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Evaluation of Antimicrobial Utilization and Concordance with National Guidelines at a Tertiary Hospital in the Southern Highlands Zone of Tanzania

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Abstract. Antimicrobial resistance is a growing concern in sub-Saharan Africa, and antimicrobial stewardship (AMS) programs have not been widely implemented in this region. We evaluated antibiotic prescribing patterns and concordance with national guidelines at Mbeya Zonal Referral Hospital (MZRH) in Tanzania. Adult inpatient medical records were chronologically reviewed from January 1, 2018 until 100 records documenting antibiotic therapy were evaluated. The primary endpoint was concordance with national guidelines for indication-based antibiotic selection and duration. Data were summarized using descriptive statistics. Overall, 155 records with sufficient data were reviewed. The 100 records which involved antibiotic therapy represented 171 unique antibiotic courses. The most common indication for antibiotics was bacterial pneumonia. Ceftriaxone and metronidazole, the most commonly used antibiotics, were administered in 40% and 24% of courses, respectively. Indication-based antibiotic selection was concordant with national guidelines in 63% of courses, but this fell to 15% when course duration was taken into account. Antibiotic courses were completed as prescribed 28% of the time among evaluable courses. A microbiologic culture of any kind was obtained in 17% of patients. In conclusion, antibiotic therapy was often incomplete, was generally guideline discordant, exhibited limited diversity of selection, and frequently lacked diagnostic confirmation. These data, combined with local susceptibility patterns, may be used to foster AMS efforts for improved compliance with guidelines at MZRH in the future.

INTRODUCTION

Antimicrobial resistance (AMR) is a growing problem worldwide, and low-income and middle-income countries (LMICs) are significantly impacted. As the global consumption of antibiotics continues to rise, LMICs likely shoulder a greater burden of antibiotic-resistant infections than do high-income countries.[1] Much of this resistance is a result of antibiotic overuse and misuse, including routine use without a prescription or clinician oversight in LMICs.[1,2] In addition, clinicians often prescribe antibiotics unnecessarily and inappropriately.[2] Seeing this trend, a global response has materialized and the WHO initiated a Global Action Plan on AMR in 2015.[1,3]

In many high-income countries, antimicrobial stewardship (AMS) programs have been widely implemented at health care facilities and have proven to be effective at modifying antibiotic utilization through protocol development, clinician education, and ongoing assessment of guideline adherence, all of which limit the development of AMR.[4,5] An initial critical step in establishing AMS programs is assessing current antibiotic utilization at the facility level, a primary metric for evaluating the effectiveness of AMS interventions.[4,5] Assessing clinician adherence to local and national guidelines assists in optimizing empirical antibiotic usage and improving clinical outcomes.[5] Although these AMS interventions have proven to be effective in high-income countries, establishment of AMS programs in LMICs faces unique challenges.[6] Despite this, several successful AMS programs have been implemented in Africa.[7–9]

Tanzania, located in East Africa, faces similar AMR concerns to those of other LMICs with reported high rates of extended spectrum beta-lactamase (ESBL)–producing Enterobacteriaceae and beta-lactam resistance among *Streptococcus pneumoniae* isolates.[10] Mbeya Zonal Referral Hospital (MZRH), located in the Southern Highlands Zone of Tanzania, is the referral site for a zonal population of more than six million people. Although extensive HIV-focused research has been performed in the Mbeya region, to date, no study has focused on antibiotic prescribing patterns or AMS practices there. Given the extensive AMR throughout Tanzania and the absence of any previous related research in the Southern Highlands region, MZRH presents an ideal location for study.

The University of South Carolina (UofSC) School of Medicine and College of Pharmacy have had an ongoing relationship with MZRH since 2012. The institutions have engaged in multiple research collaborations and student/faculty exchange. While collaborating on other projects, authors of this article from both institutions have anecdotally noted several barriers to optimal antibiotic utilization (e.g., medication access difficulties, lack of local guidelines, and inconsistently performed diagnostics) common to many LMICs.[6] The purpose of this study was to evaluate current antibiotic utilization and assess clinician concordance with national prescribing guidelines in a cross-sectional, retrospective convenient sample of inpatients at MZRH.

MATERIALS AND METHODS

This was a retrospective, single-center study conducted at MZRH. This study was approved by the institutional review boards at MZRH, Tanzania's National Institute for Medical Research, and the UofSC. Given this was a retrospective chart review, the study was exempt from informed consent requirements. Beginning with January 1, 2018, we chronologically reviewed all adult inpatient medical records for the MZRH male and female medical wards until 100 charts involving antibiotic therapy were included. This sample size was

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selected because it was modest enough to be achieved, given the inherent difficulties of chart abstraction at MZRH at that time, yet large enough for an adequate descriptive analysis to be completed. Included wards have patients aged 15 years and older admitted to the hospital from the emergency department or as a transfer from an outside facility for a nonsurgical primary diagnosis. Charts were chosen for review if they contained the necessary medication administration record (MAR) data, which at MZRH, during the study period, was documented on a separate, paper record. If this MAR was unavailable and review was not possible, the chart was assigned a study number, but otherwise omitted. Reviewed charts that did not involve antibiotic administration were categorized as "partial reviews," and limited metrics were gathered, including demographics, admission and discharge diagnoses, infection-pertinent comorbid conditions, length of stay, in-house mortality, and payer status. Of note, if an antibiotic was mentioned in the clinician note for a patient, but was never administered, this was also counted as a partial review, as clinician notes were often incompletely reflective of medications actually administered. If the record did involve the administration of inpatient antibiotics, it was categorized as a "full review," and, in addition to the aforementioned metrics, data on diagnostics obtained and antibiotic utilization (i.e., antibiotic name, indication, route, cost, days of therapy (DOTs) prescribed, DOTs administered, doses administered, and doses missed) were also gathered. The primary endpoint of prescribing pattern was reported as proportion of antibiotic utilization per patient, DOTs per 1,000 patient days, concordance with national guidelines, and antibiotic completion rate. Antiviral, antiparasitic, and antifungal medications were not included. Long-term prophylactic antibiotic courses for opportunistic infections were also excluded. Data were collated into Microsoft Excel for Mac 2011 (version 14.3.9, Microsoft Corp., Redmond, WA) in a de-identified manner using assigned study numbers. A separate key linking the medical records to their assigned study numbers was maintained and stored in a separate, password-protected location.

Statistical analysis was performed using descriptive statistics. Metrics that were calculated using descriptive statistics included average age, gender distribution, frequency of comorbidities, common admission and discharge diagnoses, patient payer source (insured versus cash pay), average length of stay, in-house mortality and 30-day readmission occurrences, frequency of diagnostic testing, most common antibiotics used overall and for each of the five most common infections, average number of antibiotic doses missed, frequency of antibiotic course completion and course exceeding the prescribed duration, and average antibiotic cost. Days of therapy per 1,000 patient days were calculated only for the patients included in the study, not for the general hospital population. Antibiotics prescribed for each infection were compared with disease-specific recommendations from the Tanzania Standard Treatment Guidelines and National Essential Medicines List, 5th edition,[11] which serves as a standard of care for Tanzania. Released in 2017, this document is a compilation of evidence-based recommendations from the WHO and other international medical associations. To do this, each administered antibiotic course was compared with the disease-specific recommendations in the Tanzania Standard Treatment Guidelines, categorizing them as either "concordant" or "discordant" with recommended antibiotic choice(s) and prescribed duration of treatment (in days). Both antibiotic choice concordance alone and combined choice and duration concordance were evaluated. For example, the guidelines recommend oral amoxicillin 500–1,000 mg every 8 hours for 5 days for a mild community-acquired pneumonia or ceftriaxone 1 g every 12 hours for 7–10 days for a severe case. If the documented cases of community-acquired pneumonia received either of these antibiotics, they were counted as "choice concordant." If the cases received either antibiotic for its antibiotic-specific duration, they were counted as "combined choice and duration concordant." If not, they were counted as "discordant." Only antibiotic choice and prescribed duration were taken into account; antibiotic dosage and frequency were not considered in this metric. This was performed for all antibiotic courses administered.

RESULTS

To obtain the target number of medical records, a total of 386 charts were screened. Most charts (n = 231) lacked the necessary MAR data and were excluded, whereas 155 charts contained sufficient MAR data for review. Of these, 100 charts involved antibiotic administration ("full reviews"), whereas the remaining 55 charts did not ("partial reviews") (see Figure 1). Among the 100 patients who received antibiotics, the average age was 41.3 years and males were slightly older (43.2 versus 39.4 years). The most common comorbid conditions were HIV/AIDS (37%) and diabetes mellitus (14%). The most common admission and discharge diagnoses were bacterial pneumonia and HIV/AIDS. The majority of patients (63%) were cash-pay patients, whereas only a minority (37%) were insured. The remaining demographics, comorbid conditions, and admission and discharge diagnoses are listed in Table 1. Microbiologic culture of any type and complete blood count were obtained in 17% and 67% of cases, respectively. Furthermore, a chest X-ray and urinalysis were obtained in 19% and 9% of cases, respectively. No difference was noted in microbiologic culture obtainment between insured patients (19%) and uninsured patients (18%).

A total of 171 administered antibiotic courses were noted in the 100 patients included. Ceftriaxone, the most common antibiotic given, was administered in 40% of the courses. Metronidazole and ciprofloxacin were administered in 24% and 9% of the courses, respectively. The remainder of antibiotics used included amoxicillin/clavulanate (8%), clarithromycin (5%), ampicillin/cloxacillin (4%), azithromycin (4%), ampicillin (2%), and amoxicillin (2%), and the following were all used once (< 1% each): gentamicin, cefoperazone/sulbactam, benzylpenicillin, and cephalexin. No use of trimethroprim/sulfamethoxazole was documented for the treatment of bacterial infections; its use was only for *Pneumocystis jiroveci* prophylaxis or treatment, which was excluded from this evaluation. Combination antibiotic therapy was administered in 52% of patients, with the most common combination being ceftriaxone and metronidazole (51% of combination regimens). The overall antibiotic use in DOTs among the 100 patients who received antibiotics was 761.7/1,000 patient days; among all 155 reviewed patients, this was 559.0/1,000 patient days. Days of therapy for the three most commonly used antibiotics were as follows: 304.7/1,000 patient days for ceftriaxone, 203.9/1,000 patient days for metronidazole, and 71.3/1,000 patient days for ciprofloxacin, for a total of 579.9/1,000 patient days for all three medications.

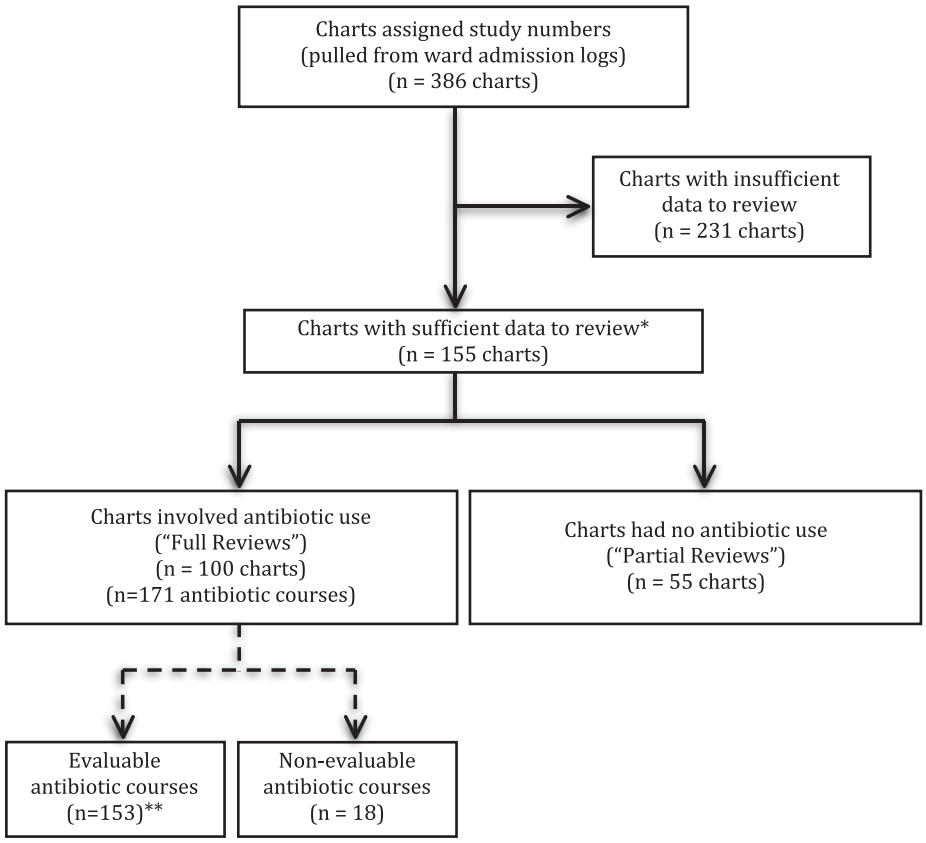

FIGURE 1. Chart review process. *Sufficient data specifically refer to the presence of a nursing medication administration record in the medical record. **An evaluable antibiotic course was one where the prescribing physician assigned a course duration or antibiotic stop date.

Overall choice concordance to Tanzania Standard Treatment Guidelines was 63% for the five most commonly encountered infectious indications; combined choice and duration concordance was found to be 15%. Choice concordance in management of bacterial pneumonia was 59%, whereas combined choice and duration concordance for this indication was 10%. Figure 2 summarizes infection-specific guideline concordance and Figure 3 details infection-specific antibiotic usage for the five most commonly encountered infections. Of a total of 171 antibiotic courses, 153 (89%) contained a documented prescribed duration ("evaluable courses"). Of these evaluable courses, 16 (11%) of these courses were truncated by discharge and 19 (12%) were truncated by patient death. Of the 118 remaining courses, 33 (28%) were completed, whereas 85 (72%) were incomplete. Of note, almost half (16 of 33, or 48%) of those completed courses exceeded their prescribed duration because of continuation by the patient apart from the physicians' knowledge or continuation by the physician without this intention reflected in the medical record. Table 2 lists course completion results for each antibiotic course administered and in total. Table 3 lists course completion results for each of the six most common antibiotic indications.

DISCUSSION

We performed an assessment of recently prescribed inpatient antibiotic utilization and evaluated concordance with national guidelines via retrospective review of a convenience sample of medical patients at MZRH in Tanzania and found a high proportion of guideline discordance and a general lack of diversity in antibiotic selection, regardless of indication.

Ceftriaxone, metronidazole, and ciprofloxacin constituted 74% of all antibiotic courses administered. Ceftriaxone, the most commonly administered antibiotic, was used in 40% of antibiotic courses. Resistance to third-generation cephalosporins among Enterobacteriaceae in Tanzania is reported ranging from 14 to 51% and 33 to 66% for *Escherichia coli* and *Klebsiella* spp., respectively.[12] Extended spectrum beta-lactamase producers, commonly harboring the *bla*CTX-M-15 allele, represented nearly 24% of urinary tract isolates in the region.[13] Whereas ciprofloxacin is currently guideline-recommended for urinary tract infections (UTIs), resistance is also commonly reported to fluoroquinolones in Tanzania, with > 80% of ESBL-producing Enterobacteriaceae demonstrating resistance to ciprofloxacin.[13] Metronidazole was used in 24% of antibiotic courses, including ~20% of both UTI and meningitis cases, indications for which it is rarely indicated, especially as empirical therapy in the absence of microbiologic data.

Prescribers adhered to the Tanzania Standard Treatment Guidelines recommendations for antibiotic choice 63% of the time, but this result fell to 15% when course duration was taken into account. This combined metric was consistently low for all studied indications. Although antibiotic prescribed duration was the primary reason for discordance in our study, many patients (72%) did not complete their prescribed and intended duration of therapy. The average number of missed

TABLE 1
Data obtained from all reviewed charts

Metric	Full reviews (*n* = 100, unless noted otherwise)	Partial reviews (*n* = 55, unless noted otherwise)	Total (*n* = 155, unless noted otherwise)
Gender (male)	50 (50%)	35 (63.6%)	85 (54.8%)
Age (years)	41.3	48.0	43.7
Average			
Male	43.2	50.0	46.0
Female	39.4	44.5	40.9
Pertinent comorbidities			
HIV/AIDS, *n* (%)	37 (37.0)	11 (20.0)	48 (31.0)
Diabetes mellitus, *n* (%)	14 (14.0)	2 (3.6)	16 (10.3)
Active cancer, *n* (%)	6 (6.0)	3 (5.5)	9 (5.8)
Liver cirrhosis, *n* (%)	3 (3.0)	1 (1.8)	4 (2.6)
CKD (dialysis), *n* (%)	7 (7.0)	0 (0)	7 (4.5)
CKD (non-dialysis), *n* (%)	3 (3.0)	3 (5.5)	6 (3.9)
Admission diagnoses			
Bacterial pneumonia, *n* (%)	32 (32.0)	7 (14.5)	39 (25.1)
HIV/AIDS, *n* (%)	27 (27.0)	9 (16.4)	36 (23.4)
Moderate/severe anemia, *n* (%)	22 (22.0)	14 (25.5)	36 (23.4)
Congestive cardiac failure, *n* (%)	9 (9.0)	14 (25.5)	23 (14.8)
Tuberculosis, *n* (%)	16 (16.0)	5 (9.1)	21 (13.5)
Malaria, *n* (%)	9 (9.0)	8 (14.5)	17 (11.0)
Discharge diagnoses			
HIV/AIDS, *n* (%)	25 (25.0)	6 (10.9)	31 (23.8)
Mod/severe anemia, *n* (%)	20 (20.0)	9 (16.4)	29 (22.3)
Bacterial pneumonia, *n* (%)	23 (23.0)	2 (3.6)	25 (18.5)
Congestive cardiac failure, *n* (%)	8 (8.0)	7 (14.5)	15 (11.5)
Peptic ulcer disease, *n* (%)	11 (11.0)	3 (5.5)	14 (10.8)
Tuberculosis, *n* (%)	11 (11.0)	2 (3.6)	13 (8.4)
Payer source (insured) (*n* = 154)	38 (38.0)	19 (35.2)	57 (37.0)
Average length of stay (days)	8.0 (*n* = 100)	5.5 (*n* = 50)	7.2 (*n* = 150)
30-day readmission occurrences (%) (*n* = 149)	7/96 (7.3)	7/53 (13.2)	14/149 (9.4)
In-house mortality occurrences (%) (*n* = 153)	32/100 (32.0)	9/53 (17.0)	41/153 (26.8)

CKD = chronic kidney disease.

doses was > 2, which for some antibiotics could indicate up to 48 hours of missed therapy. About 10% of patients exceeded the prescribed duration. Both incomplete and excessive antibiotic therapy could impact patient outcome and AMR development. Inclusion of multidisciplinary rounds highlighting nurses and potentially pharmacists may improve MAR updates and communication regarding regimen changes. It is unknown whether deviation from the national guidelines was

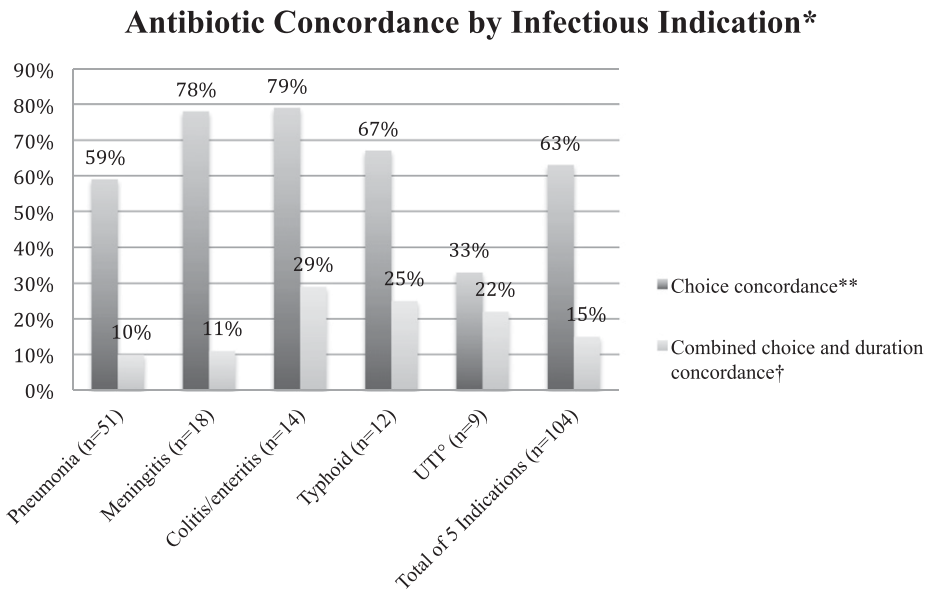

FIGURE 2. Adherence to Tanzania standard treatment guidelines per infectious indication. *For the five most commonly encountered infections among evaluable courses (*n* = 104). Remaining evaluable courses (*n* = 49) involved less frequently encountered indications (*n* = 14) or indications were not documented (*n* = 35) and are not represented here. Non-evaluable courses (*n* = 18), which had no prescribed duration of therapy, were excluded. **Choice concordance indicates that the choice of antibiotic alone was concordant with guidelines for that indication. †Combined choice and duration concordance indicates that both the choice of antibiotic and prescribed duration of therapy were concordant with guidelines for that indication. °UTI = urinary tract infection (includes both uncomplicated and complicated/pyelonephritis).

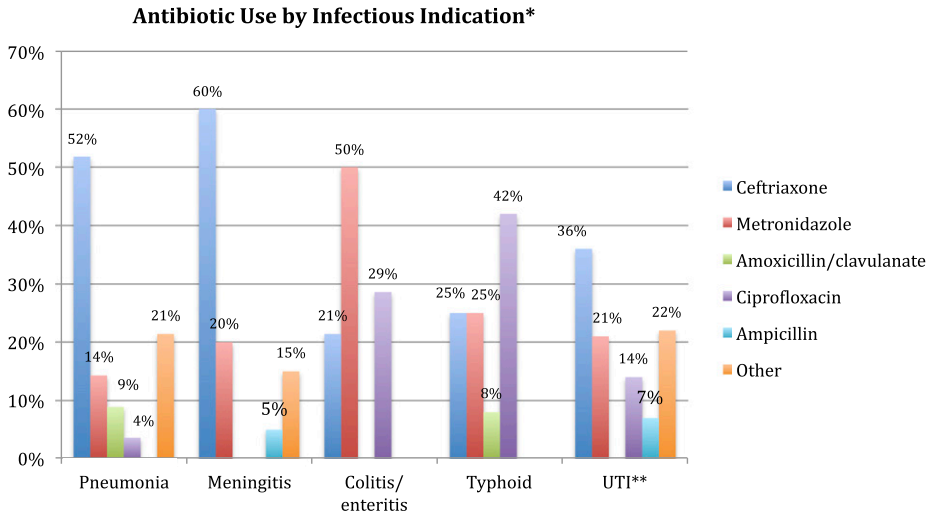

FIGURE 3. Antibiotic usage per infectious indication. *For the five most commonly encountered infections. Some antibiotic courses had > 1 indication listed. UTI = urinary tract infection (includes both uncomplicated and complicated/pyelonephritis). This figure appears in color at www.ajtmh.org.

due to conscious clinical decision-making, resource availability limitations, or lack of familiarity with the guidelines. Perhaps MZRH clinicians are not only aware of the guidelines but also recognize the widespread AMR noted throughout the East African region,[14–16] and so deviate from the guidelines intentionally. Alternatively, it is possible that many antibiotic prescribing decisions are made by relatively inexperienced interns and registrars, who may be less familiar with the guidelines. Regardless, there remains a need for intentional development of local data regarding epidemiology and antibiotic susceptibility patterns. Future study should include quantitative and qualitative assessments of clinician decision-making and knowledge of guideline recommendations, as well as assessment of the impact of antibiotic availability on clinician antibiotic utilization. Importantly, clinician guideline adherence is only as valuable as the quality of the guidelines being promoted. With approval of national health authorities, local antibiotic guidelines should be developed based on local MZRH susceptibility patterns and continually modified as these patterns evolve, to ensure the effectiveness of recommended antibiotic therapies, consistent with recommendations from other leading experts, such as the Infectious Diseases Society of America.

TABLE 2
Antibiotic course completion per administered course

Antibiotic course	1st	2nd	3rd	Total
Total number of evaluable courses	92	47	14	153
Courses truncated by discharge (%)	12 (13.0)	3 (6.4)	1 (7.1)	16 (10.5)
Courses truncated by in-house mortality (%)	9 (9.8)	7 (14.9)	3 (21.4)	19 (12.4)
Remaining courses*	71	37	10	118
Courses complete (%)	23 (32.4)	7 (18.9)	3 (30.0)	33 (28.0)
Courses incomplete (%)	48 (67.6)	30 (81.0)	7 (70.0)	85 (72.0)
Courses exceeding prescribed duration (%)†	14 (19.7)	2 (5.4)	1 (10.0)	16 (13.6)
Average number of missed doses	1.9	2.2	3.2	2.1

* Excludes those courses truncated by discharge or in-house mortality.
† These are included in the "Courses Complete" column totals.

There are several potential barriers which may impact optimal antibiotic utilization in this population. Although Tanzania's health care system offers multiple forms of health insurance, including the National Health Insurance Fund (NHIF), Community Health Fund, and other private insurance options, the uninsured still constitute most population.[17] Similarly, the majority of patients (63%) in this study were uninsured, which may have altered prescriber decision-making regarding antibiotic selection and duration of therapy at the point of prescription. Limited use of diagnostics, including radiology and microbiologic culture with susceptibilities, also represent a potential barrier for optimizing antibiotic therapy. Although this may have less impact on empirical therapy, it certainly limits clinician ability to streamline antibiotics for most appropriate definitive therapy. Only 17% of patients in the present study had a microbiologic culture of any kind performed. Interestingly, there was no difference in microbiologic culture obtainment between uninsured and insured patients. This suggests that barriers to increased utilization of diagnostics aiding in antibiotic prescribing may extend beyond patient financial burden. Available data on local and regional bacterial AMR are quite limited secondary to aforementioned limited diagnostics performed in clinical medicine. This limits clinician decision-making and may result in less variability among indication-based antibiotic prescribing. Existing clinician prescribing habits may also be a barrier, as studies have demonstrated that Tanzanian clinicians often prescribe antibiotics empirically and for conditions not requiring them.[10,18,19] Finally, challenges in the Tanzanian antibiotic supply chain may also be a barrier to optimal antibiotic use. Pharmaceuticals in Tanzanian health care facilities are frequently out of stock secondary to medication transportation difficulties and/or lack of funding, and often the government-owned supplier, MSD, is unable to respond to changing medication demand and is out of stock itself.[10] At MZRH, patients may obtain medications at an on campus pharmacy or from outside private pharmacies, but the majority procure them from the former, which is subject to these supply uncertainties. In the authors' experience at MZRH, most

TABLE 3
Antibiotic course completion per infectious indication*

Infectious indication*	Pneumonia	Meningitis	Colitis/enteritis	Urinary tract infection§	Typhoid	Sepsis
Total number of evaluable courses	48	18	11	8	5	5
Courses truncated by discharge, *n* (%)	5 (10.4)	1 (5.6)	2 (18.2)	2 (25.0)	0 (0.0)	0 (0.0)
Courses truncated by in-house mortality, *n* (%)	7 (14.6)	6 (33.3)	0 (0.0)	1 (12.5)	1 (20.0)	2 (40.0)
Remaining courses†	36	11	9	5	4	3
Courses complete, *n* (%)	10 (27.8)	2 (18.1)	3 (33.3)	1 (20.0)	1 (25.0)	2 (66.7)
Courses incomplete, *n* (%)	26 (72.2)	9 (81.8)	6 (66.7)	4 (80.0)	3 (75.0)	1 (33.3)
Courses exceeding prescribed duration, *n* (%)‡	7 (19.4)	2 (18.1)	2 (22.2)	1 (20.0)	1 (25.0)	0 (0.0)
Average number of missed doses	1.7	3.4	1.9	1.1	1.4	0.6

* Includes the six most commonly treated infections.
† Excludes those courses truncated by discharge or in-house mortality.
‡ These are included in the "Courses Complete" column totals.
§ Includes both uncomplicated and complicated/pyelonephritis.

common antibiotics were readily available, whereas certain antibiotics were persistently difficult to obtain, despite being on the NHIF formulary (e.g., IV vancomycin).

Given these concerns, AMS efforts may offer some hope in addressing the AMR issue at MZRH and throughout LMICs. Although there are unique challenges in LMICs, establishing a local AMS program can certainly improve antibiotic utilization within the institution.[6,8] Guidelines for establishing and sustaining an AMS program have been published, which outline components, functions, and expectations of a successful stewardship program.[5,20] Antimicrobial utilization is a key frontline metric for these programs, and baseline assessment is essential for establishing targeted interventions. Establishment of institutional guidelines, which include treatment and diagnostic recommendations supported by local resistance patterns, epidemiology, patient-case mix, and other local practices, is a direct deliverable from AMS programs that improves antibiotic utilization. By impacting antibiotic usage, stewardship programs directly impact other clinical and microbiological metrics, such as antibiotic resistance patterns, length of stay, and mortality. A call for global collaboration in AMS has been issued for advancement of stewardship efforts in LMICs.[21] Antimicrobial stewardship efforts are beginning to mobilize in Africa, and several successful programs have already been implemented. An effective program to encourage de-escalation from intravenous to oral metronidazole was successfully implemented in a district hospital in Kenya.[7] In 2017, Ethiopia successfully rolled out a National AMR Surveillance Plan.[8,9] Establishing AMS programs can also be fostered through distant mentorship, which has been demonstrated in some areas of Africa.[21] Engaging institutional leadership, interested stakeholders, and local experts in antibiotic stewardship should be a priority moving forward.

Limitations. There are several limitations to this study. First, sample size is relatively small, limiting statistical analysis. Also, given only a minority of records contained the necessary MAR required for review, it is possible that the reviewed records differed from the omitted ones in some way, which would introduce selection bias. However, given the consistency in prescribing physicians directing care for both omitted and reviewed patients, lack of major staffing differences between the two groups, representation of multiple wards, and similar handling of all records by staff (who were often unaware of patient insurance status), there is little reason to suspect significant selection bias. Specifically, there is little reason to suspect differences in insurance status impacted the presence/absence of a chart's MAR (and subsequent omission or inclusion in the study), as most records containing MARs from both wards represented uninsured patients. In addition, although differences are noted in characteristics between full reviews and partial reviews (see Table 1), these groups were meant only for descriptive analysis; because statistical group comparison was not intended, these differences are likely tolerable. Another limitation concerns the fact that many documented infectious processes were solely clinical diagnoses and lacked radiographic or microbiological confirmation, causing some uncertainty as to the accuracy of these diagnoses. This is often a reality of care in many LMIC health care settings. Given the inconsistent manner of clinician documentation, certain metrics were sometimes unclear or difficult to ascertain from the medical record, requiring those data points to either be interpreted by the chart abstractors or discarded, which may have introduced additional bias. There was also concern that patient medications were not consistently documented on the MAR, which may have led to some missing information not obtained during data collection. Timing of antibiotic prescriptions during patients' hospitalizations was also difficult to ascertain from the record, limiting evaluation of guideline concordance, especially for those guidelines recommending combination antimicrobial therapies, or for courses that were de-escalated from IV to oral therapy. These medical record difficulties are likely present in health care institutions throughout LMICs; in this study, data collection and chart review were performed consistently by only two investigators to mitigate these concerns. Before future studies at this site, an audit of the documentation process would be beneficial to evaluate this concern. Finally, the role of HIV, opportunistic infections, and parasitic infections, such as malaria, were not thoroughly addressed in this review, and degree of disease control was not taken into account. HIV-seropositive patients often require different empirical therapies and have a higher mortality risk, and these factors were not fully evaluated in this study.

CONCLUSION AND RECOMMENDATIONS

This study demonstrates antibiotic prescribing is common at MZRH, often lacks indication-based precision, and is often executed with a low concordance rate with national guidelines. These data support ongoing efforts to engage local stakeholders and hospital leadership to establish a local antimicrobial stewardship program (ASP). Promotion of clinician

adherence to guidelines alone may fail to improve patient outcomes, if those guidelines recommend ineffective therapies. Rather, a local ASP should combine these efforts with continuing guideline reevaluation and modification in response to regional AMR patterns, thus allowing recommendations to be evidence-based, and more likely to improve patient outcomes. Further study in this region is recommended to better understand barriers to optimal prescribing.

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