prescriptions by referral hospital and ward

| Antibiotic prescriptions | Hospital | | | | | | Hospital wards | | | | | Total, n (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bukoba RRH | Benjamin mkapa ZRH | Maweni RRH | Mbeya ZRH | Sekou Toure RRH | Temeke RRH | Adult medical | Adult surgical | Paediatrics | ICU | Mixed | |
| Amoxicillin | 17 | 0 | 1 | 0 | 1 | 0 | 2 | 0 | 1 | 0 | 16 | 19 (1.8) |
| Ampicillin | 27 | 1 | 18 | 7 | 7 | 10 | 12 | 1 | 20 | 0 | 37 | 70 (6.9) |
| Amoxicillin–clavulanate | 0 | 1 | 0 | 9 | 0 | 0 | 2 | 3 | 0 | 0 | 5 | 10 (1.0) |
| Ampicillin–cloxacillin | 12 | 0 | 3 | 81 | 33 | 43 | 16 | 37 | 40 | 17 | 62 | 172 (17.0) |
| Azithromycin | 1 | 0 | 0 | 3 | 10 | 1 | 10 | 0 | 2 | 1 | 2 | 15 (1.5) |
| Ceftriaxone | 31 | 32 | 14 | 86 | 95 | 55* | 92* | 74 | 45 | 10 | 92 | 313 (30.9) |
| Other cephalosporins† | 1 | 0 | 0 | 1 | 4 | 2 | 3 | 1 | 1 | 1 | 2 | 8 (0.8) |
| Chloramphenicol | 0 | 0 | 0 | 4 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 4 (0.4) |
| Ciprofloxacin | 0 | 2 | 0 | 6 | 1 | 2 | 5 | 1 | 2 | 0 | 3 | 11 (1.1) |
| Sulfamethoxazole/trimethoprim | 1 | 1 | 0 | 2 | 4 | 2 | 9 | 0 | 0 | 0 | 1 | 10 (1.0) |
| Erythromycin | 3 | 0 | 0 | 2 | 3 | 0 | 2 | 0 | 0 | 0 | 6 | 8 (0.8) |
| Flucloxacillin–amoxicillin | 0 | 1 | 1 | 2 | 2 | 0 | 1 | 3 | 1 | 0 | 1 | 6 (0.6) |
| Gentamicin | 16 | 6 | 10 | 20 | 18 | 42 | 1 | 5 | 60 | 15 | 31 | 112 (11.0) |
| Metronidazole | 22 | 23 | 16 | 68 | 61 | 42 | 42 | 49 | 12 | 5 | 124 | 232 (22.9) |
| Penicillin** | 1 | 0 | 1 | 1 | 0 | 10 | 2 | 0 | 9 | 0 | 2 | 13 (1.3) |
| Other antibiotics‡ | 0 | 1 | 1 | 4 | 3 | 1 | 4 | 1 | 1 | 1 | 3 | 10 (1.0) |
| Total, N (%) | 132 (13.0) | 68 (6.7) | 65 (6.4) | 296 (29.2) | 242 (23.9) | 210 (20.7) | 205 (20.2) | 175 (17.3) | 194 (19.2) | 50 (4.9) | 389 (38.4) | 1013 (100.0) |

*Ceftriaxone–salbactam (n=1).
†Cefadroxil (1); cefixime (1); cefotaxime (1); cephalexin (5).
‡Phenoxymethylpenicillin or benzylpenicillin.
§Doxycycline (2), clarithromycin (3), moxifloxacin (1), vancomycin (2) and meropenem (2).
ICU, intensive care unit; RRH, regional referral hospital; ZRH, zonal referral hospital.

**Table 3**  Distribution of antibiotic prescriptions by indications

| Antibiotic prescriptions | Indications | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| | CAI | HAI | Medical prophylaxis | Surgical prophylaxis | Other indications | Total, n (%) |
| Amoxicillin | 6 | 1 | 6 | 4 | 2 | 19 (1.8) |
| Ampicillin | 29 | 5 | 13 | 17 | 4 | 68 (6.6) |
| Amoxicillin–clavulanate | 4 | 0 | 0 | 6 | 0 | 10 (1.0) |
| Ampicillin–cloxacillin | 53 | 7 | 60 | 58 | 3 | 181 (17.5)* |
| Azithromycin | 10 | 0 | 4 | 0 | 0 | 14 (1.4) |
| Ceftriaxone | 141§ | 18 | 57 | 95 | 7 | 318 (30.8)* |
| Other cephalosporins | 6 | 0 | 1 | 0 | 1 | 8 (0.8)† |
| Chloramphenicol | 1 | 1 | 1 | 1 | 0 | 4 (0.4) |
| Ciprofloxacin | 6 | 1 | 3 | 2 | 0 | 12 (1.2)* |
| Sulfamethoxazole/trimethoprim | 9 | 0 | 1 | 0 | 0 | 10 (1.0) |
| Erythromycin | 4 | 1 | 2 | 1 | 0 | 8 (0.8) |
| Flucloxacillin–amoxicillin | 2 | 0 | 2 | 1 | 1 | 6 (0.6) |
| Gentamicin | 49 | 8 | 48 | 9 | 0 | 114 (11.0)* |
| Metronidazole | 76 | 13 | 34 | 102 | 12 | 237 (22.9)* |
| Penicillin‡ | 11 | 0 | 0 | 0 | 2 | 13 (1.2) |
| Other antibiotics§ | 4 | 1 | 3 | 1 | 1 | 10 (1.0)* |
| Total, N (%) | 411 (39.8) | 56 (5.4) | 235 (22.8) | 297 (28.8) | 33 (3.2) | 1032 (100.0)¶ |

*Antibiotics used for multiple indications.
†Cefadroxil (1); cefixime (1); cefotaxime (1); cephalexin (5).
‡Phenoxymethylpenicillin or benzylpenicillin.
§Ceftriaxone–salbactam (n=1).
¶Clarithromycin (3), doxycycline (2), meropenem (2), vancomycin (3).
CAI, community-associated infection; HAI, hospital-associated infection.

used in Benjamin Mkapa ZRH and Mbeya ZRH in five of 1013 prescriptions. The predominance of ceftriaxone and metronidazole and the small number of vancomycin and meropenem prescriptions are comparable to other studies from Nigeria, Botswana and Kenya, indicating similar economical, epidemiological and clinical predispositions in these sub-Saharan African countries.[18 21 22] Restricted use of meropenem and vancomycin is appropriate because these are the last-line treatment options for severe invasive infections caused by gram negative and gram positive bacteria, respectively. The most common indications for antibiotic prescriptions were community-acquired infections, surgical prophylaxis and medical prophylaxis. These indications are also tallying with the predominant diagnoses of skin, soft tissue, bone and joint infections and gastrointestinal tract infections.

High adherence of prescriptions to the standard treatment guidelines in the current study (84.0%) is similar to previous studies in South Africa (98.0%), Northern Ireland (72.0%–81.8%), Jordan (92.2%–92.7%), Brazil (76.5%–87.3%) and Belgium (76.6%).[23–26] In contrast to these findings, a study in Nigeria found low adherence, ranging from 0.3% to 7.2%.[22] The finding of high adherence in Mbeya ZRH (94.0%), in contrast to the 63.0% found in 2018 by another study in the same hospital, may

be accounted for by the possibility of postsurvey sensitisation and/or awareness.[28] This is further exemplified by the low proportion of antibiotic use in this hospital, which is in contrast to all other hospitals. The findings of moderate adherence to the Standard Treatment Guidelines in Sekou Toure RRH and Maweni RRH call for in-depth analysis on the underlying causes and provision of specific remedial measures.

Despite the availability of AST services in four of the six surveyed referral hospitals, only two patients were specifically treated based on laboratory results. There is generally poor availability of AST in hospitals in resource-limited countries and limited availability of trained staff. In Tanzania, only 7 of 39 hospitals reported to conduct AST and keep surveillance reports.[30] Therefore, in our study, the root causes of low AST services utilisation need to be delineated both at individual and/or hospital levels. For example; is it cost for AST services which hinder patients' access? Or constraints in laboratory supplies which limit laboratory technologists/scientists to perform AST after isolating a pathogen? Or is it lack of documentation of the laboratory results to the patients' files in the wards? Or just a coincidental finding based on the nature of the PPS methodology? In contrast to our findings, appreciable numbers of patients were managed based on laboratory

**Table 4** Factors associated with antibiotic use among patients in six hospitals

| Variable (N) | Antibiotic use (n, (%)) | Univariate analysis | | Multivariate analysis | |
|---|---|---|---|---|---|
| | | 95% CI | P value | 95% CI | P value |
| **Age category (years)** | | | | | |
| ≥2 (781) | 459 (58.8) | 1 | | | |
| <2 (167) | 132 (79.0) | 2.64 (1.78 to 3.94) | <0.001 | 1.73 (1.02 to 2.92) | 0.039 |
| **Gender** | | | | | |
| Male (395) | 263 (66.6) | 1 | | | |
| Female (553) | 328 (59.3) | 0.73 (0.56 to 0.96) | 0.023 | 0.96 (0.72 to 1.29) | 0.801 |
| **Hospital\*** | | | | | |
| Bukoba RRH (140) | 92 (65.7) | 1 | | | |
| Benjamin Mkapa ZRH (64) | 42 (65.6) | 0.99 (0.53 to 1.86) | 0.990 | | |
| Maweni RRH (54) | 36 (66.7) | 1.04 (0.54 to 2.03) | 0.900 | | |
| Mbeya ZRH (343) | 176 (51.3) | 0.55 (0.37 to 0.83) | 0.004 | | |
| Sekou Toure RRH (171) | 127 (74.3) | 1.51 (0.92 to 2.46) | 0.101 | | |
| Temeke RRH (176) | 118 (67.1) | 1.06 (0.66 to 1.70) | 0.803 | | |
| **Ward** | | | | | |
| Adult medical (267) | 128 (47.9) | 1 | | | |
| Adult surgical (119) | 98 (82.4) | 5.07 (2.99 to 8.60) | <0.001 | 4.90 (2.87 to 8.36) | <0.001 |
| Paediatrics (140) | 118 (84.3) | 5.82 (3.48 to 9.74) | <0.001 | 3.93 (2.16 to 7.15) | <0.001 |
| Intensive care unit (45) | 29 (64.4) | 1.97 (1.02 to 3.79) | 0.043 | 1.23 (0.57 to 2.64) | 0.595 |
| Mixed (377) | 218 (57.8) | 1.49 (1.09 to 2.04) | 0.013 | 1.37 (0.99 to 1.90) | 0.06 |
| **Previous hospitalisation†** | | | | | |
| No (650) | 426 (65.4) | 1 | | | |
| Yes (84) | 44 (52.4) | 0.58 (0.37 to 0.91) | 0.019 | 0.88 (0.74 to 1.03) | 0.114 |
| **CAI** | | | | | |
| No (366) | 327 (89.3) | 1 | | | |
| Yes (277) | 249 (89.9) | 1.06 (0.64 to 1.77) | 0.822 | | |
| **HAI** | | | | | |
| No (608) | 545 (89.6) | 1 | | | |
| Yes (35) | 31 (88.6) | 0.90 (0.31 to 2.61) | 0.841 | | |
| **Medical prophylaxis** | | | | | |
| No (479) | 434 (90.6) | 1 | | | |
| Yes (164) | 142 (86.6) | 0.67 (0.39 to 1.15) | 0.148 | | |
| **Surgical prophylaxis** | | | | | |
| No (474) | 419 (88.4) | 1 | | | |
| Yes (169) | 157 (92.9) | 1.71 (0.90 to 3.29) | 0.103 | | |
| **Other indications not specified** | | | | | |
| No (620) | 557 (89.8) | 1 | | | |
| Yes (23) | 19 (82.6) | 0.54 (0.18 to 1.63) | 0.272 | | |

\*Hospital variable was removed in the multivariate model because of collinearity with ward.
†Within 90 days and 214 were removed as their hospitalisation status was unknown.
CAI, community-associated infections; HAI, hospital-associated infections; RRH, regional referral hospital; ZRH, zonal referral hospital.

results in South Africa, Brazil and Belgium.[24–26] Therefore, to avert the empirical use of antibiotics in these referral hospitals, it is recommended that similar PSS be routinely conducted to assess the trend. Also, addressing hospital-based and/or individual-based factors hindering routine provision of this service in the context of the Tanzanian National Action Plan on AMR implementation is urgently needed.[8] Future research should aim to identify the root causes of poor availability and uptake of AST through in-depth interview with the key stakeholders

(ie, patients, prescribers, dispensers, laboratory experts, managers and other AMS champions).

It is well known that prescribers, patients and healthcare facilities' infrastructures can contribute to inappropriate antibiotic use, and therefore, judicious mitigation is required to ensure appropriate use of these agents and prevent AMR.[31] In this PPS, children less than 2 years of age, admission to surgical wards and admission to paediatric wards were associated with increased odds of being prescribed antibiotics. Patients admitted to surgical wards are more likely to be given antibiotics before and after surgical interventions. On the hand, children's conditions are unpredictable and in some cases progression of infectious disease to fatal outcomes is common, and therefore, some clinicians opt to prescribe antibiotics empirically. Nevertheless, a need to collect appropriate samples for culture and antimicrobial susceptibility services prior to institution of antibiotics is reiterated to guide specific treatments. Children less than 15 years of age had increased odds of being given antibiotics in a study conducted in Eritrea.[32] A study in China showed that patient pressure, time pressure, financial incentives and institutional environment can also predict antibiotic prescriptions and subsequent use.[31]

This is the first study from Tanzania that utilised the WHO PPS methodology and is being reported in the public domain. Tanzania was among five countries in the WHO African region that participated in the 2018 pilot for the WHO PPS methodology prior to its final release by WHO. Therefore, the institutional experience of the Tanzania Ministry of Health, Community Development, Gender, Elderly and Children on implementation of the WHO PPS methodology facilitated rapid transfer of learning and uptake by staff in the six hospitals. WHO's International Health Regulations Benchmark 3.4 on optimising use of antimicrobials recommended that member states monitor antimicrobial use, among other AMS activities, in designated health facilities to reach capacity level 3.[33] As WHO's AMS practical toolkit recommends, our future interventions will ensure that a suitable governance structure, such as an AMS committee, exists.[34] Hospital medicines and therapeutics committee are also recommended to be utilised as a platform for AMS interventions by the Pharmaceutical Services Unit of the Ministry of Health, Community Development, Gender, Elderly and Children. We anticipate that the participating hospitals will use the study findings through these governance structures and identify feasible targets for stewardship. In addition, our future interventions will assess why uptake of antimicrobial susceptibility services is limited and identify barriers and workflow solutions.

### Limitations

Some of the limitations in this PPS were related to its design. For example, we could not depict seasonal variations in antibiotics use. However, the study has given a baseline assessment on which other studies that use the PPS methodology can be compared. It was not possible to delineate the contribution of prescribers' professional ranks to antibiotic prescription because some patients were prescribed multiple antibiotics by different prescribers. As designed, our study did not conduct any qualitative interviews with hospital physicians.

### CONCLUSIONS AND IMPLICATIONS

Approximately 62.3% of inpatients were prescribed antibiotics empirically, with the predominance of ceftriaxone and metronidazole irrespective of wards/units, hospitals or indications. The adherence of antibiotic prescriptions to the Tanzania Standard Treatment Guidelines was encouraging (84.0%) with the exception of Sekou Toure RRH and Maweni RRH. The most common indication was community-acquired infections. Children less than 2 years of age and admission to surgical and paediatric wards had increased odds of being prescribed antibiotics. These groups should be prioritised in the mitigation strategies for antibiotic stewardship. In this PPS, all referral hospitals involved are publicly owned and therefore future studies should focus on delineating antibiotic use in both public and private hospitals. Lack of utilisation of AST services in these hospitals is worrisome and requires urgent interventions.

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