COMMUNITY ANTIBIOTIC USAGE AND THE CHARACTERIZATION OF ANTIBIOTIC RESISTANCE AMONG COMMON BACTERIAL ISOLATES IN SELECTED RURAL AND URBAN DISTRICTS OF THE DODOMA REGION, CENTRAL TANZANIA

Richard James Mabilika

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ABSTRACT

Antibiotic resistance threatens the treatment of bacterial infections globally. This cross-sectional study was conducted from August 2019 to May 2021 in Dodoma. The aim was to understand the prevalence and determinants of self-medication with antibiotics (SMA), antibiotic dispensing in community drug outlets, antibiotic prescribing in primary health care facilities and determine resistance profiles of bacterial pathogens in primary health care facilities (PHCF). Regarding SMA, 430 respondents were interviewed in Chemba District Council (rural) (161/430) and Dodoma City Council (urban) (269/430). The prevalence of SMA was 23.6% (38/161) and 23.4% (63/269) in the rural and urban respondents respectively. A shorter perceived distance to a health care facility than to a drug outlet was associated with decreased SMA practices among participants. Furthermore, 643 drug purchases were recorded in Accredited Drug Dispensing Outlets (ADDO) and community pharmacies, 84.1 % (541/643) were in Dodoma City Council (urban) and only 24.9% (160/643) purchased antibiotics. Antibiotics were dispensed in ADDO without prescriptions and beyond jurisdiction. Children <5 years accounted for over 45% (474/1021) of all the consultations recorded in the primary health care facility (PHCF); 76.3% (779/1021) of the consultations had an antibiotic with up to 55% (429/779) adherence to Standard Treatment Guidelines (STG). Pneumonia and respiratory symptoms were 16 times (adjusted OR=15.918; 95% CI: 2.151, 17.973; p = 0.007) and almost 2 times (adjusted OR=1.709; 95% CI: 1.129, 2.587; p = 0.011) more likely to prompt antibiotics, respectively. Furthermore, 621 clinical specimens were collected from out-patients in Chemba District Council (38.1%; 237/621) and Dodoma City Council (61.9%; 384/621) respectively. *S. aureus* (44) and *E. coli* (35) were the most prevalent isolates. There were high resistance rates of *E. coli* and *S. aureus* against ampicillin, ciprofloxacin and trimethoprim/sulfamethoxazole: 31.8% (14/44) of *S. aureus* were methicillin-resistant (MRSA). This study reports high SMA among those living close to community drug outlets, high un-prescribed antibiotic dispensing in ADDO, poor adherence to STG and relatively lower methicillin-resistant Staphylococcus aureus (MRSA) levels in PHCF. The study calls for more concerted efforts against the misuse of antibiotics as a means of confronting the emergence and spread of antibiotic resistance.

DECLARATION

I, Richard James Mabilika, do hereby declare to the Senate of the Nelson Mandela African Institution of Science and Technology that this dissertation is my original work and that it has neither been submitted nor being concurrently submitted for a degree award in any other institution.

Richard James Mabilika Date

The above declaration is confirmed by:

Prof. Gabriel Shirima Date

Dr. Emmanuel Mpolya Date

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CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance by The Nelson Mandela African Institution of Science and Technology, a dissertation titled *"Community Antibiotic Usage and the Characterization of Resistance among Common Bacterial Isolates in the Selected Rural and Urban Districts of the Dodoma Region, Central Tanzania"* in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Life Sciences of the Nelson Mandela African Institution of Science and Technology.

Prof. Gabriel Shirima Date

Dr. Emmanuel Mpolya Date

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DEDICATION

I dedicate this work to my parents; Mr. James Mabilika and Ms. Margaret Manoni and my Children Margaret Richard Mabilika, Mark Richard Mabilika and Zion Richard Mabilika for their un-ending love, support and prayers. I love you.

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LIST OF ABBREVIATIONS AND SYMBOLS

ADD	Accredited Drug Dispensers
ADDO	Accredited Drug Dispensing Outlet
AMR	Antibiotic Resistance
ARG	Antibiotic Resistance Genes
ARIs	Acute Respiratory Infections
CDC	Centers for Disease Control and Prevention
CFU	Colony Forming Units
CLSI	Clinical Laboratory Standard Institute
DDD	Defined Daily Doses
DDO	Drug Dispensing Outlets
DPHS	Dihydropteroate Synthase
ESBL	Extended Spectrum Beta Lactamases
FAO	Food and Agriculture Organization
GLASS	Global Antibiotic Resistance and Use Surveillance System
GSK	GlaxoSmithKline
JPIAMR	Joint Programming Initiative for Antibiotic Resistance
KNCHREC	The Northern Tanzania Health Research Ethics Committee
MoHCGEC	Ministry of Health, Community Development, Gender, Elderly and Children
MRSA	Methicillin Resistant *Staphylococcus aureus*
NACTE	National Council for Technical Education
NAP	Tanzanian National Action Plan
NBS	National Bureau of Statistics
NEMLIT	National Essential Medicines List
ODK	Open Data Kit
OR	Odds Ratios
PCR	Polymerase Chain Reaction
PD	Pharmaceutical Dispensers
PHCF	Primary Health Care Facility
PHCF	Primary Health Care Facilities
PID	Pelvic Inflammatory Diseases
SMA	Self-medication with Antibiotics
SOPs	Standard Operating Procedures

STG	Standard Treatment Guidelines
TMDA	Tanzania Medicines and Medical Devices Authority
URTI	Upper Respiratory Infection
UTIs	Urinary Tract Infections
WHO	World Health Organization
WOAH	World Organization for Animal Health
WTO	World Trade Organization

CHAPTER ONE

INTRODUCTION

1.1 Background of the Problem

Antibiotic resistance develops following changes in the genetic makeup of bacteria (WHO, 2021). It's a feature attained whenever there is contact between an antibiotic and a bacterial cell and can be transferred between bacteria cells by either vertical or horizontal gene transfers (WHO, 2021). Infections caused by antibiotic resistant pathogens are difficult and at times impossible to treat requiring the use of novel antibiotics that are not easily accessible and affordable (WHO, 2014a; CDC, 2020). It is anticipated that the global mortality rate from drug resistant infections will rise to 10 million deaths come 2050 (Jim O'Neill, 2014), 90% of these will occur in Africa and Asia (WHO, 2016). The misuse and/or overuse of antibiotics in the human and animal health sectors have altogether accelerated widespread antibiotic resistance (Ventola, 2015; WHO, 2021).

Unlike in the low-income countries where the consumption of antibiotics is mostly for human health (Friedrich, 2018), antibiotics in the high and the middle-income countries are mostly used in agricultural production (Lipsitch *et al.,* 2002; Van Boeckel *et al.,* 2015). Up to 80% of the antibiotics produced in the United States of America and Brazil are used in animal farms (Van Boeckel *et al.,* 2015). Together with campaigns by the World Health Organization (WHO), World Organization for Animal Health (WOAH) and Food and Agricultural Organization (FAO) against the unwarranted use of antibiotics for animal growth promotion (FAO *et al.,* 2017), the global consumption of antibiotics in agriculture continues to rise (Friedrich, 2018). Over 90 000 tons of antibiotics were consumed in 2017 and an 11.4% (104 000 tones) increase is expected by 2030 (Van-Boeckel *et al.,* 2015; Friedrich, 2018). Consumption of antibiotics in the human sector increased by 65% between 2000 and 2015 and while the trend is declining in some developed countries, it is expected to rise in developing countries (Sriram, 2021) due to rising economic growth and urbanizations, poor control on the access and the demand to prescribe, dispense and use antibiotics in these settings (Sangeda *et al.,* 2021a).

In a retrospective study quantifying human antibiotics imported and consumed in Tanzania mainland from 2010 to 2016, about 12 073 records for antibiotics were retrieved in which a total of 154.51 Defined Daily Doses (DDD) per 1000 inhabitants was used in a period of six years (2010-2016) per day (DDD/day) (Sangeda *et al.,* 2021a). The consumption of antibiotics based on the average defined daily doses (DDD) per 1000 inhabitants per day (DDD/1000/D) between 2017-2019 was 80.8 ± 39.35; being highest in 2017 (136.41 DDD/1000/D) (Chalker *et al.,* 2015a). Compared to the consumption trends in private health care facilities, there was a 59.7% and 62.6% decrease in antibiotic consumption in public health care facilities between 2017-2019 (Chalker *et al.,* 2015a) an observation likely to be influenced by poor adherence of prescribers in the private health care facilities to standard treatment guidelines as opposed to the practice in public health care facilities (Mbwasi *et al.,* 2020; Sangeda *et al.,* 2021). As is the case in many developing countries, the overall consumption of antibiotics in Tanzania is predicted to continue rising (Sangeda *et al.,* 2021a) for reasons such as poor public health systems and policies, the unregulated sale of antibiotics, high prevalence of infectious diseases (Friedrich, 2018), limited access to appropriate antibiotics, and poor diagnostic tools (Friedrich, 2018; Mbwasi *et al.,* 2020; Sangeda *et al.,* 2021a).

The Tanzanian National Action Plan on AMR (NAP-AMR 2017 – 2022) aligned strategic objectives number one: awareness, risk communication on AMR, strategic objective number two: Strengthening the knowledge and evidence base through surveillance and research*,* strategic objective number four: optimizing the use of antibiotic agents in human as key areas to guide and inform on antibiotic stewardship programs in the country (MoHCGEC, 2017). Similarly, strategic objectives number two, three and five in the newly launched NAP-AMR (2023-2028) upholds the importance of antibiotic use and resistance research and surveillance under a One-Health approach as a key strategy against AMR (MoH, 2023). The World Health Organization (WHO) along with the Ministry of Health have been conducting point prevalence surveillance on antibiotic consumption in selected hospitals, with the aim of identifying gaps on the rational use of antibiotics in hospital settings (WHO, 2022). Studies conducted among in-patients in these selected hospitals have reported among others, high levels of antibiotic prescribing (>60%) and poor utilization of the antibiotic susceptibility testing facilities vested in these high level of care hospitals (Seni *et al.,* 2020). Following these discoveries, the NAP AMR 2023-2028 intends to enroll all tertiary and regional referral hospitals along with selected hospitals at the district level into the antibiotic stewardship programs for an improved use of antibiotics in these settings (MoH, 2023).

The NAP AMR 2017-2022 and 2023-2028 have altogether continually emphasized on the surveillance and research on AMU in tertiary hospitals (regional referral, zonal referral, and National hospitals) to generate data for a guided implementation of AMS programs in these settings (MoHCGEC, 2017; MoH, 2023). Nevertheless, the primary health care tier (dispensary and health centers) and the community drug outlets at the village/street and ward level form the first contact of care for people in need of health care services in the community settings;

they are an important area for which antibiotic stewardship programs ought to be instituted (Irene, 2020). For reasons such as limited financial and diagnostic resources the implementation of the NAP AMR strategic objectives has not been heightened in the lower-level health care facilities and the community at large (MoHCGEC, 2017; MoH, 2023); data for decision on the appropriate interventions is thus lacking in these settings. This study conveniently conducted in Dodoma region reports on the prevalence and predictors of Self Medication with Antibiotics (SMA), antibiotic prescribing in health care facilities, antibiotic dispensing in community drug outlets as well as the resistance patterns of the commonly community-acquired bacterial pathogens among outpatients in public primary health care facilities in the rural and urban settings of the Dodoma region, Central Tanzania.

1.2 Statement of the Problem

Surveillance of antibiotic use and the resistance patterns of bacterial pathogens are instrumental actions in estimating the level of antibiotic use/ misuse and the burden of resistance for the administration of appropriate interventions (WHO, 2022). Like in many developing countries, the consumption of antibiotics and the associated bacterial resistance in Tanzania is much more attributed to the use of antibiotics in the human health sector (Woolhouse *et al.,* 2015; Friedrich, 2018). In 2017, Tanzania launched her first five-year National Action Plan on AMR (NAP AMR 2017-2022) and by the end of the year 2022, the former was then succeeded by second NAP AMR 2023-2028 (MoHCGEC, 2017; MoH, 2023). In both action plans, emphasis on the surveillance and research and the implementation of AMR stewardship programs have highly been directed towards zonal and regional referral hospitals, leaving the primary health care tier and community settings unattended (MoHCGEC, 2017; MoH, 2023).

Majority of the antibiotic use and resistance studies in the recent past have thus been from regional/zonal hospitals, facilities with well-established diagnostics and expertise and mostly situated in cities (Horumpende *et al.,* 2020; Seni *et al.,* 2020; Gabriel *et al.,* 2021; Nate, 2022; Nkinda *et al.,* 2022). While appropriate interventions on the rational prescribing, dispensing and use of antibiotics are now being carried out in tertiary hospitals (regional and zonal referral hospitals) across the country (MoH, 2023); there is a gap on the data for decisions and the administration of interventions regarding antibiotic prescribing and dispensing practices in primary health care facilities and community drug shops and the resistance patterns of bacterial pathogens in both the rural and urban communities (Irene, 2020; Durrance-Bagale *et al.,* 2021; WHO, 2022; MoH, 2023). Therefore, this study aims to generate data for decision making on the appropriate intervention programs against antibiotic misuse/overuse and the development of antibiotic resistance in the community settings.

1.3 Rationale of the Study

Antibiotic resistant infections have several consequences including among others prolonged and more expensive treatments, increased mortality rates, long hospital stays, and the risk of spreading resistant microorganisms to other patients (World Bank, 2016; MoHCGEC, 2017). The development of novel antibiotics to confront resistant infections is no longer a viable strategy as large proportion of pharmaceutical companies have deserted the antibiotic research field (Ventola, 2015). There has also been a scaling down of antibiotic research in academic institutions due to funding constraints (Ventola, 2015), necessitating rationality in using the available antibiotics and the urgency to detect and control resistance (Essack *et al.,* 2017).

The Tanzania National Action Plans on Antibiotic Resistance adopted the surveillance of antibiotic resistance (AMR) and use as a critical aspect in providing data on the extent and trends of the AMR problem in the country (MoHCGEC, 2017; MoH, 2023). Research on antibiotic usage and bacterial resistance patterns is instrumental in determining the nature and accurate quantification of the problem (Okeke *et al.,* 2005; Friedrich, 2018), implementation of the Tanzania National Action Plans on Antibiotic Resistance 2017 – 2022 and 2023 - 2028 (MoHCGEC, 2017; MoH, 2023), development of new tools and policies and the allocation of resources to address antibiotic resistance.

1.4 Research Objectives

1.4.1 General Objective

The overall aim of this study was to determine the community antibiotic usage and characterize antibiotic resistance of bacterial pathogens among patients with bacterial infections attending in primary health care facilities in the Dodoma region.

1.4.2 Specific Objectives

(i) Determine the prevalence and predictors of self-medication with antibiotics in Chemba District Council and Dodoma City Council.

(ii) Assess the prevalence and determinants of antibiotic dispensing in community drug outlets in Chemba District Council and Dodoma City Council.

(iii) Evaluate the patterns and predictors of antibiotic prescriptions in primary health care facilities in Chemba District Council and Dodoma City Council.

(iv) Investigate antibiotic resistance patterns of the prevalent bacterial pathogens among patients with bacterial infections attending in primary health care facilities in Chemba District Council and Dodoma City Council.

1.5 Research Questions

(i) What are the trends of self-medication with antibiotics in Chemba District Council and Dodoma City Council?

(ii) What are the practices regarding antibiotic dispensing in community drug outlets in Chemba District Council and Dodoma City Council?

(iii) What are patterns and drivers of antibiotic prescriptions in primary health care facilities in Chemba District Council and Dodoma City Council?

(iv) What are the antibiotic resistance patterns of the bacterial pathogens among patients presenting to primary health care facilities in Chemba District Council and Dodoma City Council?

1.6 Significance of the Study

In Tanzania, the trends of antibiotic use and the associated resistance in secondary and tertiary hospitals have been relatively reported (Horumpende *et al.,* 2020; Seni *et al.,* 2020; Gabriel *et al.,* 2021; Nate, 2022; Nkinda *et al.,* 2022); however, that of community settings and primary health care facilities remains underrepresented (Saleem, 2018). Thus the need for a community-based antibiotic consumption and resistance research and surveillance on the drivers of SMA in households, antibiotic dispensing and prescribing in community drug shops and primary health care facilities (Cambaco *et al.,* 2020; Balachandra *et al.,* 2021; Do *et al.,* 2021; Gutema *et al.,* 2021; Lam *et al.,* 2021; Iskandar *et al.,* 2021); to generate data for guided stewardship programs in the fight against antibiotic resistance in the lower level of care health facilities, drug shops and the community at large.

1.7 Delineation of the Study

The present study was conducted to investigated the community antibiotic usage and antibiotic resistance of bacterial pathogens among patients with bacterial infections attending in primary health care facilities in the Dodoma region. In addition, antibiotic dispensing in community drug outlets and the patterns and predictors of antibiotic prescriptions in primary health care facilities in both Chemba District Council and Dodoma City Council were investigated. The general aim was to generate data for decision making on the appropriate intervention programs against antibiotic misuse/overuse and the development of antibiotic resistance in the community settings.

CHAPTER TWO

LITERATURE REVIEW

2.1 Emergence and Spread of Antibiotic Resistance

Antibiotic resistance is a natural phenomenon whereby bacteria genetically change over time to become unresponsive to antibiotics that used to inhibit or kill them (WHO, 2015a). It develops whenever bacterial cells come in contact with antibiotics where susceptible ones are killed or inhibited, while the rest survive and multiply (Ayukekbong *et al.,* 2017). Following the discovery of penicillin in 1928 and their subsequent clinical use along with sulfonamides in the early 1940s, antibiotics have remained important therapeutic agents in the treatment of bacterial infections globally (WHO, 2015a). Their therapeutic efficacies have however progressively declined (Cars *et al.,* 2011). The existence of penicillinase (lactamase), an enzyme known for its ability to deactivate beta-lactam antibiotics (penicillin) was reported years before penicillin was kept in use, suggestive of antibiotic resistance with a natural occurrence (Davies & Davies, 2010).

After penicillin and sulfonamides were introduced and widely used, antibiotic resistant strains increased widely and prompted the development of novel semi synthetic derivatives in use today (Davies & Davies, 2010). Inherent bacterial mutations and the exchange of antibiotic resistant genes among bacterial communities by either vertical (parent to offspring), horizontal (cell to cell) or plasmid mediated gene transfers have generally been the mechanisms behind the development and spread of antibiotic resistant genes among bacteria species (Davies & Davies, 2010). Even though antibiotic resistance happens naturally, the inappropriate handling and control of antibiotics and their precursors during production/manufacturing, distribution (supply chain) (Prestinaci *et al.,* 2015) and their unwarranted use in clinical and agricultural settings has largely contributed to the development of antibiotic resistance (Friedrich, 2018). The positive impact of using antibiotics for animal fattening in the 1950s has ever since been the reason for excessive use of antibiotics in the agricultural sector (Davies & Davies, 2010).

Approximately 77 - 80% (131 000 -171 000 tons) of the global volume of antibiotics are used in the agricultural sector (livestock) and only 20 - 30% in the management of human related diseases (Ritchie, 2017). Nevertheless, the use of antibiotics for agricultural production is lower in developing countries than in the developed world (Grace, 2015); animals in the former are more likely to die from susceptible bacterial infections for lacking antibiotics (Grace, 2015).

In the developing world, over 80% of the antibiotics are sold in the vast community drug shops and over 50% of these used inappropriately (WHO, 2016).

Soil is regarded as a rich source and an important pool of antibiotic resistant genes (ARGs) (Davies & Davies, 2010). The unknown ARGs for tetracycline along with non-mobile dihydropteroate synthase (DPHS) genes conferring resistance for sulfonamides have been detected in forest soils with no history of exposure to these antibiotics (Willms *et al.,* 2019). These and many other ARGs that remain un-detected in the soil can be taken up by medically important bacteria causing antibiotic resistant infections in human and animals (Cycoń *et al.,* 2019). A large proportion of antibiotics in clinical practice also originate from microorganisms abundant in the soil that happens to be intrinsically resistant (Davies & Davies, 2010). Additionally, fecally contaminated water and organic manure commonly used in agriculture may serve as an independent route to the dissemination of resistance genes in the soil (Lyimo *et al.,* 2016; Pérez-Valera *et al.,* 2019).

2.2 Drivers of Antibiotic Resistance

The WHO considers antibiotic resistance as one of the biggest threats to a healthier world (WHO, 2021). Coordinated multi-sectoral initiatives to contain its emergence and subsequent spread are imperatively vital (MoHCGEC, 2017). Because of the apparent socio-economic differences between the high-income countries and those in the low- and middle-income countries, the factors behind the emergence of antibiotic resistance may also differ. Below are the different factors behind the emergence and spread of antibiotic resistance in the low- and middle-income countries:

2.2.1 Urbanization

In search of jobs, health care services and employment opportunities, high proportion of people in developing countries are migrating to urban areas (Vikesland *et al.,* 2019). An increase in the population density creates an environment that perpetuates the transmission of bacterial infections increasing the volume of antibiotics consumed (Bruinsma *et al.,* 2003). Urbanization also increases the level of antibiotic residues in the environment; creating a pathway to the evolution of antibiotic resistant pathogens (Aujoulat *et al.,* 2021).

2.2.2 Poor sanitation and Waste Disposal Infrastructure

Lack of clean water and poor sanitation is another major setback in the control of antibiotic usage and resistance in developing countries (WHO, 2020). The WHO estimates that approximately 2 billion people have limited access to toilets and latrines and about 673 million people defecate in streets gutters, bushes and in water bodies (WHO, 2019a). Unclean/unsafe water, poor waste disposal and sewage systems are a key source of infections (Wuijts *et al.,* 2017; WHO, 2019a). Wastewater harboring antibiotic residues and antibiotic resistant genes are a common occurrence in communities with poor environmental sanitation practices (Bürgmann *et al.,* 2018). Effective sanitation programs and clean water sources are thus key to any successful antibiotic resistance control programs (WHO, 2019a).

2.2.3 Counterfeit and Substandard Antibiotics

Deliberately mislabeled with respect to identity, content, quantity and source; counterfeit antibiotics account for over 50% of the total load of counterfeit drugs worldwide (Kelesidis & Falagas, 2015; Iskandar *et al.,* 2020). The quality of antibiotics sold mostly over the counter in many developing countries is a major area of concern (Ayukekbong *et al.,* 2017). Southeast Asia and Africa are mainly the regions with the highest rates of fake antibiotics (Kelesidis *et al.,* 2007). About 7.6% of the major antibiotics used in Africa do not contain any active ingredients (Kelesidis *et al.,* 2007). Studies in Mwanza, Mbeya and Kilimanjaro in Tanzania have reported disparities on the sensitivity of the generically similar antibiotics towards test organisms; a condition suggestive of counterfeit or substandard medicines in the market (Mwambete, 2014). Counterfeit antibiotics expose bacteria pathogens to sub-inhibitory drug concentrations unable to completely eliminate them and thus pave a way for these to develop resistance (Kelesidis & Falagas, 2015).

2.2.4 Weak Regulatory Frameworks and Legislations

Misuse of antibiotics is a major driver to the emergence and spread of resistant pathogens in both the developing and developed countries (Dadgostar, 2019). Self-medication with antibiotics (SMA) driven by the belief that antibiotics are effective even in viral infections has led to these vital antibiotic agents being widely used in conditions that don't require them (WHO, 2015a). The distribution and sale of antibiotics is an important area in addressing the misuse and/or overuse of antibiotics (Porter *et al.,* 2020). Laws and regulations pertaining to the sale and use of antibiotics in both the animal and human health sectors are an effective tool in ensuring appropriate use of these vital medicines (Porter *et al.,* 2020). In Tanzania, the Tanzania Medicines and Medical Devices Authority (TMDA) along with the Pharmacy Council are vested with the mandate to oversee and regulate the manufacturing, importation, distribution and use of antibiotics (Pharmacy Council of Tanzania, 2019; Mbwasi *et al.,* 2020; MoH, 2023). Nevertheless, several studies in Tanzania have continually reported inappropriate sale of antibiotics in community drug outlets without prescriptions (Erku *et al.,* 2017; Horumpende *et al.,* 2018a; Horumpende *et al.,* 2018b; Rhee *et al.,* 2019; Ndaki *et al.,* 2021a). This calls for a more stringent regulation and law enforcement by the relevant authorities in these settings.

2.2.5 Agricultural Intensification

In the developed and the middle-income countries, the use of antibiotics in the agricultural sector is another important area worth to be checked (WOAH, 2016; FAO *et al.,* 2017). Agricultural intensification is associated with increased animal stocking and a raise in the use of commercial animal feeds along with an increased use of antibiotics for growth promotion, prophylaxis and in the treatment of bacterial infections in animals (Kirchhelle, 2018). In the US for-example, 85% of the antibiotics produced are predominantly used in factory animal farms for treatment and as prophylaxis (Lo, 2019). Even though the antibiotics used in animal farms may be different from those in clinical practice, the chemical nature of these agents are identical and the resulting resistance to one group will have the same implication to the other (O'Neill, 2015). Studies have also associated the carriage of antibiotic resistant bacteria and genes in animal and plant-based food stuffs with the spread of antibiotic resistant pathogens (Thanner *et al.,* 2016). The use of antibiotics for prophylaxis, treatment and growth promotion has also been reported in Tanzania (Azabo *et al.,* 2022), majority of the farmers do not observe the withdraw period as recommended by authorities (Mdegela *et al.,* 2021). This increases the potential for the consumption of food stuffs with antibiotic residues by the general population which is an independent pathway in the emergence of antibiotic resistant pathoegns (Frida *et al.,* 2017; Mdegela *et al.,* 2021; Azabo *et al.,* 2022).

Antibiotic residues from agricultural activities have also been the source of water pollution (Wall *et al.,* 2016), these can propagate the development of antibiotic resistant genes among the aquatic microbes (Kimera *et al.,* 2020). Studies involving wild fish in China have all reported varying degrees of antibiotic residues (Ma *et al.,* 2021), raising the potentiality for the emergence of antibiotic resistance from the aquatic food chain (Mdegela *et al.,* 2021).

2.2.6 Lack of Appropriate Diagnostics

Lack of good quality diagnostics in lower-level health care facilities in developing countries is a drawback to the rational use of antibiotics (Larson, 2007). With the intention to scale down unwarranted antibiotic prescriptions, the WHO stresses on the need for health care facilities to use and rely on rapid microbiological diagnostics to guide all the antibiotic related therapeutic encounters (WHO, 2016) despite all the limitations in developing countries. The GlaxoSmithKline (GSK), a British pharma company in collaboration with other pharmaceutical and diagnostic manufacturers are working to develop rapid diagnostics specific for multidrug resistant microbes to ensure that these pathogens are only managed with appropriate antibiotics (Elvidge, 2017). The new diagnostic technologies will help reduce the time required to identify and ascertain antibiotic susceptibility of bacterial pathogens from clinical samples as opposed to the currently used conventional identification procedures (Sharma & Dwivedi, 2017).

2.2.7 Poverty

Poverty is an independent driver towards the use of antibiotics and the subsequent development of antibiotic resistance (King *et al.,* 2022; Obua *et al.,* 2023). Poor diagnostics, inadequate treatment of bacterial infections, poor health care access, and the inappropriate use of antibiotics all accelerate the emergence of antibiotic resistance in poverty-stricken areas (Planta, 2007; Azabo *et al.,* 2022; King *et al.,* 2022; Green *et al.,* 2023; Obua *et al.,* 2023).

2.3 Antibiotic Usage and Resistance in Tanzania

2.3.1 Antibiotic Usage

Surveys in Tanzania show high degrees of inappropriate and irrational use of antibiotics in both health care facilities and community drug dispensing outlets (WHO, 2014b). Studies by Kamuhabwa and Kisoma (2015) and Teuscher (1993) on the prescribing practices in Dar es Salaam and Morogoro Tanzania, respectively have reported among others cost and availability of drugs as determinants of prescribing decisions, rather than positive microbiological results. In rural settings, community drug outlets are a lifeline where people get access to medicines due to their easy accessibility (Gulland, 2018). However, studies have reported precarious conditions where dispensing is done by untrained staff who dispense incomplete antibiotic doses without prescriptions (Minzi & Manyilizu, 2013). Fortified procaine penicillin powder, an injectable formulation was for example dispensed as a topical preparation for wounds (Minzi & Manyilizu, 2013). Coughs, colds and diarrhea reported in community drug outlets and primary health care facilities are mostly managed with antibiotics (Kagashe *et al.,* 2011).

2.3.2 Epidemiology of Resistant Bacteria Pathogens in Tanzania

The susceptibility of bacterial pathogens to antibiotics has continually been decreasing over the years (Mshana *et al.,* 2013b; WHO, 2016). Studies have reported over 25% gram-negative

Enterobacteriaceae to be extended spectrum beta lactamase (ESBL) producers, highly resistant to sulfamethoxazole/trimethoprim, gentamycin, tetracycline and ciprofloxacin (Mshana *et al.,* 2013b; Moremi *et al.,* 2014), which are antibiotics recommended in the management of several bacterial infections in Tanzania (Ministry of Health and Social Welfare-Tanzania, 2017). Regarding *Klebsiella pneumoniae* isolates from blood, urine, wound swabs and pus more than 90% were resistant to gentamycin and over 50% resistant to ciprofloxacin (Mshana *et al.,* 2013a). Following PCR phylogenetic analysis, $bla_{CTX\text{-}M\text{-}15}$ was detected to be the most prevalent ESBL allele (76%) followed by $bla_{TEM\text{-}104}$, $bla_{SHV\text{-}11}$ and $bla_{TEM\text{-}176}$, respectively (Mshana *et al.,* 2013a) .

Carbapenemase genes responsible for reducing susceptibility of microbes to carbapenem have been reported in a study where 35% of the 227 PCR analyzed multidrug resistant gram-negative bacteria isolates were positive for carbapenemase genes with the IMP genes being the most prevalent (20%) followed by VIM (12%) (Mushi *et al.,* 2014). The genes reported were predominantly from *K. pneumonia, P. aeruginosa* and *E. coli* (Mushi *et al.,* 2014). Furthermore, Seni *et al.* (2016) confirmed 55 stool samples out of 334 to harbour ESBL producing enterobacteriacea with *E. coli* having the highest ESBL carriage (15.1%) followed by *K. pneumoniae* (3.8%). Of these, 42 isolates were subjected to PCR assay where majority 37 (88.1%) carried $bla_{CTX\text{-}M\text{-}15}$ genes (Seni *et al.,* 2016). The findings by Mshana *et al.* (2016) on ESBL producing *Enterobacteriaceae* were also comparable to the findings of another study conducted in Mwanza that established transferable ESBL genes in samples collected from hospitalized patients (Nelson *et al.,* 2014). However, ESBL strains identified in postnatal women tended to differ from those in neonates a phenomenon suggestive of a different transmission cycle (Nelson *et al.,* 2014). Although Seni *et al.* (2016), detected 53 isolates to be susceptible to meropenem, 47.2% (25/53) revealed also resistance patterns of ESBL producers (*E. coli* and *Klebsiella spp*) to sulfamethoxazole + Trimethoprim and ciprofloxacin.

Nevertheless, the number of studies documenting antibiotic consumption and the resulting bacteria resistance profiles in Tanzania is inadequate, majority of the studies conducted involved isolates and samples collected within tertiary hospitals (Mshana *et al.,* 2013a; Mushi *et al.,* 2014; Moremi *et al.,* 2014; Nelson *et al.,* 2014; Seni *et al.,* 2016; Manyahi *et al.,* 2020a). Little has been reported on the patterns of antibiotic consumption and the trend and nature of antibiotic resistance among bacteria populations of public health importance in the community setting.

2.3.3 Stewardship Programs

Interventions involving training and peer coaching of primary health care workers on rational prescribing and dispensing of antibiotics have been in place since 2012 (HPSS, 2012). The Pharmacy Council of Tanzania in collaboration with the National Council for Technical Education (NACTE) devised pharmacy training curriculums with the aim of improving the number and conduct of pharmaceutical workforce in both primary health care facilities and community drug dispensing outlets (Pharmacy Council of Tanzania, 2019). Indeed, the number of colleges offering these programs has increased substantially from 6 in 2014 to around 64 in 2021, along with an increase in the number of pharmaceutical professionals from 1200 pharmacists in 2015 to 2500 in 2021; 900 pharmaceutical technicians in 2015 to 3500 in 2021 and zero pharmaceutical dispensers in 2015 to 1100 in 2021 (Pharmacy Council of Tanzania, 2019). These initiatives are anticipated to positively influence rationality in community antibiotic dispensing and usage.

2.4 Implications of the Antibiotic Resistance Pandemic

The World Bank estimates that developing and developed countries would lose at least 5% and 3.8% of their GDP to AMR management respectively (World Bank, 2016); with over 20 million people being pushed into extreme poverty by 2050 (World Bank, 2016). Running animal farms in the developed and the middle-income countries and the clinical management of diseases in the developing countries would require the use of surrogate antibiotics that are inherently expensive and as a result increasing health care and agricultural costs (Founou *et al.,* 2017). Trade on livestock and livestock products is postulated to have the highest AMR vulnerability not only because of the resistant infections, but also the possibilities of animal-based products bearing drug residues (World Bank, 2016). These are likely to hinder international trade of animals and animal products as stipulated in the Sanitary and Phytosanitary measures (WTO, 1998).

In impoverished areas where affordability and accessibility of antibiotics is limited, drug resistant infections have been the major drivers to increased morbidity and mortality rates (Manyahi *et al.,* 2020a). The WHO estimated around 1 million deaths from antibiotic resistant infections with 25% attributed to drug resistant TB in resource limited settings (WHO, 2019b). In addition, some of the commonly community acquired infections such as upper respiratory, urinary infections and STIs are now becoming untreatable (WHO, 2019b). In a study on antibiotic resistance as a predictor of death in children with confirmed blood stream infection in Tanzania, majority were associated with drug resistant infections attributable to gram negative bacteria pathogens (Manyahi *et al.,* 2020a).

2.5 Road Map to Antibiotic Global Interventions

Information concerning the global coverage of AMR is limited, partly due to lack of good quality data from most developing countries (FAO *et al.,* 2017). In 2014 for example, among the six WHO regions, the largest data gathered were mainly from Europe and America with Africa accounting for the poorest data set (WHO, 2015a). Based on this discrepancy WHO in 2015 launched the "Global Antibiotic Resistance Surveillance System (GLASS)" to normalize and enforce the gathering and sharing of AMR data by the global community (WHO, 2015b). Annual GLASS reports are anticipated to raise awareness and improve the global understanding of the AMR pandemic (WHO, 2015b).

The AMR is a crosscutting and multi-sectoral issue that requires globally coordinated solutions from the human health, animal and plant sectors (WOAH, 2016) thus a One Health Approach is required for mitigation of AMR. Recognizing the need for each sector in the control of AMR, a tripartite partnership between the WOAH-FAO-WHO under "One Health" has been proven as a means of successfully addressing animal, human and plant related use of antibiotics (FAO *et al.,* 2017). This collaboration is expected to drive the enacting of policies that will guide individual countries on how best they can fight AMR (WHO, 2015a). In 2015 the WHO launched the "Global Action Plan on AMR" crafted in unison with the other partners (WOAH, and FAO) (WHO, 2015a); this was further strengthened by the United Nation's proclamation on confronting AMR and the affirmation of the "One Health" approach along with the Global Action Plan (UN, 2016).

A joint declaration by >100 pharmaceutical companies signed in 2016 aimed at establishing coordinated efforts among stakeholders towards assured availability of the existing antibiotics, vaccines, diagnostics while at the same time enforcing the discovery and development of newer antibiotics and preserving the existing ones from being misused (IFPMA, 2017). In its "Roadmap of actions for AMR 2019 – 2024" report, the joint programming initiative on AMR (JPIAMR), a Swedish based global organization has been organizing funds for research groups across the globe, aimed at accelerating the development of newer antibiotics and diagnostics as well as support activities related to raising AMR awareness globally (JPIAMR, 2018).

Considering the nature and circumstances for the spread of AMR, coordinated efforts are inevitable (Prestinaci *et al.,* 2015). In the hospital settings for example, infection control, and advocacy campaigns on rational use of antibiotics are vital (Nicolle, 2001; Collins, 2008). Actions to control antibiotic misuse should take into account among others, better diagnostics, prudent antibiotic use campaigns and training (Prestinaci *et al.,* 2015). The culmination of antibiotic resistance includes among others, increased mortality, prolonged hospital stays, lack of appropriate antibiotics among surgical patients and increased costs especially in under-resourced countries (WHO, 2014a).

2.6 Conceptual Framework

The conceptual framework (Fig. 1) was developed to depict the three areas (health care facilities, households and community drug shops) from which parameters pertaining to the use of antibiotics for human health in community settings and health care facilities can be deduced. Primary health care facilities and community drug shops constitute the first health care platform from which the general population can access antibiotics and other health care related services at the community level (Irene, 2020). The conduct of health care workers in these lower level of care facilities greatly influences the accessibility of antibiotics and the emergence of antibiotic resistance (Mbwasi *et al.,* 2020).

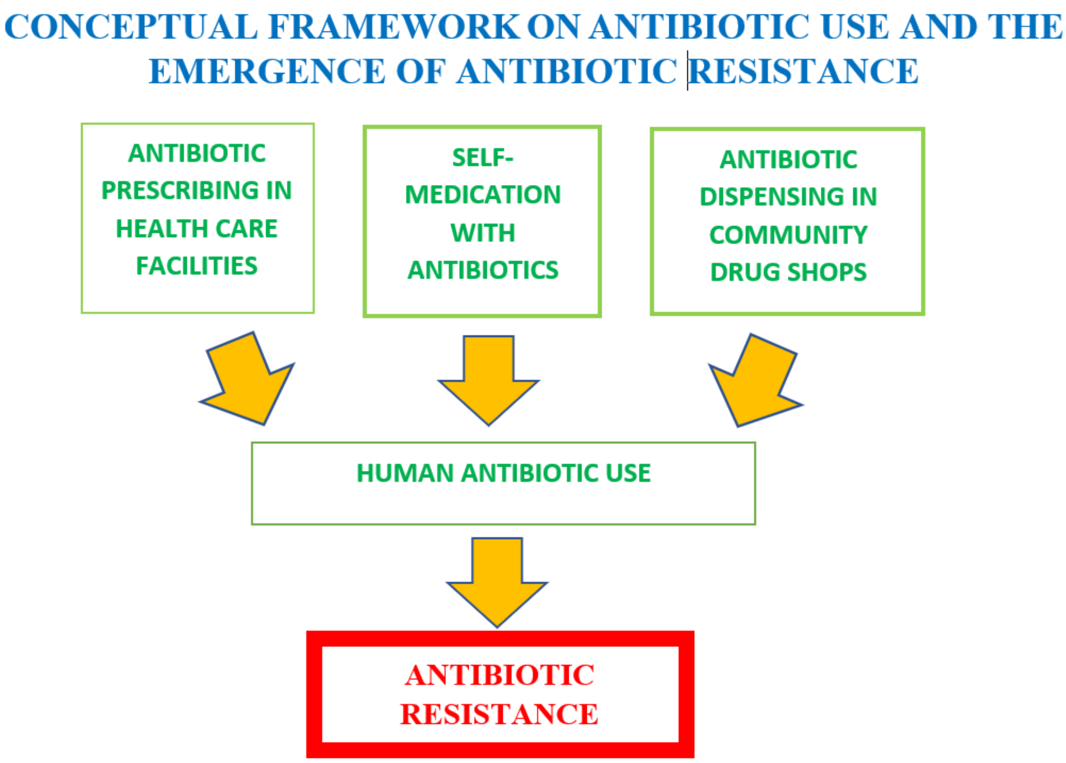

Figure 1: Conceptual framework on the pillars of community antibiotic usage

2.7 Operational Definitions and Measurements for Objectives 1 – 4

Self-medication with antibiotics (SMA): Participants who used antibiotics to treat self-diagnosed disorders or symptoms or used leftover prescribed antibiotics without consulting a prescriber in the past 12 months were considered to have practiced SMA in study.

Social demographics: Participants 18 years and above were asked about their social profile including age, sex, marital status, education and occupation.

Perceived household distance from a health care facility or a drug outlet: Respondents were asked to report the perceived distance from their households to a health care facility (Hospital/health center/dispensary) or a community drug outlet.

Awareness on antibiotics and antibiotic resistance: Respondents were asked on whether they knew what antibiotics, what they are used for and the dangers of antibiotic resistance. Participants who answered all the questions correctly were considered to be aware while those who didn’t were considered un-aware.

Rural locality: In this context, a rural locality is one with a population density of less than 45 people per square kilometer together with absence of modern infrastructure of roads and railways, absence of 3-star hotels and low density of shops - reflective of low household income

Urban localities: In this context, an urban locality is one with a population density of equal or more than 45 people per square kilometer together with presence of modern infrastructure of roads and railways, presence of 3-star hotels and high density of shops -reflective of high household income.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

This study was conducted in the Dodoma from August 2019 to May 2021, and was aimed at exploring the existing condition regarding the use of antibiotics in the community settings (household and drug shops) and primary health care facilities, establish the differences on the use of antibiotics in the rural and urban settings, identify the drivers thereof and postulate mitigations to improve the conduct of all players regarding antibiotic use and resistance from a community standpoint. There are limited studies documenting the community antibiotic use and the associated antibiotic resistance patterns of the bacterial pathogens of public health importance in Central Tanzania. This study was conducted in the rural and urban areas of the Dodoma region Central Tanzania to generate data needed to guide the institution of community based stewardship programs against the development of antibiotic resistance. In this context, a rural district has a population density of fewer than 45 people per square kilometer with a lack of modern infrastructure, such as roads and railways; and a low density of shops, reflective of low household income. An urban district has a population density of 45 or more people per square kilometre with modern infrastructure, such as roads and railways; and a high density of shops, reflective of high household income.

The Dodoma region is divided into seven districts (NBS 2016), which in this study were divided into rural (Chemba, Bahi, Mpwapwa, and Chamwino Districts) and urban (Dodoma City Council, Kondoa and Kongwa) categories. One representative district from each category was then randomly selected. Dodoma City Council and Chemba District Council represented the urban and rural settings, respectively. Dodoma City Council (urban) has a population of approximately 460 000, and Chemba District Council (rural) has a population of approximately 250 000 (NBS, 2016). Dodoma City Council covers approximately 2769 square kilometres and has 4 hospitals, 13 health centres, 48 dispensaries, 364 Accredited Drug Dispensing Outlets (ADDOs), and 62 pharmacist-operated pharmacies (NBS, 2016). Chemba District Council covers a total of 7653 square kilometres and has 4 health centres, 35 dispensaries and 87 ADDOs (NBS, 2016).

The average household size is 4.6 persons in Chemba District Council (rural) and 4.2 persons in Dodoma City Council (urban); over 70% of those residing in Chemba District Council are employed in agriculture, while only 57% of those in Dodoma City Council practice agriculture

(NBS, 2016). Moreover, 71% of the urban residents have access to piped water compared to only 15% of those in the rural district (NBS, 2016).

3.2 Inclusion and Exclusion Criteria

3.2.1 Objective 1: Prevalence and Predictors of Self-Medication with Antibiotics in Dodoma Region, Central Tanzania

For the first objective, all adults who were present during the interview, and who reported as permanent occupants of the household were deemed fit to participate. Adults who reported not to be permanent household residents and children (below 18 years) were excluded from this study.

3.2.2 Objective 2: Prevalence and Determinants of Antibiotic Dispensing in Community Drug Outlets Of Dodoma Region, Central Tanzania

For the second objective, the sampling frame involved community drug outlets in both the rural and urban districts. All clients/patients buying medicines in the randomly selected community drug outlets were deemed fit to participate, clients/patients who entered a community drug outlet and did not purchase any item were excluded from this study.

3.2.3 Objective 3: Patterns and Predictors of Antibiotic Prescriptions in Primary Health Care Facilities of Dodoma Region, Central Tanzania

For the third objective, the sampling frame was primary health care facilities in the two districts. Data collection under this objective was based on the WHO indicators of antibiotic prescribing and the Tanzanian Standard Treatment Guidelines (Atif *et al.,* 2016; Ministry of Health and Social Welfare-Tanzania, 2017). One-year retrospective prescribing data from January, 2020 to December, 2020 were randomly sought and recorded from the selected health facilities. Medical records were used to gather retrospective information pertaining to patients' age and sex, qualifications of prescribers, empirical diagnosis and the type and the number of medicines prescribed. All records from prescription books in primary health care facilities recorded between from January, 2020 to December, 2020 were deemed relevant; however. Records from maternity clinics were excluded.

3.2.4 Objective 4: Prevalence and Antibiotic Resistance Patterns of Gram-Negative and Gram-Positive Bacteria Pathogens Isolated from Out-Patients in Public Primary Health Care Facilities in Dodoma Region, Central Tanzania

For the forth objectives, consulting clinicians made the decisions on whether or not the patient donates clinical specimen and the type of clinical specimen to be collected. A detailed description of the Swahili translated consent form was given to all the potential participants, clinical specimens were only collected from the consenting participants.

3.3 Sampling Technique

The sampling technique employed was multistage stratified random sampling involving a rural and an urbandistricts as representative strata. Rural (Chemba, Bahi, Mpwapwa, and Chamwino) and urban (Dodoma City Council, Kondoa and Kongwa) district names were each written on a piece of paper and placed in the corresponding rural or urban basket. Chemba District Council was randomly drawn from the rural strata and Dodoma City Council from the urban strata. In the second stage, probability proportionate to size sampling was used to decide the total number of households, dispensing consultations, prescription consultations and clinical specimens to be included in objectives 1, 2, 3 and 4, respectively. In 2016, there were 93 339 households in Dodoma City Council and approximately 47 100 households in Chemba District Council (NBS, 2016). Additionally, in 2019 there were 426 community drug outlets in Dodoma City Council and about 87 in Chemba District Council (Pharmacy Council of Tanzania, 2021). Proportionately, twice as many households, prescription consultations, clinical specimens and five times as many dispensing consultations were recorded in Dodoma City Council as in Chemba District Council.

3.3.1 Sample Size Calculation

The sample size calculation for specific objective 1-4 was based on the unknown prevalence (P) of 50% with a 95% confidence level and was calculated using the survey formula described by Kothari (2004) and shown in Equation 1. The degree of precision was 5%, with a design effect of 1. The response rate was 90%. There was no population correction factor since the total population in the sampling frame was well above 5000.

$$\text{Sample size} = \frac{d-eff}{\mathrm{r}} \cdot \frac{3.8p(1-p)}{\mathrm{d2}} \cdot \underbrace{\frac{N}{\mathrm{N}+\frac{3.8p(1-p)}{\mathrm{d2}}}}_{\mathrm{CF}} = 427 \qquad (1)$$

Whereby, p = proportion of the population having the characteristic (0.5), d = the degree of precision (0.05), d-eff = design effect (= 1), r = response rate (0.9), N = sampling frame (population size), CF = correction factor (1 when $N > 5000$).

The minimum estimated sample size for the four specific objectives was 427 participants.

(i) Objective One

For the first objective, households were selected according to the ICF International DHS Toolkit (ICF International, 2012). The full list of all occupied households was obtained from the Council offices, and households were selected using systematic selection: Systematic random sampling was used to select participants whereas the first participant was selected randomly and the rest selected after every other patient/client. A random starting point was selected, and a die with the first four faces representing the four cardinal directions (1 = east, 2 = west, 3 = north and 4 = south) was tossed to determine the direction. In the selected direction, 10 households were selected, after which the die was tossed again to determine the next direction. From each household, an adult aged 18 years or more was randomly selected for the interview. When more than one able-bodied adult was present in the household, priority was given to the head of the household or any other person acting in a similar capacity at the moment, regardless of sex.

(ii) Objective Two

In the second objective, community drug outlets were randomly selected from lists kept by district Pharmacists, 54 and 10 community drug outlets were randomly selected in Dodoma City Council and Chemba District Council, respectively. Ten customers were then randomly selected from each drug outlet and having filled out consent forms were interviewed.

(iii) Objective Three

The sampling frame in the third objective was primary health care facilities in the two districts. Data collection under this objective was based on the WHO indicators of antibiotic prescribing and the Tanzanian Standard Treatment Guidelines (Ministry of Health and Social Welfare-Tanzania, 2017). One-year retrospective prescribing data from January 2020 to December 2020 were randomly sought and recorded from the selected health facilities.

(iv) Objective Four

Additionally, in the fourth objective, using probability proportionate to size sampling, 2 health centers and 20 dispensaries were randomly selected from Chemba district council while 6 health centers and 24 dispensaries were randomly selected from Dodoma city council. All patients with suspected bacterial infections attending primary health care facilities in the two districts were asked to participate. Consulting clinicians in each health care facility were responsible with clerking and selecting patients with suspected bacterial infections and also made decision on the nature of clinical specimen to be collected for microbiological analysis. Clinical specimens were collected by clinical laboratory technicians and transported to the central zone microbiology laboratory for further processing.

3.4 Data Collection

3.4.1 Open Data Kit (ODK) digital questionnaire

Fifteen data collectors (nine pharmaceutical technicians and six clinical laboratory technicians) were recruited and oriented to the digital data collection questionnaires using supplied Android smartphones. Data for objectives 1 – 4 were collected using an Open Data Kit (ODK) digital questionnaire. The questionnaires were adopted from similar studies (Kandelaki *et al.,* 2015; Worku & Tewahido, 2018; Horumpende *et al.,* 2018b; Mzee *et al.,* 2021) and modified to incorporate prevalence, predictors, nature and type of antibiotics commonly prescribed, dispensed and used in the rural and urban settings. The modified English structured questionnaires were translated into Swahili for easy comprehension among respondents and data collectors, and their suitability tested in a pilot study before they were adopted for use in this study.

In the first objective, the questionnaires inquired about the socio-demographic information of the respondents (age, sex, education, district of residence and occupation), their history of SMA in the previous year, conditions prompting SMA, sources of antibiotics, awareness of antibiotic resistance, perceived household distance from health care facilities (hospital/health centre/dispensary) and community drug outlets and types of antibiotics used. For the purposes of this study, participants who had used antibiotics to treat self-diagnosed disorders or symptoms or used leftover prescribed antibiotics without consulting a prescriber in the previous 12 months were considered to have practiced SMA.

In the second objective, the questionnaires enquired about patients' and dispensers' demographics, community drug outlet registration status, presence or absence of prescriptions, type and nature of drugs dispensed, percentage of antibiotic dispensing and compliance to prescription orders by community drug dispensers.

Questionnaires in the third objective enquired on patients' and prescribers' demographics, primary health care facility information, type and nature of drugs prescribed, patients' diagnosis and the adherence of prescribers to standard treatment guidelines and the national essential medicines list.

With regard to the fourth objective, questionnaires recorded variables such as patients' demographics, primary health care facility information, and the nature of clinical specimen collected.

3.4.2 Specimen Collection

In the fourth objective, a total of 621 clinical samples (stool, urine, throat swabs, wound swabs) from 621patients were collected by laboratory technicians using appropriate clinical specimen collection containers from 1st of October, 2020 to 27th November, 2020.

3.5 Specimen Analysis

3.5.1 Microbiological Analysis

Microbiological analysis for the collected specimen was done at the central zone microbiology laboratory located at the Dodoma regional referral hospital. The central zone microbiology laboratory standard operating procedures (SOPs) were used to process the clinical specimens. Only clean and uncontaminated cultures identified to potentially harbor pathogenic micro-organisms were processed. Biochemical tests were used in the identification and subsequent isolation of the bacterial pathogens. Disc diffusion methods were used in the determination of antibiotic susceptibility of the isolated pathogens and interpreted as per the Clinical Laboratory Standards Institute guidelines (CLSI, 2020). The antibiotic discs used were from HiMedia Laboratories Pvt. Limited manufactured in Mumbai India; these included Amoxicillin/Clavulanic Acid (30 mcg), Ampicillin (10 mcg), Azithromycin (15 mcg), Amikacin (30 mcg), Ciprofloxacin (5 mcg), Ceftriaxone (30 mcg), Cefotaxime (30 mcg), Cefepime (30 mcg), Gentamicin (120 mcg and 10 mcg), Meropenem (10 mcg) and Nitrofurantoin (200 mcg). Cefoxitin (30 mcg) was used to detect methicillin resistant *Staphylococcus aureus* (MRSA), isolates with a zone of inhibition below 21 mm were considered resistant to methicillin (CLSI, 2020).

3.5.2 Quality Control

Staphylococcus aureus ATCC 25 923 and *Escherichia coli* ATCC 25 922 were used as control strains for gram-positive and gram-negative pathogens, respectively (CLSI, 2020). In addition, molecular typed MRSA strain was the positive control for MRSA resistant organisms (CLSI, 2020).

3.6 Data Processing, Coding and Statistical Analyses

In the first objective, the collected data were downloaded from KoBo Collect software in Excel format, cleaned and then exported to R statistical software version 3.4.4 (2018) for analysis. The SMA was used as an outcome variable, and univariate and multivariate analyses were performed using various predictor variables. Descriptive statistics of the demographic information and various predictors were presented in tabular format, while the frequency of complaints leading to SMA is presented graphically. Finally, regression models to determine the odds of SMA with various predictors were presented for both crude odds ratios (univariate analyses) and adjusted odds ratios (multivariate analyses). The statistical significance of the results across all the variables was <0.05.

In the second objective, the collected data were downloaded from the KoBo Collect software in an Excel format, cleaned and then exported to R statistical software version 3.4.4 (2018) for analysis. Using antibiotic dispensing as an outcome variable, univariate, bivariate and multivariate analyses were performed. Data analysis involved the calculation of measures of central tendency and the stratification of antibiotic self-medication based on several categorical variables in the bivariate analyses. Finally, multivariate analyses were performed to determine the independent effect of variables on the probability of antibiotic dispensing in the all-variables model. The statistical significance of the results across all the variables was <0.05

In the third objective, basic descriptive statistics, such as frequency and percentages, were evaluated and used to describe baseline characteristics. A chi-square test of association was also employed to test the association of diseases diagnosed and the status of antibiotic prescription. Antibiotic prescription was an outcome variable in this study, and other independent variables included diagnosis as well as social and demographic characteristics. The SAS version 9.4 (2015) was used for data analysis, and the significance of all statistical tests was set at the 5% level of significance.

The outcome variable had two responses (Yes/No); thus, a binary logistic regression model was used to determine factors associated with receiving antibiotics. The general logistic regression model is shown in Equation 2:

$$\operatorname{logit}[\pi(x)] = \log\left(\frac{\pi(x)}{1-\pi(x)}\right) = \beta_0 + \beta_1 x_1 + \ldots\ldots + \beta_p x_p \qquad (2)$$

Whereby, $\pi(x)$ is the likelihood of receiving antibiotics, "Yes", x_i's are sets of independent variables and β_i's are their respective parameters.

The results of the model are presented in the form of regression parameter estimates and estimated odds ratios (ORs). The statistical significance of the results across all the variables was <0.05.

In the fourth objective, the SPSS software version 25 (2017) was used for analysis. Descriptive statistics for demographics and sensitivity of bacterial pathogens to various antibiotics were determined.

3.7 Ethical Clearance

Ethical clearance was sought and granted by the Northern Zone Health Research Ethics Committee (Approval code: KNCHREC0020). Chemba District Council and Dodoma City Council Executive Directors were consulted for permissions to conduct the study in their respective areas. Consent forms were used to obtain consent from participants. A detailed description of the Swahili translated consent form was given to all potential participants. The consenting participant in each household, community drug outlet and health care facility were recruited, interviewed and/or asked to donate clinical specimens.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Results

4.1.1 Prevalence and Predictors of Self-Medication with Antibiotics in Dodoma Region, Central Tanzania

(i) Socio-demographic Characteristics and Prevalence of Self-Medication with Antibiotics among Participants in Chemba District Council (Rural) and Dodoma City Council (Urban)

A total of 430 participants, one from each randomly selected household, were interviewed; of these, 62.6% (269/430) were from Dodoma City Council. The overall response rates were almost comparable between participants from Chemba District Council 90.4% (161/178) and Dodoma City Council 91.8% (269/293). The majority (>65%) of the participants in both the rural and urban localities were female. With regard to age distribution, the median age of the participants in the rural district was 36 (IQR=13.7), which was lower than the median age of 40 (IQR=12.8) among the participants in the urban district. The majority of the respondents in both the rural 76.4% (123/161) and urban 82.2% (221/269) districts had a primary school education. Regarding marital status, 82.6% (133/161) and 87.4% (235/269) in the rural and urban localities, respectively were single. The majority of the participants in the rural setting were farmers 74.5%(120/161), which was slightly higher than the percentage in the urban setting, where 68.8% (185/269) reported that farming was their main economic activity. Additionally, approximately one-third of the participants in the urban district were small business owners 33.8% (91/269), which was higher than the percentage in the rural district 13% (21/161). The proportion of participants with health insurance was higher in rural district 22.4% (36/161) than in the urban district 11.2% (30/269).

Regarding the perceived distance from the household to a health care facility (hospital/health centre/dispensary) or a community drug outlet, the majority 76.4% (123/161) of the participants in the rural setting perceived that they lived closer to a health care facility than to a community drug outlet. Among the participants in the urban district, 57.2% (154/269) reported a shorter distance from their household to a health care facility. The proportion of participants reporting awareness of the concept of antibiotic resistance and the associated complications was higher in the rural district 38.5% (62/161) than in the urban setting 26.4% (71/269) (Table 1).

Generally, 23.5% (101/430) of the participants in both the rural and urban districts reported having practiced SMA within the previous year, with 23.6% (38/161) in the rural district and 23.4% (63/269) in the urban settings.

Table 1: Socio-Demographic Characteristics and Prevalence of Self-Medication with Antibiotics (SMA) among Participants in the Rural and Urban Settings

Variables	Rural (n=161)			Urban (n=269)		
	Levels	n(%)	Prevalence of SMA n(%): 38 (23.6)	Levels	n(%)	Prevalence of SMA n(%): 63 (23.4)
Sex	Female	119 (73.9)	30 (78.9)	Female	183 (68)	43 (68.3)
	Male	42 (23.1)	8 (21.1)	Male	86 (32)	20 (31.7)
Age	Mean	38.9	-	Mean	43.2	-
	Median	36	-	Median	40	-
	IQR	13.7	-	IQR	12.8	-
	Min	18	-	min	19	-
	Max	82	-	max	86	-
Age categories	18-30 yrs	51 (31.7)	15 (39.5)	18-30 ys	49 (18.2)	21 (33.3)
	31-45 yrs	67 (41.6)	16 (42.1)	31-45 yrs	118 (43.9)	25 (39.7)
	45+ yrs	43 (26.7)	7 (18.4)	45+ yrs	102 (37.9)	17 (27.0)
Education	None	11 (6.8)	1 (2.6)	None	7 (2.6)	2 (3.2)
	Primary school	123 (76.4)	30 (78.9)	Primary school	221 (82.2)	43 (68.3)
	Secondary +	27 (16.8)	7 (18.4)	Secondary +	41 (15.2)	18 (28.6)
Marital status	Single	133 (82.6)	27 (71.1)	Single	235 (87.4)	52 (82.5)
	Married	18 (11.2)	8 (21.1)	Married	22 (8.2)	10 (15.9)
	Widowed	10 (6.2)	3 (7.8)	Widowed	12 (4.5)	1 (1.6)
Occupation	Farmer	120 (74.5)	29 (79.3)	Farmer	185 (68.8)	28 (44.4)
	Livestock and farming	20 (12.4)	1 (2.6)	Livestock and farming	24 (8.9)	7 (11.1)
	Small business	21(13)	5 (13.2)	Small business	91 (33.8)	32 (50.8)
	Employed	21(13)	6 (15.8)	Employed	16 (5.9)	7 (11.1)
Ownership of health insurance	YES	36 (22.4)	7 (18.4)	YES	30 (11.2)	7 (11.1)
	NO	125 (77.6)	31 (81.6)	NO	239 (88.8)	56 (88.9)
Perceived proximity	Drug outlet	38 (23.6)	34 (89.5)	Drug outlet	115 (42.8)	43 (68.3)
	Health center	123 (76.4)	4 (10.5)	Health center	154 (57.2)	20 (31.7)

Variables	Rural (n=161)			Urban (n=269)		
	Levels	**n(%)**	**Prevalence of SMA n(%): 38 (23.6)**	**Levels**	**n(%)**	**Prevalence of SMA n(%): 63 (23.4)**
between drug outlet and health facility						
Ever heard of AMR	YES	62 (38.5)	14 (36.8)	YES	71 (26.4)	17 (27)
	NO	99 (61.5)	24 (63.2)	NO	198 (73.6)	46 (73)
Frequency of self-medication	Mean	1.9	-	mean	2.2	-
	Median	2	-	median	2	-
	IQR	0.78	-	IQR	1.06	-
	Min	1	-	Min	1	-
	Max	4	-	Max	5	-

(ii) Complaints Leading to SMA and the Antibiotics Frequently Used

Cough complaints accounted for the majority of SMA practices among both the rural and urban participants (76.3% and 82%, respectively). Other commonly reported complaints prompting SMA were, ordered by proportion, body pain (71.1%), fever (63.2%), flu (44.7%) and diarrhoea (31.3%) in the rural, whereas diarrhoea (48.2%), flu (47.1%), body pain (41.5%) and fever (39.7%) were the complaints that prompted SMA in the urban settings (Fig. 2).

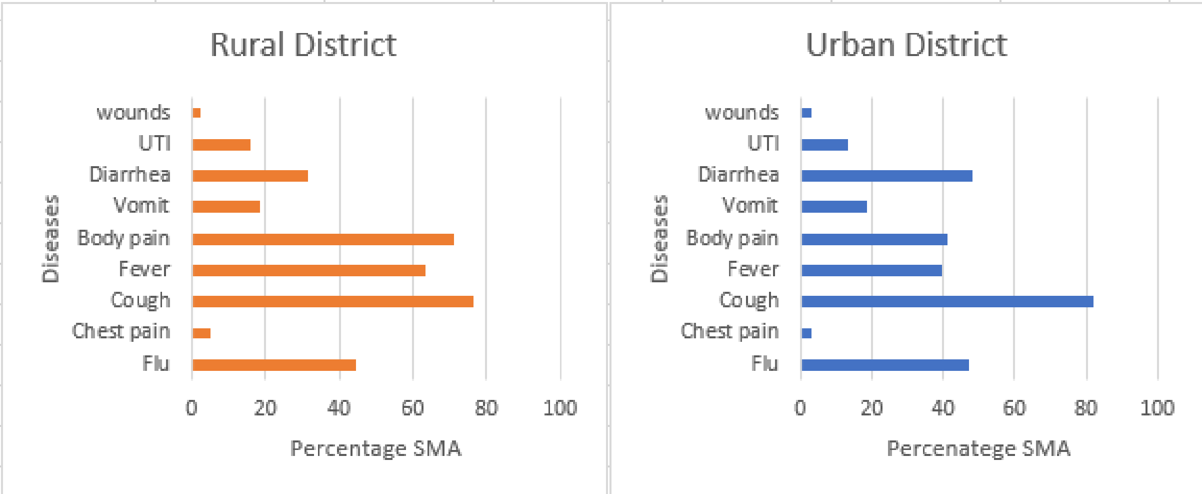

Figure 2: Complaints prompting SMA in the rural (left) and urban (right)settings

Generally, a larger number of antibiotic varieties was used by the urban participants (13 antibiotics) than by their rural counterparts (9 antibiotics) (Fig. 2). The most commonly used antibiotic for self-medication among both the rural (47.3%) and urban (40.9%) participants was amoxicillin (Fig. 3).

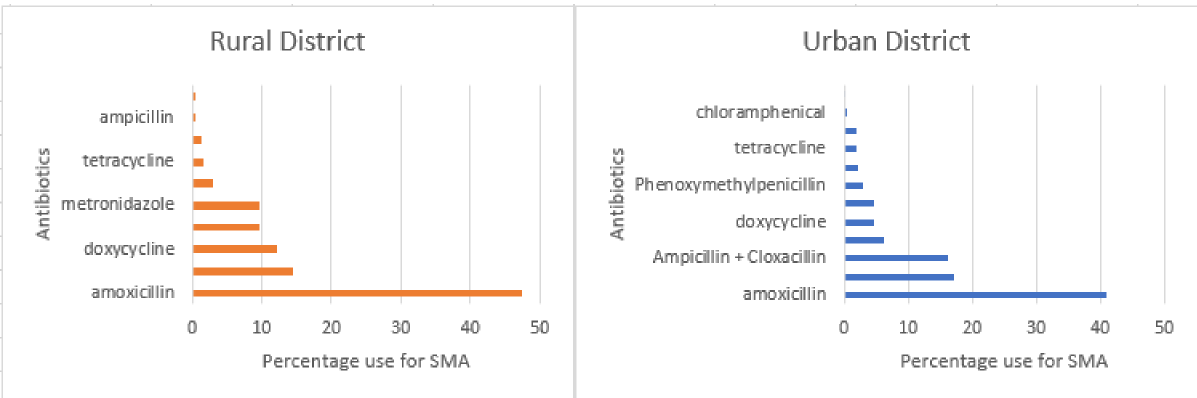

Figure 3: Types of antibiotics for SMA used by individuals in the rural (left) and urban (right) settings

(iii) Predictors of SMA In the Rural and Urban Settings

Univariate Logistic Regression Model

In the univariate model (Table 2), there was a comparable increase in the odds of SMA among participants with single marital status in both settings; compared to those in the married category, single participants were 1.27 times (crude OR: 1.27; 95% CI: 1.030, 1.567; p=0.0237) and 1.26 times (crude OR: 1.26; 95% CI: 1.051, 1.517; p=0.013) more likely to practise SMA in the rural and urban districts, respectively. Compared to the nonfarming participants in this study, the odds of SMA decreased by 23% (crude OR: 0.77; 95% CI: 0.691, 0.852; p<0.001) among farmers in the urban setting, while the likelihood of SMA among farmers in the rural setting was 1.02 times (crude OR: 1.02; 95% CI: 0.879, 1.190; p=0.775) higher; however, the latter observation was not statistically significant. Although the results were not statistically significant, the odds of SMA were 5% (crude OR: 0.95; 95% CI: 0.809, 1.110; p=0.508) and 0.1% (crude OR: 0.99; 95% CI: 0.850, 1.174; p=0.991) lower for participants with any form of health insurance than for participants lacking health insurance in the rural and urban settings, respectively.

With regard to the perceived distance to a community drug outlet or a health care facility, the participants perceiving a shorter distance to a health care facility had a 58% lower likelihood of SMA in the rural setting (crude OR: 0.42; 95% CI: 0.390, 0.457; p<0.001) and a 22% lower likelihood in the urban setting (crude OR: 0.78; 95% CI: 0.710, 0.864; p<0.001) compared to those perceiving a shorter distance to a community drug outlet.

Multivariate Logistic Regression Model

The participants who reported living closer to a health care facility than a drug outlet had 58% (adjusted OR: 0.42; 95% CI: 0.388, 0.458; p<0.001) and 16% (adjusted OR: 0.84; 95% CI: 0.755, 0.929; p<0.001) lower odds of SMA than those who reported living closer to a drug outlet in the rural and urban districts, respectively. Compared to other occupations in this study, the odds of SMA among the farming participants decreased by 17% (adjusted OR: 0.83; 95% CI: 0.716, 0.955; p=0.01) and 8% (adjusted OR: 0.92; 95% CI: 0.813.1.030; p = 0.146) in the urban and rural districts, respectively (Table 2).

Table 2: Predictors of self-medication with antibiotics in the rural and urban settings

Variables		Rural						Urban					
		Univariate model			Multivariate model			Univariate model			Multivariate model		
		cOR	95%CI	p-value	aOR	95%CI	p-value	cOR	95%CI	p-value	aOR	95%CI	p-value
Sex	Female	Ref			Ref			Ref			Ref		
	Male	0.94	0.81,1.09	0.422	1.027	1.913,3.33	0.556	0.998	0.895,1.112	0.965	0.960	0.856,1.077	0.492
Age		0.997	0.992,1.00	0.2	0.999	0.995,1.003	0.697	0.994	0.990,0.998	0.198	0.997	0.992,1.002	0.222
Education	None	Ref			Ref			Ref			Ref		
	Primary	1.165	0.896,1.516	0.256	1.057	0.904,1.236	0.485	0.912	0.667,1.248	0.569	0.830	0.611,1.126	0.231
	Secondary and more	1.183	0.877,1.596	0.272	1.011	0.831	0.916	1.166	0.835,1.628	0.369	0.918	0.648,1.300	0.630
Marital status	Married	Ref			Ref			Ref			Ref		
	Single	1.273	1.036,1.567	0.024	1.041	0.893,1.21	0.605	1.262	1.051,1.517	0.013	0.975	0.797,1.192	0.805
	Widowed	1.102	0.840,1.445	0.484	1.129	0.963,1.324	0.136	0.871	0.682,1.111	0.267	0.957	0.748,1.222	0.723
Occupation	Farming: NO	Ref			Ref			Ref			Ref		
	Farming: YES	1.022	0.879,1.190	0.775	0.916	0.813,1.030	0.146	0.767	0.691,0.852	<0.001	0.827	0.716,0.955	0.010
	Farming and livestock: NO	Ref						Ref			Ref		
	Farming and livestock: YES	0.809	0.664,0.985	0.037	0,957	0.821,1.114	0.573	1.065	0.891,1.272	0.488	1.017	0.818,1.264	0.878
	Business: NO	Ref						Ref			Ref		
	Business: YES	1.002	0.824,1.219	0.981	0.932	0.827,1.051	0.253	1.194	0.074,1.327	0.0001	1.096	0.975,1.232	0.126
	Employed: NO	Ref						Ref			Ref		
	Employed: YES	1.059	0.871,1.288	0.568	1.06	0.936,1.2001	0.361	1.241	1.002,1.536	0.048	1.133	0.873,1.471	0.348
Ownership of health insurance	NO	Ref			Ref			Ref			Ref		
	YES	0.948	0.809,1.110	0.508	0.935	0.848,1.032	0.184	0.999	0.850,1.174	0.991	0.925	0.766,1.116	0.416
Perceived distance to a health care or drug outlet	Drug outlet	Ref			Ref			Ref			Ref		
	Health facility	0.422	0.390,0.457	<0.001	0.421	0.388,0.458	<0.001	0.783	0.710,0.864	<0.001	0.837	0.755,0.929	<0.001
Awareness of Antibiotic Resistance	NO	Ref			Ref			Ref			Ref		
	YES	0.984	0.859,1.126	0.811	1.06	0.984,1.141	0.123	1.007	0.897,1.130	0.904	0.936	0.832,1.053	0.270

cOR = crude odds ratio
aOR = adjusted odds

4.1.2 ratioPrevalence and Determinants of Antibiotic Dispensing in Community Drug Outlets of Dodoma Region, Central Tanzania

(i) Socio-Demographic Characteristics of Respondents in Community Drug Outlets

A total of 64 drug outlets were visited in this study, the majority had both the necessary registration certificates 97.7% (59/61) and pharmaceutical reference books 73.8 % (45/61) as per the guidelines by the Pharmacy Council of Tanzania. A total of 643 drug dispensing interactions were recorded, a majority 84.1 % (541/643) of which were from Dodoma City Council. Of the 643 respondents in the current study, 50.3 % (324) were females.

Over half 51.6 % (332/643) of the participants in this study reported having a secondary school education and above. The ADDO and community pharmacies were the two types of community drug outlets recorded; a majority 74.7% (482/643) of the drug dispensing encounters were recorded in ADDO. The prevalence of antibiotic dispensing was 24.9% (160/643); the majority 75% (120/160) of which were dispensed without prescriptions (Table1). Of the encounters with antibiotics, 86.3% (138/160) were recorded in ADDO and 58% (80/138) of these not being in the ADDO stocking and dispensing jurisdiction.

The most commonly dispensed antibiotics were amoxicillin (25.6%), ampicillin/Cloxacillin (20.6%), azithromycin (11.3%), Ciprofloxacin and doxycycline (7.5%); these accounted for over 70% of all the antibiotics dispensed in this study.

Table 3: Socio-demographic characteristics of respondents in community drug outlets

Variable	Response	Number (%)
Sex	Male	319 (49.7)
	Female	324 (50.3)
Education level	None	68 (10.6)
	Primary education	243 (37.8)
	Secondary or more	332 (51.6)
Types of drug outlets	ADDO	482 (75)
	Community pharmacy	161 (25)
Presence of drug outlet registration certificates	NO	2 (2.3)
	YES	59 (97.7)
Presence of Pharmaceutical reference books	NO	16 (26.2)
	YES	45 (73.8)
Dispensing by qualification	Pharmacist	38 (5.9)
	Pharm technician	130 (20.2)
	Pharm assistant	41 (6.4)
	Pharm dispenser	242 (37.6)
	ADD	151 (23.5)
	Nurse	30 (4.7)
	Clinical officer	11 (1.7)
District	Chemba District Council	102 (15.9)
	Dodoma city Council	541 (84.1)
Encounters with or without antibiotics	NO	483 (75.1)
	YES	160 (24.8)
Antibiotic encounters with prescription	NO	120 (75)
	YES	40 (25)

Pharmaceutical reference book: Code of ethics of pharmaceutical personnel, Standard treatment guideline and the Tanzania National Formulary

(ii) Stratification Analysis of Demographic Characteristics Against Antibiotic Dispensing

Antibiotic dispensing among female clients was 28.4% (92/324) being slightly higher than 21.3% (68/319) of antibiotic dispensing recorded among males ($p = 0.045$). The proportion of antibiotic dispensing among clients attending community drug outlets in Chemba District Council was 41.2% (42/102), this being relatively higher when compared to 21.8% (118/541) of antibiotic dispensing among clients in Dodoma City Council ($p = 0$). The most common disease complaints that prompted antibiotic dispensing were cough (42.9%; 33/77; $p = 0$), sore throat (50%; 10/20; $p = 0.015$), urinary tract related symptoms (93.3%; 28/30; $p = 0$), and wounds (53.7%; $p = 0$) (Table 4).

Table 4: Cross tabulation of demographic factors against antibiotic purchase or non-purchase

Characteristics	Antibiotic purchase No: 483 (75.1%)	Antibiotic purchase Yes: 160 (24.9%)	Chi square test	P value
Sex			4.31	0.045
Male	251 (78.7%)	68 (21.3%)		
Female	232 (71.6%)	92 (28.4%)		
Age				0.021
Young (15-45)	379 (73.2%)	139 (26.8%)		
Old (46 and above)	104 (83.2%)	21 (16.8%)		
Place of residence			17.22	<0.001
Chemba (Rural)	60 (58.8%)	42 (41.2%)		
Dodoma city (Urban)	423 (78.2%)	118 (21.8%)		
Education status			0.80	0.672
None	51 (75%)	17 (25%)		
Primary education	178 (73.3%)	65 (26.7%)		
Secondary education or more	254 (76.5%)	78 (23.5%)		
Runny nose			5.26	0.024
YES	66 (85.7%)	11 (14.3%)		
NO	417 (73.7%)	149 (26.3%)		
Stuffy nose			0.25	0.746
YES	9 (69.2%)	4 (30.8%)		
NO	474 (75.2%)	156 (24.8%)		
Cough			15.12	<0.001
YES	44 (57.1%)	33 (42.9%)		
NO	439 (77.6%)	127 (22.4%)		
Sore throat			6.97	0.015
YES	10 (50%)	10 (50%)		
NO	473 (75.9%)	150 (24.1%)		
Fever			1.93	0.195
YES	50 (68.5%)	23 (31.5%)		
NO	433 (76%)	137 (24%)		
Pain			34.36	<0.001
YES	172 (90.5%)	18 (9.5%)		
NO	311 (68.7%)	142 (31.3%)		
Nausea and vomiting			1.08	0.432
YES	17 (85%)	3 (15%)		
NO	466 (74.8%)	157 (25.2%)		
Diarrhea			6.28	0.013
YES	49 (89.1%)	6 (10.9%)		
NO	434 (73.8%)	154 (26.2%)		
UTI symptoms			7.23	<0.001
YES	2 (6.7%)	28 (93.3%)		
NO	469 (78%)	132 (22%)		
Wound			19.4	<0.001
YES	19 (46.3%)	22 (53.7%)		
NO	464 (77.1%)	138 (22.9%)		

(iii) Logistic Regression Models

The Un-Adjusted Logistic Regression Model

Compared to their female counterparts, the likelihood of antibiotic dispensing among male clients decreased by 7% (cOR=0.93; 95%CI: 0.87-1; p = 0.038). There were 1.5 times (cOR=1.51; 95%CI: 1.39-1.64; $p < 0.001$) increases in the odds of antibiotic dispensing among participants in Dodoma City Council compared to those in Chemba District Council. Compared to all other dispensers, PD were by 89% more likely to dispense antibiotics (cOR=0.89; 95%CI: 0.81-0.97; p = 0.006). Compared to all other disease complaints, there was a two-times increase in the odds of antibiotic dispensing among clients reporting urinary tract related symptoms (cOR=2.05; 95%CI: 1.77-2.38; $p < 0.001$), while that among clients with cough and sore throat increased by 1.22 times (cOR=1.22; 95%CI: 1.11-1.35; $p < 0.001$) and 1.3 times (cOR=1.30; 95%CI: 1.07-1.57; p = 0.008), respectively (Table 5).

Multivariate Logistic Regression Model

Compared to all other diseases reported, antibiotic dispensing among individuals reporting runny nose decreased by 11% (aOR=0.89; 95%CI: 0.81-0.98; p = 0.025). Compared to other diseases reported, the odds of antibiotic dispensing among those with cough, sore throat and fever increased by 1.3 times (aOR=1.29; 95%CI: 1.18-1.41; $p < 0.001$), 1.31 times (aOR=1.31; 95%CI: 1.11-1.54; p = 0.001) and 1.2 times (aOR=1.18; 95%CI: 1.08-1.30; p = 0.001), respectively. The odds of antibiotic dispensing among patients with wounds increased by 1.2 times (aOR=1.23; 95%CI: 1.23-1.57; $p < 0.001$) while there was two times increase in antibiotic dispensing among those reporting any urinary tract related complains (aOR=2.01; 95%CI: 1.75-2.31; $p < 0.001$). Compared to those lacking prescriptions, there was 1.3 times increase in antibiotic dispensing among customers with a medical prescription (aOR=1.30; 95%CI:1.18-1.43; $p < 0.001$) (Table 5).

Table 5: Un-adjusted and adjusted odds ratios of determinants for antibiotic dispensing in community drug outlets

Determinants		Unadjusted model		Adjusted model	
		cOR (95%CI)	***p*-value**	**aOR (95%CI)**	***p*-value**
Sex	Female	Reference		Reference	
	Male	0.93 (0.87,1)	0.038	0.96 (0.91,1.02)	0.167
Age	Old	Reference		Reference	
	Young	1(0.996,1.0)	0.125	1 (0.997,1.001)	0.515
District					
	Chemba District Council	Reference		Reference	
	Dodoma City Council	1.51(1.39,1.64)	<0.001	0.93 (0.84,1.02)	0.106
Dispenser qualification		Reference		Reference	
	Clinical officer	1.78 (1.38,2.31)	<0.001	1.77 (1.41,2.24)	<0.001
	One-year trained dispenser	0.89 (0.81,0.97)	0.006	0.94 (0.87,1.02)	0.163
	Pharmaceutical Technician	0.86 (0.78,0.95)	0.004	0.97 (0.87,1.08)	0.532
	Pharmaceutical assistant	0.94 (0.81,1.07)	0.398	0.95 (0.83,1.08)	0.402
	Pharmacist	0.93 (0.80,1.09)	0.374	0.97 (0.82,1.14)	0.699
	Nurse	0.82 (0.70,0.97)	0.019	0.89 (0.76,1.04)	0.133
Type of drug outlet	ADDO	Reference		Reference	
	Pharmacies	0.94 (0.87,1.02)	0.137	0.92 (0.84,1.01)	0.070
Runny nose	No	Reference		Reference	
	Yes	0.89 (0.80,0.98)	0.022	0.89 (0.81,0.98)	0.024
Stuffy nose	No	Reference		Reference	
	Yes	1.06 (0.84,1.35)	0.621	1.05 (0.85,1.28)	0.671
Cough	No	Reference		Reference	
	Yes	1.22(1.11,1.35)	<0.001	1.29 (1.18,1.41)	<0.001
Sore-throat	No	Reference		Reference	
	Yes	1.30 (1.07,1.57)	0.008	1.31 (1.11,1.54)	0.001
Fever	No	Reference		Reference	
	Yes	1.08 (0.97,1.20)	0.165	1.18 (1.08,1.30)	<0.001
Body pain	No	Reference		Reference	
	Yes	0.80 (0.75,0.86)	<0.001	0.92 (0.85,0.99)	0.020
Vomiting/nausea	No	Reference		Reference	
	Yes	0.90 (0.74,1.09)	0.300	0.92 (0.78,1.09)	0.326
Diarrhea	No	Reference		Reference	
	Yes	0.86 (0.76,0.97)	0.012	0.92 (0.83,1.02)	0.127
Wounds	No	Reference		Reference	
	Yes	1.36 (1.19,1.56)	<0.001	1.39 (1.23,1.57)	<0.001
Urinary tract symptoms					
	No	Reference		Reference	
	Yes	2.05 (1.76,2.37)	<0.001	2.01 (1.75,2.31)	<0.001
Prescription					
	No	Reference		Reference	
	Yes	1.28 (1.16,1.40)	<0.0001	1.21 (1.10,1.33)	<0.0001

aOR = adjusted odds ratios
cOR = crude odds ratios

4.1.3 Patterns and Predictors of Antibiotic Prescriptions in Primary Health Care Facilities of Dodoma Tanzania

(i) Patients' and Prescribers' Characteristics

Of the 1021 retrospective prescribing encounters in this study, 61.8% (631/1021) were from Dodoma City Council. The majority (94.1%; 961/1021) of the prescribing encounters were those recorded from public primary health care facilities, and only 5.8% accounted for prescriptions in private and other faith-based primary health care facilities. Children under the age of five accounted for over 45% (474/1021) of all the encounters recorded. There were more consultations involving females 54.6% (557/1021) than those involving males, while the majority 94.6% (966/1021) of prescribers were individuals with a diploma in clinical medicine (Table 6).

Table 6: Demographic characteristics of patients and proportion of antibiotic prescriptions in primary health care facilities

Variable	Frequency	Percentage
District		
Chemba	390	38.2
Dodoma	631	61.8
Type of health facility		
Dispensary	748	73.3
Health centre	273	26.7
Ownership		
Private	60	5.9
Government	961	94.1
Age of patients		
<5	474	46.4
5-18	140	13.7
19-35	175	17.1
36-45	60	5.9
46-55	39	3.8
56+	133	13.0
Sex		
Male	464	45.5
Female	557	54.6
Prescribers' education		
Certificate	6	0.59
Diploma	966	94.61
Degree	49	4.80

The most common empirical diagnoses were upper respiratory tract infections (URTIs), urinary tract infections (UTIs) and diarrhoea, which accounted for 30.3%, 12.1% and 7.7%, respectively (Fig. 4).

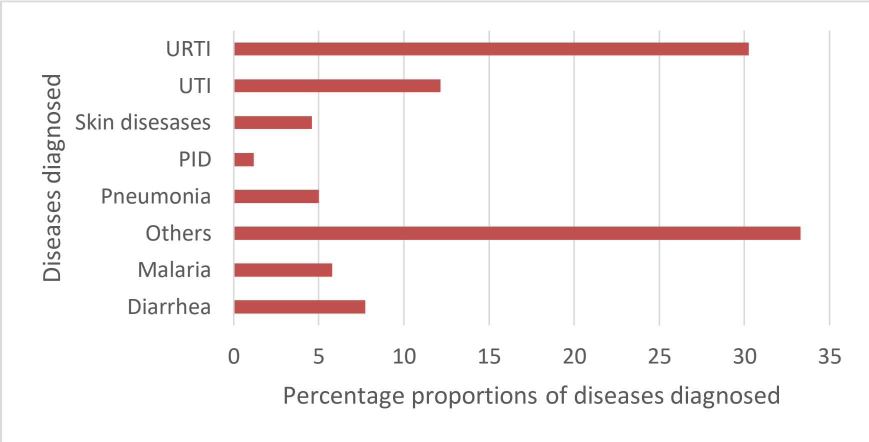

Figure 4: Proportions of individuals diagnosed with common diseases (Others: A group of conditions not presented in the chart)

Of the 1021 prescribing encounters in this study, 76.3% (779/1021) had an antibiotic prescribed, with amoxicillin and sulfamethoxazole + Trimethoprim accounting for over 60% of all the prescribed antibiotics (Fig. 5).

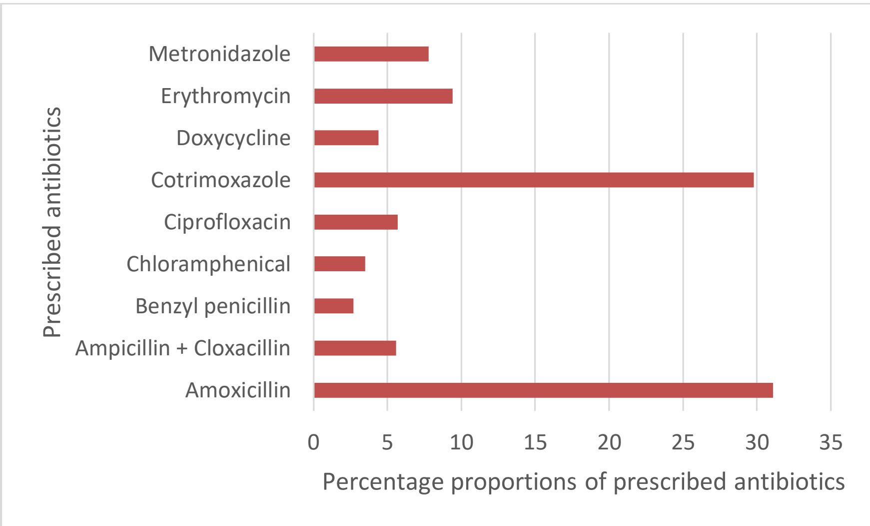

Figure 5: Commonly prescribed antibiotics

The majority 98.3% (766/779) of the antibiotics prescribed were listed on the National Essential Medicines List (NEMLIT) and were all in the '*access'* category as per the WHO *AWaRe* (Access, Watch and Reserve) antibiotic classification system as classified in the Tanzanian Standard Treatment Guidelines (STG). Majority 55% (429/779) of the antibiotic prescriptions were aligned to the empirical diagnoses as per the Standard Treatment Guidelines (STG).

(ii) Stratification of Social, Demographic and Clinical Predictors for Antibiotic Prescription Status

The proportions of antibiotic prescriptions among male patients 78.8% (439/557) were significantly higher ($p = 0.038$) compared to female patients 73.3% (340/464). Prescribers with a diploma in clinical medicine were accounted for the majority 95.9% (747/779) of antibiotic prescriptions. The most common diagnoses for which antibiotics were prescribed included urinary tract infection (UTI) (100%; $p < 0.001$), upper respiratory infection (82.1%; $p = 0.05$), pneumonia (98%; $p = 0.0002$), diarrhea (73.4%; $p = 0.53$), skin diseases (53.2%; $p = 0.0001$) and pelvic inflammatory diseases (PIDs) (41.7%; $p = 0.101$) (Table 7). Nevertheless, a significant proportion (54.2%; $p = 0.0001$) of patients diagnosed with malaria were prescribed with antibiotics.

Table 7: Association of antibiotics prescriptions by social, demographic and clinical predictors

Variable	Non-antibiotics (N=242) N (%)	Antibiotics (N=779) N (%)	X^2	*p* value
District			1.6815	0.195
Chemba	101(25.90)	289 (74.1)		
Dodoma	141(22.35)	490 (77.7)		
Type of health facility			0.6126	0.434
Dispensary	182 (24.33)	566 (75.7)		
Health centre	60 (21.98)	213 (78)		
Ownership			0.7560	0.385
Private	17 (28.33)	43 (71.7)		
Government	225 (23.41)	736 (76.59)		
Age			7.1384	0.211
<5	124 (26.16)	350 (73.8)		
5-18	38 (27.14)	102 (72.9)		
19-35	37 (21.14)	138 (78.9)		
36-45	10 (16.67)	50 (83.3)		
46-55	9 (23.08)	30 (76.9)		
56+	24 (18.05)	109 (82)		
Sex			4.2948	0.038
Male	118 (21.18)	439 (78.8)		
Female	124 (26.72)	340 (73.3)		
Level of prescriber education			5.4522	0.020
Degree	19 (37.25)	32 (62.8)		
Diploma	223 (22.99)	747 (77)		
UTI			43.8463	<0.001
No	242 (26.98)	655 (73)		
Yes	0 (0.00)	124 (100)		
URTI			3.7990	0.051
No	212 (24.85)	641(75.1)		
Yes	30 (17.86)	138(82.1)		
Diarrhoea			0.3927	0.531
No	221(23.46)	721(76.5)		
Yes	21(26.58)	58 (73.4)		
Pneumonia			14.0314	0.002
No	241(24.85)	729 (75.2)		
Yes	1(1.96)	50 (98.0)		
Pregnancy				0.709
No	239 (23.64)	772 (76.4)		
Yes	3 (30.00)	7 (70)		
Malaria			16.8512	<0.001
No	215 (22.35)	747 (77.6)		
Yes	27 (45.76)	32 (54.2)		
PID				0.010
No	235 (23.29)	774 (76.7)		
Yes	7 (58.33)	5 (41.7)		
Dermatological conditions			14.5453	0.001
No	220 (22.59)	754 (77.4)		
Yes	22 (46.81)	25 (53.2)		
Other diseases			6.4661	0.011
No	134 (21.07)	502 (78.9)		
Yes	108 (28.05)	277 (72)		

(iii) Binary Logistic Regression Analysis of Antibiotic Prescriptions by Social, Demographic and Clinical Predictors

Univariate Logistic Regression Analysis

Patients attending primary health care facilities in Dodoma City Council were 1.22 times more likely to be prescribed antibiotics than those in Chemba district (crude OR=1.22; 95% CI: 0.905, 1.630; $p < 0.001$). Compared to their female counterparts, male patients were 26% less likely to be prescribed antibiotics (crude OR=0.74; 95% CI: 0.552, 0.984; $p = 0.037$). Compared to medical doctors (degree in medicine), there was an almost twofold increase (crude OR=1.99; 95% CI: 1.106, 3.577; $p = 0.022$) in the odds of antibiotic prescriptions among clinical officers (diploma in clinical medicine). Patients diagnosed with upper respiratory tract infection and pneumonia were 1.52 times (crude OR=1.52; 95% CI: 0.995, 2.324; $p = 0.053$) and 16.5 times (crude OR=16.53; 95% CI: 2.271, 20.270; $p = 0.006$) more likely to be prescribed antibiotics, respectively, than patients who did not have these conditions. Patients with malaria, skin diseases and other disease conditions were 65.9% (crude OR=0.34; 95% CI: 0.200, 0.582; $p > 0.001$), 67% (crude OR=0.33; 95% CI: 0.183, 0.600; $p > 0.003$) and 31% (crude OR=0.69; 95% CI: 0.511, 0.918; $p > 0.011$) less likely to be prescribed antibiotics, respectively (Table 8).

Table 8: Binary logistic analysis for predictors of antibiotic prescriptions

Variable	Univariate analysis		Multivariate analysis	
	cOR [95% CI]	**p value**	**aOR [95% CI]**	***p* value**
District				
Chemba	Ref		Ref	
Dodoma	1.215 [0.905, 1.630]	0.257	1.117 [0.811, 1.537]	0.498
Sex				
Female	Ref		Ref	
Male	0.737 [0.552, 0.984]	0.039	0.767 [0.567, 1.039]	0.086
Prescriber education				
Degree	Ref		Ref	
Diploma	1.989 [1.106, 3.577]	0.022	2.546 [1.359, 4.769]	0.004
URTI				
No	Ref		Ref	
Yes	1.521 [0.995, 2.324]	0.053	1.471 [0.899, 2.407]	0.124
Pneumonia				
No	Ref		Ref	
Yes	16.528 [2.271, 20.270]	0.006	15.928 [2.151, 17.973]	0.007
Malaria				
No	Ref		Ref	
Yes	0.341 [0.200, 0.582]	<0.001	0.287 [0.160, 0.514]	<0.001
Dermatological conditions				
No	Ref		Ref	
Yes	0.332 [0.183, 0.600]	<0.001	0.331 [0.174, 0.630]	<0.001
Other diseases				
No	Ref		Ref	
Yes	0.685 [0.511, 0.918]	0.011	0.740 [0.510, 1.074]	0.113

cOR = Crude odds ratios
aOR = Adjusted odds ratios
Ref = Reference variable

Multivariate Logistic Regression Analysis

In the adjusted model, antibiotic prescriptions among prescribers with a diploma in clinical medicine were almost three times higher than those reported among those with a degree in medicine (adjusted OR=2.55; 95% CI: 1.359, 4.769; $p = 0.004$). Patients with pneumonia and upper respiratory tract infection were 16 (adjusted OR=15.92; 95% CI: 2.151, 17.973; $p = 0.007$) and 1.71 (adjusted OR=1.71; 95% CI: 1.129, 2.587; $p = 0.011$) times more likely to be prescribed antibiotics, respectively. Patients with malaria, skin diseases and other disease conditions were 71.3% (adjusted OR=0.29; 95% CI: 0.160, 0.514; $p < 0.001$) and 67% (adjusted OR=0.33; 95% CI: 0.174, 0.630; $p = 0.001$) less likely to be prescribed antibiotics (Table 8).

4.1.4 Prevalence and Antibiotic Resistance Patterns of Gram Negative and Positive Bacteria Pathogens Isolated from Out-Patients in Public Primary Health Care Facilities of Dodoma Region, Central Tanzania

(i) Demographic Characteristics of Participants and Sources of Clinical Specimens

A total of 237 and 384 participants were enrolled from Chemba District Council and Dodoma City Council, respectively. Over 70% of all the participants were females and had primary school education. Urine samples accounted for the majority (70.2%; 436/621) of the clinical specimen collected in this study. The response rate was 91.5% (621/679) (Table 9).

Table 9: Out-patient demographic characteristics and source of clinical specimen

Variable	Frequency	Percentage
District of residence		
Chemba council	237	38.2
Dodoma city council	384	61.8
Sex		
Female	435	70.0
Male	186	30.0
Age of patient		
<21	213	34.3
21-25	169	27.2
26-30	90	14.5
31+	149	24.0
Education		
None	105	32.7
Primary school	474	76.3
Secondary school or more	42	6.8
Sample source		
Stool	157	25.3
Urine	436	70.2
Wound swab	10	1.6
Throat swab	18	2.9

(ii) Culture Results and Identification

Of the 621 samples collected and processed in this study, 118 (19%) were confirmed to be culture positive (Table 10). The *S. aureus* (44) and *E. coli* (35) were the most prevalent isolates in this study, these were by 90.9% (40/44) and 97.1% (34/35) predominantly from urine specimen respectively (Table 10).

Table 10: Pathogenic bacterial isolates per specimen types from Chemba District Council (rural) and Dodoma City Council (urban)

Bacteria pathogens	Specimen Types							
	Dodoma City Council (urban)				Chemba District Council (rural)			
	Urine	Stool	Throat swabs	Wound swabs	Urine	Stool	Throat swabs	Wound swabs
Escherichia coli	22	-	-	3	10	-	-	-
Staphylococcus aureus	37		2	2	3	-	-	-
Enterobacter spp	3	-	-	-	12	-	-	-
Klebsiella spp	2	-	-	-	4	-	-	-
Proteus spp	5	1	-	2	2	-	-	3
Salmonella typhi	-	1	-	-	-	-	-	-
Serratia spp	-	-	-	-	8	-	-	-
Total samples	**336**	**150**	**18**	**7**	**100**	**7**		**3**

(-) means no growth of pathogenic micro-organisms

(iii) Antibiotic Susceptibility Patterns

Gram Negative Isolates

The gram-negative isolates from Dodoma City Council and Chemba District Council were; *Escherichia coli* (25 vs 10), *Enterobacter species* (3 vs 12), *Klebsiella pneumonia* (2 vs 6), *Proteus spp* (7 vs 3), respectively. The *Serratia spp* (10) were only isolated from patients in Chemba District Council whereas, *salmonella typhi* (1) was isolated from Dodoma city council (Table 10).

The notable resistance rates for *E. coli* isolates from Dodoma City Council and Chemba District Council were 48% (12/25) and 20% (2/10) for ciprofloxacin, 84% (21/25) and 80% (8/10) for ampicillin, 84% (21/25) and 90% (9/10) for trimethoprim/sulfamethoxazole respectively (Table 11).

Enterobacter spp isolated in Dodoma city council were 66.7% (2/3) resistant to nitrofurantoin and ampicillin and 100% (3/3) resistant to sulfamethoxazole + Trimethoprim; whereas those from Chemba District Council were 41.6% (5/12) resistant to gentamycin and cefoxitin, 66.7% (8/12) resistant to ampicillin and 83.4% (10/12) resistant to trimethoprim/sulfamethoxazole (Table 11).

Gram Positive Isolates

A total of 44 isolates of *Staphylococcus aureus* were collected in this current study, 93.2% (41/44) of which were isolated from clinical samples among out-patients in Dodoma City

Council and only 6.8% (3/44) from Chemba District Council. The notable resistance rates for *S. aureus* isolates from Dodoma City Council were in the order of 85.4% (35/41) for trimethoprim/sulfamethoxazole, 43.9% (18/41) for nitrofurantoin, 41.5% (17/41) for ampicillin; whereas *S. aureus* isolates in Chemba were by 33.3% (1/3), 66.7% (2/3) and 66.7% (2/3) resistant to gentamycin, vancomycin and ampicillin, respectively (Table 11).

Methicillin Resistant S. aureus

Of the 44 *Staphylococcus aureus* isolates tested for methicillin resistance using cefoxitin, 14 (31.8%) were resistant and thus confirmed to be methicillin resistant *S. aureus* (MRSA). Of the 14 MRSA, 85.7% (12) were from Dodoma City Council and 14.3% (2) from Chemba District Council.

Table 11: Summary statistics for the sensitivity of bacterial pathogens to antibiotics in Chemba District Council (Rural) and Dodoma City Council (Urban)

Variable	Dodoma City Council (Urban)						Chemba District Council (Rural)					
	Gram -ve N= 36					Gram +ve N= 41	Gram –ve = 27					Gram +ve N= 3
	E coli N=25	Enterobacter N=3	*Klebsiella spp* N=2	*Proteus vulgaris*N=7	Salmonella typhi N=1	*S. aureus* N=41	E coli N=10	Enterobacter N=12	*Klebsiella spp* N=4	*Proteus vulgaris* N=3	Serratia N=8	S. aureus N=3
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Gentamycin												
I	1(4)	3(100)	0(0.00)	0(0.00)	0(0.0)	1(2.4)	0(0.0)	2(16.7)	0(0.0)	0(0.00)	0(0.00)	0(0.0)
S	17(68)	0(0.0)	1(50)	6(85.7)	1(100)	32(78)	7(70)	5(41.7)	4(100)	1(33.3)	6(75.0)	2(66.7)
R	7(28)	0(0.0)	1(50)	1(14.3)	0(0.00)	11(19.5)	3(30)	5(41.6)	0(0.0)	2(66.7)	2(25.0)	1(33.3)
Amikacin												
I	6(24)	0(0.0)	0(0.0)	1(14.3)	0(0.0)	2(4.9)	0(0.0)	0(0.0)	1(25)	3(100)	0(0.00)	0(0.0)
S	15(60)	3(100)	2(100)	5(71.4)	1(100)	34(82.9)	6(60)	12(80)	3(75)	0(0.0)	7(87.5)	2(66.7)
R	4(16)	0(0.0)	0(0.00)	1(14.3)	0(0.00)	5(12.2)	4(40)	0(0.0)	0(0.0)	0(0.0)	1(12.5)	1(33.3)
Ciprofloxacin												
I	0(0.0)	1(33.3)	0(0.00)	0(0.00)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(33.3)	0(0.00)	0(0.0)
S	13(52)	2(66.7)	2(100)	7(100)	1(100)	26(63.4)	8(80)	9(75)	4(100)	2(66.7)	5(62.5)	2(66.7)
R	12(48)	0(0.0)	(0.00)	0(0.0)	0(0.0)	15(36.3)	2(20)	3(25)	0(0.0)	0(0.0)	3(37.5)	1(33.3)
Ceftriaxone												
I	0(0.0)	0(0.00)	0(0.00)	0(0.00)	0(0.0)	-	1(10)	0(0.00)	0(0.0)	0(0.0)	0(0.00)	-
S	18(72)	3(100)	2(100)	7(100)	1(100)	-	6(60)	10(83.3)	4(100)	3(100)	6(75.0)	-
R	7(28)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	-	3(30)	2(16.7)	0(0.0)	0(0.0)	2(25.0)	-
Amoxicillin Clavulanic acid												
I	6(24)	0(0.0)	0(0.0)	0(0.00)	0(0.0)	-	1(10)	2(16.7)	0(0.0)	1(33.3)	0(0.0)	-
S	14(56)	3(100)	2(100)	6(85.4)	1(100)	-	6(60)	7(58.3)	4(100)	2(66.7)	8(0.00)	-
R	5(20)	0(0.0)	0(0.0)	1(14.6)	0(0.0)	-	3(30)	3(25)	0(0.0)	0(0.0)	0(100)	-
						-						
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Nitrofurantoin												
I	4(16)	0(0.00)	0(0.00)	0(0.00)	0(0.0)	0(0.00)	0(0.0)	0(0.00)	0(0.0)	0(0.00)	0(0.00)	0(0.0)
S	15(60)	1(33.3)	1(50)	5(74.4)	1(100)	23(56.1)	7(70)	8(66.7)	2(50)	1(33.3)	7(87.5)	3(100)
R	6(24)	2(66.7)	1(50)	2(25.6)	0(0.00)	18(43.9)	3(30)	4(33.3)	2(50)	2(66.7)	1(12.5)	0(0.0)
Cefepime												
I	0(0.0)	0(0.00)	0(0.00)	0(0.00)	0(0.0)	-	0(0.0)	0(0.00)	0(0.0)	0(0.00)	0(0.00)	-
S	19(76)	3(100)	2(100)	7(100)	1(100)	-	8(80)	9(75)	4(100)	3(100)	6(75.0)	-
R	6(24)	0(0.0)	0(0.0)	0(0.0)	0(0.00)	-	2(20)	3(25)	0(0.0)	0(0.0)	2(25.0)	-

Variable	Dodoma City Council (Urban)						Chemba District Council (Rural)					
	Gram -ve N= 36					Gram +ve N= 41	Gram –ve = 27					Gram +ve N= 3
	***E coli* N=25**	**Enterobacter N=3**	***Klebsiella spp* N=2**	***Proteus vulgaris*N=7**	**Salmonella typhi N=1**	***S. aureus* N=41**	**E coli N=10**	**Enterobacter N=12**	***Klebsiella spp* N=4**	***Proteus vulgaris* N=3**	**Serratia N=8**	**S. aureus N=3**
	N (%)	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**
Vancomycin												
I	-	-	-	-	-	2(4.9)	0(0.0)	0(0.0)	0(0.0)	0(0.00)	0(0.00)	-
S	-	-	-	-	-	29(70.7)	0(0.0)	2(16.7)	0(0.0)	0(0.0)	0(0.00)	-
R	-	-	-	-	-	10(24.4)	10(100)	10(83.3)	4(100)	3(100)	8(100)	-
Cefoxitin												
I	0(0.0)	0(0.00)	0(0.00)	0(0.00)	0(0.0)	0(0.0)	0(0.0)	0(0.00)	0(0.0)	0(0.00)	0(0.00)	0(0.0)
S	19(76)	3(100)	2(100)	7(100)	1(100)	28(68.3)	7(70)	7(58.3)	4(100)	3(100)	6(75.0)	2(66.7)
R	6(24)	0(0.0)	0(0.0)	0(0.0)	0(0.00)	13(31.7)	3(30)	5(41.6)	0(0.0)	0(0.0)	2(25.0)	1(33.3)
Ampicillin												
I	0(0.0)	0(0.00)	0(0.00)	0(0.00)	0(0.0)	3(7.3)	0(0.0)	0(0.00)	-	0(0.0)	0(0.00)	0(0.0)
S	4(16)	1(33.3)	0(0.00)	2(28.6)	1(100)	21(51.2)	2(20)	4(33.3)	-	0(0.0)	1(12.5)	1(33.3)
R	21(84)	2(66.7)	2(100)	5(71.4)	0(0.00)	17(41.5)	8(80)	8(66.7)	-	3(100)	7(87.5)	2(66.7)
Cefotaxime												
I	3(12)	0(0.0)	0(0.00)	0(0.0)	0(0.0)	-	0(0.0)	2(16.7)	0(0.0)	0(0.00)	1(12.5)	-
S	17(68)	2(66.7)	1(50)	7(100)	1(100)	-	7(70)	6(50)	4(100)	3(100)	5(62.5)	-
R	5(20)	1(33.3)	1(50)	(0.0)	0(0.00)	-	3(30)	4(33.3)	0(0.0)	0(0.0)	2(25.0)	-
Azithromycin												
I	3(12)	-	0(0.00)	-	0(0.0)	0(0.0)	1(10)	-	0(0.0)	0(0.0)	-	0(0.0)
S	14(56)	-	2(100)	-	1(100)	35(85.4)	6(60)	-	4(100)	2(66.7)	-	2(66.7)
R	8(32)	-	0(0.0)	-	0(0.00)	6(14.6)	3(30)	-	0(0.0)	1(33.3)	-	1(33.3)
Sulfamethoxazole + Trimethoprim												
I	0(0.0)	0(0.0)	0(0.00)	0(0.00)	0(0.0)	0(0.00)	0(0.0)	1(8.3)	0(0.0)	0(0.0)	1(12.5)	0(0.0)
S	4(16)	0(0.0)	0(0.0)	1(14.3)	1(100)	6(14.6)	1(10)	1(8.3)	0(0.0)	0(0.0)	4(50.0)	1(33.3)
R	21(84)	3(100)	2(100)	6(85.7)	0(0.00)	35(85.4)	9(90)	10(83.4)	4(100)	3(100)	3(37.5)	2(66.7)
Meropenum												
I	0(0.0)	0(0.0)	0(0.00)	0(0.00)	0 (0.0)	0(0.00)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.00)	0(0.0)
S	22(88)	3(100)	2(100)	7(100)	1(100)	39(95.1)	8(80)	10(83.3)	4(100)	3(100)	6(75.0)	2(66.7)
R	3(12)	0(0.0)	0(0.00)	0(0.00)	0(0.00)	2(4.9)	2(20)	2(16.7)	0(0.0)	0(0.0)	2(25.0)	1(33.3)

I = Intermediate; S = Sensitive; R = Resistance

4.2 Discussion

The study aims to explore the use of antibiotics in the community settings (household and drug shops) and primary health care facilities, establish the differences (if any) on the use of antibiotics in the rural and urban settings, identify the drivers thereof and postulate mitigations to improve the conduct of all players regarding antibiotic use and resistance from a community standpoint.

4.2.1 Prevalence and Predictors of Self-Medication with Antibiotics in Dodoma Region, Central Tanzania

The overall prevalence of SMA among the rural and urban respondents in this study was comparable; an observation likely to be explained by the fact that even with a lesser number of community drug shops, SMA in the rural can easily be practiced by borrowing antibiotics within and between households and not necessarily buying them from community drug shops as might be the case in the urban areas where drug shops are so abundant (Horumpende *et al.,* 2018b). This observation is incongruent with the results reported by studies in Northen Tanzania, where higher SMA was found among urban respondents than among their rural counterparts (Hertz *et al.,* 2019). In another study, more SMA was found among respondents in rural than in urban localities (Kalyani, 2020). Our study, therefore, reveals the need to focus equally on strategies to reduce SMA practices in both rural and urban settings.

Furthermore, the most commonly used antibiotic for self-medication in the two districts (rural vs. urban) was amoxicillin, and others were ampicillin+cloxacillin fixed drug combination, metronidazole and doxycycline. The observation that amoxicillin is the most self-medicated antibiotic in this study is congruent with the studies done in Asmara Eritrea, Northern Tanzania, Northeastern Ethiopia and Peru, where the drug was one of the most common used antibiotics (Núñez *et al.,* 2016; Gelayee, 2017; Horumpende *et al.,* 2018a; Ateshim *et al.,* 2019). Amoxicillin, metronidazole and doxycycline and are classified in the "*Access, Watch and Reserve – AWaRe*" access group in the Tanzanian Standard Treatment Guideline (STG) (Ministry of Health and Social Welfare-Tanzania, 2017); they are in the list of allowable antibiotics in Accredited Drug Dispensing Outlets (ADDO) where they are easily sold without prescriptions thus increasing their potential for misuse and overuse through SMA (Pharmacy Council of Tanzania 2015; Mbwasi *et al.,* 2020; Do *et al.,* 2021; Lam *et al.,* 2021; Sangeda *et al.,* 2021b).

Participants from both the rural and urban localities who reported a longer perceived distance from their household to a community drug outlet and a shorter perceived distance to a health care facility (dispensary/health centre/hospital) were less likely to practice SMA. This observation is partly due to the fact that antibiotics for self-medication can easily be accessed and purchased from the poorly regulated community drug outlets (Green *et al.,* 2023). This finding is comparable to another study in Northern Tanzania, where high SMA practices were reported among people living near community drug outlets (Horumpende *et al.,* 2018a). Initiatives to contain irresponsible dispensing across community drug stores as well as antibiotic stewardship campaigns involving health care providers, community drug dispensers and the community at large are therefore imperative.

The majority of the respondents from both the rural and urban settings in this study were farmers, who had the lowest odds of SMA compared to participants in other occupations (employed, business, and livestock keeping and farming). This finding may have resulted from the fact that the majority of the farming participants resided in low-population-density areas where households are scattered far from each other with a lower number of community drug outlets and the presence of at least a nearby dispensary or health center, reinforcing the observation that a longer distance from a household to a drug outlet reduces the risk of SMA (Horumpende *et al.,* 2018a). Additionally, the potential for the spread of infectious diseases is lower among those living in low density areas (farmers) as compared to those in densely populated areas, hence the need for more antibiotics in the latter (Swaminathan *et al.,* 2017; Kumburu *et al.,* 2017; Todorovic *et al.,* 2019). This information is especially valuable to policy makers and town planners in high density areas where sanitation measures are inevitable to prevent environmental contamination and infection transmission.

Although the results were not statistically significant, participants with health insurance in both the rural and urban settings were less likely to practice SMA than those who were uninsured; this observation is similar to the findings of a study in Kenya (Ngigi, 2013). It is equally important for campaigns to be held to encourage people to subscribe to health insurance schemes, especially in developing countries such as Tanzania, where infectious diseases are prevalent and the majority of people cannot afford to pay cash for medical services (WHO, 2004). Nevertheless, with an increase in the population with health insurance, the need for prescribers to adhere to standard treatment guidelines and avoid overprescribing antibiotics is inevitable. The current study provides an insight into SMA practices in both rural and urban settings for appropriate interventions in the fight against antibiotic resistance (AMR) in two socially and economically different communities.

The limitation of this study is that data collection was performed during the day (morning to early evening), leaving the possibility of missing household members who might have left early in the morning. Additionally, for respondents who did not remember the antibiotics they had used, we showed them a variety of antibiotics for identification; this is a challenge because some medications may have a similar appearance yet belong to different therapeutic groups.

4.2.2 Prevalence and Determinants of Antibiotic Dispensing in Community Drug Outlets

Accredited Drug Dispensing Outlets (ADDO) are community drug outlets intended to serve the rural and peri-urban communities with a limited list of antibiotics to be strictly dispensed in presence of a valid prescription (Chalker *et al.,* 2015a). Nevertheless, in this study, the dispensing of antibiotics in ADDO was rampant with up to 80% of all the antibiotics recorded being dispensed in these outlets; even worse without valid prescriptions. Furthermore, 58% of all the antibiotics dispensed in ADDO were above those stipulated in the ADDO medicines list. The observation in our current study contradicts the founding objectives of the ADDO program in Tanzania (Bigdeli *et al.,* 2014; Chalker *et al.,* 2015a) thus, the need for a more enhanced regulatory enforcement on the conduct of both the owners and dispensers in these settings.

Majority (75%) of the encounters with antibiotics in this study were dispensed without medical prescriptions. Studies in community drug outlets in Pakistan and Eritrea have reported high levels of unprescribed antibiotic dispensing (Horumpende *et al.,* 2018b). In a study conducted in Tanzania using mystery clients, over 80% of all the mystery clients were dispensed with antibiotics (Ndaki *et al.,* 2021a). Antibiotic dispensing without a prescription was mostly documented among Accredited Drug Dispensers (ADD) and Pharmaceutical Dispensers (PD), the lowest cadres in the dispensing hierarchy; an observation likely to be influenced by a lack of emphasis on rational antibiotic dispensing during their training and dispensing pressure from drug shop owners.

Compared to all other disease complaints there was a 50% increase in the odds of antibiotic dispensing among clients with respiratory symptoms such as cough and sore throat. In a simulated client study on the dispensing of antibiotics in Tanzania; 34% of the clients presenting with cough and sore throat were dispensed with antibiotics (Chalker *et al.,* 2015a). Additionally, in a simulated client study, all clients who reported a runny nose in both ADDO and community pharmacies were dispensed with antibiotics (Mshana *et al.,* 2018). A systematic review on un-prescribed dispensing of antibiotics in community drug outlets in sub-

Saharan Africa reported upper respiratory symptoms as conditions most commonly dispensed with antibiotics (Belachew *et al.,* 2021a). Respiratory symptoms such as coughs, stuffy nose and runny nose may have a viral etiology as well; the use of antibiotics only in such cases is thus un-justified (Chalker *et al.,* 2015a). With this observation, there is a need to rollout antibiotic stewardship programs among the owners of community drug outlets and the drug dispensers on the need for rational dispensing of antibiotics.

The odds for antibiotic dispensing among patients presenting with fever tended to increase by 18% compared to the non-feverish clients; 31.5% of clients with fever in this study were dispensed with antibiotics. A similar observation has been reported in Bangladesh where antibiotics were also dispensed to patients reported with fever (Nahar *et al.,* 2020). In another study, over 70% of all individuals reporting fever were dispensed with antibiotics, 69.5 % of which being cephalosporins (Hendrie *et al.,* 2019). Even though fever is among the common symptoms of bacterial infections (Ndhlovu *et al.,* 2015), it also remains common in other extra-bacterial infections and non-infectious conditions (Mcgregor & Moore 2015; Almaaytah *et al.,* 2015; Tun *et al.,* 2016a). It is vital that before antibiotics are instituted patients' symptomatology must justify their use (Mcgregor & Moore, 2015), in cases where microbiological tests can be sought initiation of antibiotic therapy should await laboratory confirmation (Tun *et al.,* 2016a).

Clients presenting with sore or painful urination in the current study were two times more likely to be dispensed with an antibiotic as compared to the rest of the reported conditions; 93.3% of all clients with urinary tract related symptoms were dispensed with antibiotics. Several studies have also reported high levels of antibiotic dispensing among clients reporting urinary tract related symptoms; in a simulated client study on the un-prescribed dispensing of antibiotics, 83.3% of clients reporting urinary tract symptoms were dispensed with antibiotics (Almaaytah & Mukattash, 2015). In a systematic review on un-prescribed antibiotic dispensing, urinary tract related symptoms accounted for 30.6% of all the cases with antibiotics (Batista *et al.,* 2020a). Additionally, a more recent and contextually relevant study in Northern Tanzania has also reported an almost 100% antibiotic dispensing among simulated clients reporting with burning sensation during urination (Mshana *et al.,* 2018). Initiatives involving both community engagement on mitigating the causes of urinary related conditions and emphasis to pharmaceutical personnel on the need for laboratory diagnosis of the UTI suspected cases before dispensing antibiotics are imperatively vital.

Furthermore, there was a 39% increase in the odds of antibiotic dispensing to patients with wounds in this current study. Even though there is supporting evidence on the wound healing impairment resulting from microbial interference warranting the use of antibiotics (WHO, 2015c), this happens only when the bacteria burden exceeds 104 colony forming units (CFU) per unit measure (WHO, 2015c), the use of antibiotics should thus be reserved for patients with limited ability to contain the infecting pathogens (WHO, 2015c). The WHO recommends that topical and systemic antibiotics be instituted in the management of wounds only after the infecting agent has been identified and its antibiotic susceptibility ascertained (Bowler *et al.,* 2001; WHO, 2015c). While septic and chronic wounds might need antibiotics (Caldwell, 2020), the use of antiseptics should rather be encouraged among patients with fresh wounds to allow natural tissue healing (Atiyeh *et al.,* 2009).

Community drug outlets make an important point of health care (Batista *et al.,* 2020a), they are considered the first lifeline to which the community accesses medicines for the management of various disease conditions (Chalker *et al.,* 2015a). Nevertheless, these drug outlets have also been associated with the unregulated sale of antibiotics, playing a pivotal role in accelerating the development of antibiotic resistance (Lambojon, 2021). A more robust control by the relevant regulatory authorities on the day-to-day activities in these drug outlets is crucial if we are to limit the irrational dispensing and use of antibiotics.

4.2.3 Patterns and predictors of antibiotic prescriptions in primary health care facilities

In this study, children under the age of five accounted for almost half of all antibiotic prescribing encounters in Dodoma City Council and Chemba District Council, all of which were without laboratory justification. The observation in our current study is congruent with a study in northwest Cameroon, where 44% of children under the age of 10 years visiting primary health care facilities were also prescribed antibiotics (Chem *et al.,* 2018). Additionally, a study on the use of antibiotics for childhood illnesses reported that over 50% of the 61355 children under five years attending primary health care facilities were prescribed antibiotics, 58% of which were for pneumonia diagnoses made only on the basis of clinical presentations (Sié *et al.,* 2021). In another study in southwestern Nigeria, over 98% of all antibiotic prescriptions in children <5 years were based on clinical symptoms (Adisa *et al.,* 2018). The findings of this current study show that children are most at risk of consuming a large proportion of antibiotics without laboratory justification. Nevertheless, current laboratory pathogen identification and susceptibility testing techniques require over 48 hours (Perilla *et al.,* 2003), making it difficult in cases where urgent medical care is deemed necessary, necessitating the use of blanket treatment (Heller & Spence, 2019). More rapid diagnostics are thus key towards a more successful antibiotic stewardship campaign.

The odds of antibiotic prescriptions by the clinical officers (diploma in clinical medicine) were almost three times higher than those of medical doctors (Medical Doctor degree). In a study on the use of antibiotics for cough and/or diarrhoea in northern Tanzania, clinical officers were also among the prescribers associated with excessive and inappropriate antibiotic prescriptions for nausea, vomiting and diarrhoea conditions; they were also most likely to prescribe wrong dosages to patients (doses that were too high or too low) (Gwimile *et al.,* 2012). In Tanzania, clinical officers constitute a majority of prescribers across the primary health care spectrum in both rural and urban areas (Ministry of Health, 2003); therefore, they are the first-contact health care personnel and thus are an important rational antibiotic advocacy intervention point (Ministry of Health, 2003). There is thus a need for regular antibiotic stewardship campaigns and training on the importance of rationality in antibiotic prescription and use among prescribers in primary health care as one key strategy in curbing antibiotic resistance.

Among the medical conditions recorded, symptomatic pneumonia was an important predictor for antibiotic prescriptions in this study. Similar findings have been reported in Burkina Faso (Sié *et al.,* 2021) and Uganda (Kutyabami *et al.,* 2021) where majority of empirically diagnosed pneumonia cases received antibiotics. Confounded by delayed laboratory diagnosis the prognosis for pneumonia is especially poor in children, justifying the urgency for empirical treatment (Marangu, 2019). Rapid and reliable diagnostics are thus key towards rational antibiotic prescriptions.

Malaria, being a protozoan disease, should be managed by antiprotozoal medicines; the use of antibiotics for the management of malaria is consequently unwarranted and inappropriate (Ministry of Health and Social Welfare-Tanzania, 2017). In the current study, over half 54.2% (32/59) of the malaria cases were prescribed with antibiotics. This is supported by the previous study in primary health care facilities in Dodoma where 25% of malaria cases were prescribed with antibiotics contrary to the Tanzanian treatment guidelines (Wiedenmayer *et al.,* 2021). This finding was further supported by a study conducted in Cameroon where uncomplicated malaria was treated with antibiotics against treatment guidelines (Chem *et al.,* 2018). Administering antibiotics to patients whose disease is not bacterial is a gross misuse of these vital medicines and paves the way for the development of antibiotic resistance (WHO, 2015b). The high levels of antibiotic prescriptions among patients empirically reported with malaria in primary health care facilities could be due to poor or lack of diagnostics pushing prescribers to opt for blanket treatment when confronted with life-threatening conditions (Chem *et al.,* 2018).

Over half (53.2%; 25/57) of patients with dermatological conditions in this study were prescribed with systemic antibiotics; being a 66.9% decrease in the odds of systemic antibiotic prescriptions as compared to patients with other disease conditions. The observation in this current study is lower than that reported in a study on the prescription of antibiotics among patients with dermatological conditions where the odds of empiric antibiotic prescriptions among patients with suspected bacterial diagnoses (66/207) were almost 5 times higher compared to all others (Haynes, 2018). In another study involving 683 patients, 35% (239/683) of the cases were prescribed with topical antibiotics, 44.8% (306/683) had systemic antibiotics, and 14.6% (100/683) were prescribed both topical and systemic antibiotics (Heal *et al.,* 2019). Additionally, in another study on drug utilization in the management of common skin illnesses, 17% of the 207 cases diagnosed with skin conditions were prescribed with antibiotics (Mate *et al.,* 2019). Nevertheless, the presentations of dermatological conditions are quite varied, ranging from mere allergic irritations, fungal infections, and viral and bacterial infections, along with other injury and secondary skin-related infections (Hees, 2017). Ascertaining an etiology for dermatological conditions can thus be tricky, making it difficult to tell whether there was justified use of antibiotics in each of these cases (Hees, 2017). Therefore, it is, however, imperative that medical practitioners understand the need to use and prescribe antibiotics rationally for sustained efficacy.

Upper respiratory infection (URTI) was another empirically diagnosed condition in the current study, and antibiotic prescriptions among patients with URTI were almost double when compared to those with other disease conditions. This is comparatively higher than that in another similar study where 44% of the URTI cases attended were prescribed with antibiotics (Alkaff *et al.,* 2019). Another study involving 92821 children between 3 to < 5 years consulted, 27.5% were prescribed with antibiotics that accounted for over 60% of all the antibiotic prescriptions (Xue *et al.,* 2021). This further suggests the need for rapid screening test to guide the use of antibiotics in children who are frequently vulnerable to URTI especially in the tropical regions.

The observations in the current study do not account for how patients' history and physical examinations were recorded. However, the study gives a clue on the general practices of prescribers in low-level health care facility settings and provide information for which interventions can be made to improve their antibiotic prescribing skills in a more concerted effort against both the urgency and spread of antibiotic resistance.

4.2.4 Prevalence and Antibiotic Resistance Patterns of Gram Negative and Positive Bacteria Isolated from Out-Patients in Public Primary Health Care Facilities

The emergence and spread of resistant bacterial pathogens are a growing threat to global health, food security and the environment (WHO, 2020). This study evaluates the prevalence and *invitro* antibiotic susceptibility patterns of bacterial pathogens from out-patients in primary health care facilities.

The most prevalent pathogens isolated in this study were *S. aureus* (44 isolates), *E. coli* (35 isolates), and *Enterobacter spp* (15 isolates). The three isolates are considered among the bacterial pathogens of community health importance and thus key in the surveillance and control for antibiotic resistance. The distribution of *S. aureus* and *E. coli* isolates in this study was much higher among patients in urban settings than those in rural areas, an observation likely to be explained by the bigger population density that accelerates the spread of infectious diseases in the latter compared to that in the former. Similar observation was reported in Ghana (Egyir *et al.,* 2014) with *S. aureus* and *E. coli* being predominant in urban settings. However, other studies did not consider possible disparity between urban and rural settings that may arise due to social-economic differences (Hoa *et al.,* 2009a; Egyir *et al.,* 2014).

The prevalence of antibiotic resistance for *E. coli* isolates from patients in both the urban and rural localities in this study were generally low; majority of the isolates were susceptible to almost all the antibiotics tested with the exception of ciprofloxacin, ampicillin, sulfamethoxazole + Trimethoprim. Mgaya *et al.* (2021) reported high resistance of *E coli* from poultry isolates to ciprofloxacin (40.2%), ampicillin (70.9%), and sulfamethoxazole + Trimethoprim (80.5%) whereas, Mnyambwa *et al.* (2021) reported the same trend in Tanzania with *E coli* being highly resistant to ampicillin and ciprofloxacin, respectively. The high resistance of *E. coli* to ciprofloxacin, ampicillin and sulfamethoxazole + trimethoprim reported in the current and other studies in Tanzania may be attributed to overuse of these antibiotics as they are easily accessible in the community outlets (Matowe, 2011; Chalker *et al.,* 2015a; Horumpende *et al.,* 2018b). Ciprofloxacin has long been in use as the first line antibiotic in the treatment of urinary tract infections in Tanzania (Ministry of Health and Social Welfare-Tanzania, 2017) thus increasing the potential for misuse or/and over-use. Also, use of sulfamethoxazole + trimethoprim in the management of opportunistic bacterial infections among HIV patients (WHO, 2006), and its un-regulated sale of antibiotics in drug shops (Matowe, 2011; Almaaytah *et al.,* 2015; Nepal *et al.,* 2019; Ndaki *et al.,* 2021a) are likely to be the reason for this widespread resistance.

Majority of the *Staphylococcus aureus* isolated in this study were from patients attending primary health care facilities in Dodoma city council (Urban) and only three *S. aureus* isolates were from Chemba district council. The susceptibility of all the 44 *S. aureus* isolates to various antibiotics was satisfactorily high except for sulfamethoxazole + trimethoprim, ampicillin and ciprofloxacin which had the resistance rates above 30%. Additionally, 30% of the *S. aureus* isolates in Dodoma city council were resistant to cefoxitin making them methicillin resistant *S. aureus* (MRSA). The findings in this study are comparable with those in a review involving 45 studies in Tanzania in which *S. aureus* resistance was predominantly high against sulfamethoxazole + trimethoprim, ampicillin and erythromycin with an overall methicillin resistance (MRSA) of 26% (Mzee *et al.,* 2021). However, other studies involving inpatients in tertiary hospitals reported higher levels of MRSA (66.7% and 36.7%) in Tanzania and elsewhere (Dowzicky & Chmelařová, 2019) an observation partly attributed to the increased likelihood of patients contracting nosocomial infections in these high-level of care facilities (Donker *et al.,* 2010; Wangai *et al.,* 2019), as opposed to outpatients in primary health care facilities, as is the case in this current study.

Majority of the isolates in this study were highly susceptible to meropenum, amoxicillin clavulanic acid, ceftriaxone, cefixime, cefotaxime and azithromycin. These antibiotics are classified in the "Watch" or "Reserve" categories in the "AWaRe" antibiotic classification of the Tanzanian Standard Treatment Guideline (Ministry of Health and Social Welfare-Tanzania, 2017) and thus have restricted access in both the hospital and community settings (Ministry of Health and Social Welfare-Tanzania, 2017).

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The aim of this study was to establish the prevalence and predictors of self-medication with antibiotics, antibiotic dispensing in community drug outlets, antibiotic prescriptions in primary health care facilities and the resistance patterns of the common bacterial isolates from out-patients attending primary health care facilities in Dodoma Tanzania.

The prevalence of SMA was almost comparable in the rural and urban districts; in both cases, a low risk of SMA was seen among farmers compared to nonfarming participants. A shorter perceived distance from a household to a community drug outlet than to a health care facility increased the risk of SMA. A low prevalence of SMA was also seen among health insured participants.

High levels of antibiotic dispensing without prescriptions and involving antibiotics beyond jurisdiction were recorded in Accredited Drug Dispensing Outlets (DDO). Accredited drug dispensers and pharmaceutical dispensers were responsible for the majority of unprescribed dispensing of antibiotics. Antibiotics were mostly dispensed for cough, sore throat, fever, wounds and urinary tract disturbances. Additionally, high rates of antibiotic prescriptions and poor adherence to Standard Treatment Guidelines (STG) were recorded among prescribers in primary health care facilities. Prescribers with a diploma in clinical medicine were much more likely to prescribe antibiotics. There was an increase in the odds of antibiotic prescriptions among patients empirically diagnosed with urinary tract infections (UTIs), acute respiratory infections (ARIs) and pneumonia.

Additionally, this study reports high resistance rates of *E. coli, S. aureus* and *enterobacter spp* against trimethoprim/sulfamethoxazole, ampicillin, ciprofloxacin. There were relatively lower MRSA levels compared to those reported in tertiary hospitals.

This study therefore informs on the wider effort to fight against antibiotic resistance from a community perspective and adds to the specific set of predictors to focus for such an effort, thus opening up more angles from which to tackle this growing pandemic.

5.2 Recommendations

Tailored community antibiotic stewardship campaigns on the dangers of antibiotic resistance as well as enforcing existing laws and enacting others to regulate the conduct of drug dispensers regarding the sale of antibiotics in community drug outlets are needed. Regulatory authorities (Pharmacy Council of Tanzania and the Tanzania Medicines and Medical Devices Authority) ought to institute more stringent law enforcement mechanism to prevent the unauthorized stocking of antibiotics by ADDO.

Regular training of prescribers on the importance of adhering to national treatment guidelines, antibiotic stewardship, and rationality in prescribing antibiotics. Continued surveillance and monitoring of bacterial resistance patterns in the lower cadre health care settings for the accurate quantification of antibiotic resistance and the development of appropriate and tailored interventions in these settings.

It is also equally important that campaigns be held to encourage people to subscribe to health insurance schemes as well initiatives intended at improving primary health care diagnostic facilities be instituted, this is key towards a more successful antibiotic stewardship campaign in these settings.

REFERENCES

Adisa, R., Orherhe, O. M., & Fakeye, T. O. (2018). Evaluation of antibiotic prescriptions and use in under-five children in Ibadan, SouthWestern Nigeria. *African Health Sciences*, 18(4), 1189-1201.

Aditi, S. (2021). *The State of the World's Antibiotics 2021 A Global Analysis of Antimicrobial Resistance and Its Drivers*. Washington DC. https://scholar.google.com

Ahmad, T., Khan, F. U., Ali, S., Rahman, A. U., & Ali Khan, S. (2022). Assessment of without prescription antibiotic dispensing at community pharmacies in Hazara Division, Pakistan: A simulated client's study. *PLoS One*, 17(2), e0263756.

Alkaff, R. N., Kamigaki, T., Saito, M., Ariyanti, F., Iriani, D. U., & Oshitani, H. (2019). Use of antibiotics for common illnesses among children aged under 5 years in a rural community in Indonesia: A cross-sectional study. *Tropical Medicine and Health*, 47(1), 1-9.

Almaaytah, A., Mukattash, T. L., & Hajaj, J. (2015). Dispensing of non-prescribed antibiotics in Jordan. *Patient Preference and Adherence*, 2015,1389-1395.

Ateshim, Y., Bereket, B., Major, F., Emun, Y., Woldai, B., Pasha, I., Habte, E., & Russom, M. (2019). Prevalence of self-medication with antibiotics and associated factors in the community of Asmara, Eritrea: A descriptive cross sectional survey. *BMC Public Health*, 19(1), 1-7.

Atif, M., Azeem, M., Sarwar, M.R., Shahid, S., Javaid, S., Ikram, H., Baig, U., & Scahill, S. (2016). WHO/INRUD prescribing indicators and prescribing trends of antibiotics in the Accident and Emergency Department of Bahawal Victoria Hospital, Pakistan. *Springerplus,* 5(1), 1-7.

Atiyeh, B. S., Dibo, S. A., & Hayek, S. N. (2009). Wound cleansing, topical antiseptics and wound healing. *International Wound Journal,* 6(6), 420-430.

Aujoulat, F., Ragot, R., Toubiana, M., Bancon-Montigny, C., Monfort, P., Salles, C., Masnou, A., Delpoux, S., Rio, M., Tournoud, M. G., & Marchand, P. (2021) Environmental antimicrobial resistance in a small urban Mediterranean river: A focus on endemic beta-lactamases in clinically relevant bacteria. *Water*, 13(15), 2010.

Ayukekbong, J. A., Ntemgwa, M., & Atabe, A. N. (2017). The threat of antimicrobial resistance in developing countries: Causes and control strategies. *Antimicrobial Resistance & Infection Control,* 6(1), 1-8.

Azabo, R., Mshana, S., Matee, M., & Kimera, S. I. (2022). Antimicrobial usage in cattle and poultry production in Dar es Salaam, Tanzania: pattern and quantity. *BMC Veterinary Research*, 18, 1-12.

Bahta, M., Tesfamariam, S., Weldemariam, D. G., Yemane, H., Tesfamariam, E. H., Alem, T., & Russom, M. (2020). Dispensing of antibiotics without prescription and associated factors in drug retail outlets of Eritrea: A simulated client method. *PLoS One*, 15(1), e0228013.

Balachandra, S. S., Sawant, P. S., Huilgol, P. G., Vithya, T., Kumar, G. S., & Prasad, R. (2021). Antimicrobial resistance (AMR) at the community level: An urban and rural case study from Karnataka. *Journal of Family Medicine and Primary Care*, 10(3), 1404.

Batista, A. D. A., Rodrigues, D., Figueiras, A., Zapata-Cachafeiro, M., Roque, F., & Herdeiro, M. T. (2020). Antibiotic dispensation without a prescription worldwide: A systematic review. *Antibiotics,* 9(11), 786.

Belachew, S. A., Hall, L., & Selvey, L. A. (2021). Non-prescription dispensing of antibiotic agents among community drug retail outlets in Sub-Saharan African countries: A systematic review and meta-analysis. *Antimicrobial Resistance & Infection Control*, 10(1), 1-15.

Bigdeli, M., Peters, D. H., Wagner, A. K., & World Health Organization. (2014). *Medicines in Health Systems: Advancing Access, Affordability And Appropriate Use.* https:// scholar. google. com

Bowler, P. G., Duerden, B. I., & Armstrong, D. G. (2001). Wound microbiology and associated approaches to wound management. *Clinical Microbiology Reviews*, 14(2), 244-269

Bruinsma, N., Hutchinson, J. M., Van Den Bogaard, A. E., Giamarellou, H., Degener, J., & Stobberingh, E. E. (2003). Influence of population density on antibiotic resistance. *Journal of Antimicrobial Chemotherapy*, 51(2), 385-390.

Bürgmann, H., Frigon, D., H Gaze, W., M Manaia, C., Pruden, A., Singer, A.C., F Smets, B., & Zhang, T. (2018). Water and sanitation: An essential battlefront in the war on antimicrobial resistance. *FEMS Microbiology Ecology,* 94(9),101.

Lo, C. (2019). *Herd Health: Agriculture's Role in the Global AMR Crisis.* https://www.pharmaceutical-technology.com/features/animal-antibiotics.

Cambaco, O., Alonso Menendez, Y., Kinsman, J., Sigaúque, B., Wertheim, H., Do, N., Gyapong, M., John-Langba, J., Sevene, E., & Munguambe, K. (2020). Community knowledge and practices regarding antibiotic use in rural Mozambique: Where is the starting point for prevention of antibiotic resistance? *Bmc Public Health,* 20(1), 1-15.

Cars, O., Hedin, A., & Heddini, A. (2011). The global need for effective antibiotics: Moving towards concerted action. *Drug Resistance Updates,* 14(2), 68-69.

CDC. (2020). *About Antibiotic Resistance*. https://www.cdc.gov/drugresistance/about.html.

Chalker, J. C., Vialle-Valentin, C., Liana, J., Mbwasi, R., Semali, I. A., Kihiyo, B., Shekalaghe, E., Dillip, A., Kimatta, S., Valimba, R., & Embrey, M. (2015). What roles do accredited drug dispensing outlets in Tanzania play in facilitating access to antimicrobials? Results of a multi-method analysis. *Antimicrobial Resistance and Infection Control,* 4(1), 1-11.

Anong, D. N., & Akoachere, J. F. K. (2018). Prescribing patterns and associated factors of antibiotic prescription in primary health care facilities of Kumbo East and Kumbo West Health Districts, North West Cameroon. *PloS One,* 13(3), e0193353.

CLSI. (2020). *Performance Standards for Antimicrobial Susceptibility Testing*. https:// scholar. google. com

Collins, A. S. (2011). *Preventing Health Care: Associated Infections.* https:// scholar. google. com

Van Hees, C., & Naafs, B. (2011). *Common Skin Diseases in Africa: An Illustrated Guide. In Common Skin Diseases in Africa: An illustrated guide (pp. 89-89).* https://scholar.google.com

Cycoń, M., Mrozik, A., & Piotrowska-Seget, Z. (2019). Antibiotics in the soil environment: Degradation and their impact on microbial activity and diversity. *Frontiers in Microbiology*, 10, 338.

Dadgostar, P. (2019). Antimicrobial resistance: Implications and costs. *Infection And Drug Resistance*, 2019, 3903-3910.

Davies, J., & Davies, D. (2010). Resistance origins and evolution of antibiotic. *Microbiology and Molecular Biology Reviews,* 74(3), 417-33.

Caldwell, M. D. (2020). Bacteria and antibiotics in wound healing. *Surgical Clinics,* 100(4), 757-776.

Do, N. T., Vu, H. T., Nguyen, C. T., Punpuing, S., Khan, W. A., Gyapong, M., Asante, K. P., Munguambe, K., Gómez-Olivé, F. X., John-Langba, J., & Tran, T. K. (2021). Community-based antibiotic access and use in six low-income and middle-income countries: a mixed-method approach. *The Lancet Global Health*, 9(5), e610-e619.

Donker, T., Wallinga, J., & Grundmann, H. (2010). Patient referral patterns and the spread of hospital-acquired infections through national health care networks. *PLoS Computational Biology*, 6(3), e1000715.

Balode, A., Punda-Polić, V., & Dowzicky, M. J. (2013). Antimicrobial susceptibility of gram-negative and gram-positive bacteria collected from countries in Eastern Europe: results from the Tigecycline Evaluation and Surveillance Trial (TEST) 2004–2010. *International Journal of Antimicrobial Agents*, 41(6), 527-535.

Durrance-Bagale, A., Jung, A. S., Frumence, G., Mboera, L., Mshana, S. E., Sindato, C., Clark, T. G., Matee, M., & Legido-Quigley, H. (2021). Framing the drivers of antimicrobial resistance in Tanzania. *Antibiotics,* 10(8), 991.

Egyir, B., Guardabassi, L., Esson, J., Nielsen, S. S., Newman, M. J., Addo, K. K., & Larsen, A. R. (2014). Insights into nasal carriage of Staphylococcus aureus in an urban and a rural community in Ghana. *PLoS One,* 9(4), e96119.

Cuong, N. V., Padungtod, P., Thwaites, G., & Carrique-Mas, J. J. (2018). Antimicrobial usage in animal production: A review of the literature with a focus on low-and middle-income countries. *Antibiotics,* 7(3), 1-20.

Essack, S. Y., Desta, A. T., Abotsi, R. E., & Agoba, E. E. (2017). Antimicrobial resistance in the WHO African region: Current status and roadmap for action. *Journal of Public Health*, 39(1), 8-13.

FAO, W., & WH, O. (2017). Global framework for development & stewardship to combat antimicrobial resistance: Draft roadmap. *World Organisation for Animal Health*, 8, 1-29.

Founou, R. C., Founou, L. L., & Essack, S. Y. (2017). Clinical and economic impact of antibiotic resistance in developing countries: A systematic review and meta-analysis. *PloS One*, 12(12), e0189621.

Mgonja, F., Mosha, R., Mabiki, F., & Choongo, K. (2017). *Oxytetracycline Residue Levels in Beef in Dodoma Region, Tanzania*. https://scholar.google.com

McCracken, K., & Phillips, D. R. (2017). *Global health: An Introduction to Current and Future Trends.* https://scholar.google.com

Gabriel, S., Manumbu, L., Mkusa, O., Kilonzi, M., Marealle, A. I., Mutagonda, R. F., Mlyuka, H. J., Mikomangwa, W. P., & Minzi, O. (2021). Knowledge of use of antibiotics among consumers in Tanzania. *JAC-Antimicrobial Resistance*, 3(4), 1-8.

Gelayee, D. A. (2017). Self-medication pattern among social Science University students in Northwest Ethiopia. *Journal of Pharmaceutics*, 2017, 1-6.

Grace, D. (2015). *Review of Evidence on Antimicrobial Resistance and Animal Agriculture in Developing Countries*. https://scholar.google.com

Green, D. L., Keenan, K., Fredricks, K. J., Huque, S. I., Mushi, M. F., Kansiime, C., Asiimwe, B., Kiiru, J., Mshana, S. E., Neema, S., & Mwanga, J. R. (2023). The role of multidimensional poverty in antibiotic misuse: A mixed-methods study of self-medication and non-adherence in Kenya, Tanzania, and Uganda. *The Lancet Global Health*, 11(1), e59-e68.

Gulland, A. (2018). *How African Drug Sellers are Getting a Makeover in an Effort to Combat Superbugs.* https://www.telegraph.co.uk/news/0/african-drug-sellers-getting-makeover-effort-combat-superbugs/. Accessed 19 Oct 2018

Gutema, G., Ali, S., & Suleman, S. (2021). Trends of community-based systemic antibiotic consumption: Comparative analyses of data from Ethiopia and Norway calls for public health policy actions. *Plos One,* 16(5), e0251400.

Gwimile, J. J., Shekalaghe, S. A., Kapanda, G. N., & Kisanga, E. R. (2012). Antibiotic prescribing practice in management of cough and/or diarrhoea in Moshi Municipality, Northern Tanzania: Cross-sectional descriptive study. *Pan African Medical Journal,* 12(1), 1-8.

H. Ritchie. (2017). *How do we Reduce Antibiotic Resistance from Livestock?* https://ourworldindata.org/antibiotic-resistance-from-livestock.

Haynes, D., Lasarev, M., & Keller, J. (2018). Systemic antibiotic use for nonbacterial dermatological conditions among referring providers. *International Journal of Dermatology,* 57(5), 566-571.

Heal, C., Gorges, H., Van Driel, M. L., Tapley, A., Davis, J., Davey, A., Holliday, L., Ball, J., Najib, N., Spike, N., & FitzGerald, K. (2019). Antibiotic stewardship in skin infections: A cross-sectional analysis of early-career GP's management of impetigo. *BMJ Open*, 9(10), e031527.

Heller, A. A., & Spence, D. M. (2019). A Rapid Method for Post-Antibiotic Bacterial Susceptibility Testing. *PLoS One,* 14(1), e0210534.

Nepal, A., Hendrie, D., Robinson, S., & Selvey, L. A. (2019). Survey of the pattern of antibiotic dispensing in private pharmacies in Nepal. *BMJ Open*, 9(10), e032422.

Hoa, N. Q., Larson, M., Chuc, N. T. K., Eriksson, B., Trung, N. V., & Stålsby, C. L. (2009). Antibiotics and paediatric acute respiratory infections in rural Vietnam: Health-care providers' knowledge, practical competence and reported practice. *Tropical Medicine & International Health,* 14(5), 546-555.

Horumpende, P. G., Mshana, S. E., Mouw, E. F., Mmbaga, B. T., Chilongola, J. O., & de Mast, Q. (2020). Point prevalence survey of antimicrobial use in three hospitals in North-Eastern Tanzania. *Antimicrobial Resistance & Infection Control*, 9, 1-6

Horumpende, P. G., Said, S. H., Mazuguni, F. S., Antony, M. L., Kumburu, H. H., Sonda, T. B., Mwanziva, C. E., Mshana, S. E., Mmbaga, B. T., Kajeguka, D. C., & Chilongola, J. O. (2018). Prevalence, determinants and knowledge of antibacterial self-medication: A cross sectional study in North-eastern Tanzania. *PLoS One*, 13(10), e0206623.

Horumpende, P. G., Sonda, T. B., Van Zwetselaar, M., Antony, M. L., Tenu, F. F., Mwanziva, C. E., Shao, E. R., Mshana, S. E., Mmbaga, B. T., & Chilongola, J. O. (2018). Prescription and non-prescription antibiotic dispensing practices in part I and part II pharmacies in

Moshi Municipality, Kilimanjaro Region in Tanzania: A simulated clients approach. *Plos One*, 13(11), e0207465.

HPSS. (2012). *Rational use of Medicines to Improve Quality of Therapy.* http://www.hpss.or.tz

ICF International. (2012). *Demographic and Health Survey Sampling and Household Listing Manual.* https://www.google.com

IFPMA. (2017). *Industry Roadmap for Progress on Combating Antimicrobial Resistance*. https://www.amrindustryalliance.org

Brinkmann, I., & Kibuule, D. (2020). Effectiveness of antibiotic stewardship programmes in primary health care settings in developing countries. *Research in Social and Administrative Pharmacy,* 16(9), 1309-1313.

Iskandar, K., Molinier, L., Hallit, S., Sartelli, M., Catena, F., Coccolini, F., Craig-Hardcastle, T., Roques, C., & Salameh, P. (2020). Drivers of antibiotic resistance transmission in low- and middle-income countries from a "one health" perspective: A review. *Antibiotics,* 9(7), 372.

Iskandar, K., Molinier, L., Hallit, S., Sartelli, M., Hardcastle, T. C., Haque, M., Lugova, H., Dhingra, S., Sharma, P., Islam, S., & Mohammed, I. (202). Surveillance of antimicrobial resistance in low-and middle-income countries: A scattered picture. *Antimicrobial Resistance & Infection Control*, 10(1), 1-19.

O'Neill, J. (2014). *Antimicrobial Resistance: Tackling a Crisis for the Health and Wealth of Nations.* https://scholar.google.com

Jim, O. (2015). *Antimicrobials in Agriculture and the Environment: Reducing Unnecessary Use and Waste.* https://scholar.google.com

JPIAMR. (2018). Roadmap of Actions 2019 - 2024. https://www.jpiamr.eu/jpiamr-roadmap-of-actions-2019-2024.

Hertz, J. T., Madut, D. B., Tesha, R. A., William, G., Simmons, R. A., Galson, S.W., Maro, V. P., Crump, J. A., & Rubach, M. P. (2019). Self-medication with non-prescribed pharmaceutical agents in an area of low malaria transmission in northern Tanzania: A community-based survey. *Transactions of The Royal Society of Tropical Medicine and Hygiene*, 113(4), 183-188.

Kagashe, G. A., Minzi, O., & Matowe, L. (2011). An assessment of dispensing practices in private pharmacies in Dar-es-Salaam, Tanzania. *International Journal of Pharmacy Practice,* 19(1), 30-35.

Kamuhabwa, A. A., & Kisoma, S. (2015). Factors influencing prescribing practices of medical practitioners in public and private health facilities in dar es salaam, Tanzania. *Tropical Journal of Pharmaceutical Research,* 14(11), 2107-2113.

Qiu, P. L., Liu, S. Y., Bradshaw, M., Rooney-Latham, S., Takamatsu, S., Bulgakov, T. S., Tang, S. R., Feng, J., Jin, D. N., Aroge, T., & Li, Y. (2020). Multi-locus phylogeny and taxonomy of an unresolved, heterogeneous species complex within the genus Golovinomyces (Ascomycota, Erysiphales), including *G. ambrosiae, G. circumfusus and G. spadiceus*. *BMC Microbiology,* 20, 1-16.

Kelesidis, T., & Falagas, M. (2015). Medicamentos antimicrobianos de calidad inferior/falsificados. *Clinical Microbiology Reviews*, 28(2), 443-464.

Kelesidis, T., Kelesidis, I., Rafailidis, P. I., & Falagas, M. E. (2007). Counterfeit or substandard antimicrobial drugs: A review of the scientific evidence. *Journal of Antimicrobial Chemotherapy*, 60(2), 214-236.

Kimera, Z. I., Mshana, S. E., Rweyemamu, M. M., Mboera, L. E., & Matee, M. I. (2020). Antimicrobial use and resistance in food-producing animals and the environment: An African perspective. *Antimicrobial Resistance & Infection Control,* 9, 1-12.

King, T., Schindler, R., Chavda, S., & Conly, J. (2022). Dimensions of poverty as risk factors for antimicrobial resistant organisms in Canada: A structured narrative review. *Antimicrobial Resistance & Infection Control,* 11(1), 1-14.

Kirchhelle, C. (2018). Pharming animals: A global history of antibiotics in food production (1935–2017). *Palgrave Communications*, 4(1), 1-13.

Kothari, C. R. (2004). *Research Methodology: Methods and Techniques*. New Age International. https://scholar.google.com

Kumburu, H. H., Sonda, T., Mmbaga, B. T., Alifrangis, M., Lund, O., Kibiki, G., & Aarestrup, F. M. (2017). Patterns of infections, aetiological agents and antimicrobial resistance at a tertiary care hospital in northern Tanzania. *Tropical Medicine & International Health*, 22(4), 454-464.

Kutyabami, P., Munanura, E. I., Kalidi, R., Balikuna, S., Ndagire, M., Kaggwa, B., Nambatya, W., Kamba, P. F., Musiimenta, A., Kesi, D. N., & Nambasa, V. (2021). Evaluation of the clinical use of ceftriaxone among in-patients in selected health facilities in Uganda. *Antibiotics,* 10(7), 779.

Lam, T. T., Dang, D. A., Tran, H. H., Do, D. V., Le, H., Negin, J., Jan, S., Marks, G. B., Nguyen, T. A., Fox, G. J., & Beardsley, J. (2021). What are the most effective community-based antimicrobial stewardship interventions in low-and middle-income countries? A narrative review. *Journal of Antimicrobial Chemotherapy,* 76(5), 1117-1129.

Malik, U. R., Chang, J., Hashmi, F., Atif, N., Basir, H., Hayat, K., Khan, F. U., Kabba, J. A., Lambojon, K., & Fang, Y. (2021). A simulated client exploration of nonprescription dispensing of antibiotics at drugstores for pediatric acute diarrhea and upper respiratory infection in Lahore, Pakistan. *Infection and Drug Resistance,* 1129-1140.

Larson, E. (2007). Community factors in the development of antibiotic resistance. *Annual Review of Public Health,* 28, 435-447.

Lipsitch, M., Singer, R. S., & Levin, B. R. (2002). Antibiotics in agriculture: When is it time to close the barn door? *Proceedings of the National Academy of Sciences,* 99(9), 5752-5754.

Diamond, D. M., Campbell, A. M., Park, C. R., Halonen, J., & Zoladz, P. R. (2007). The temporal dynamics model of emotional memory processing: A synthesis on the neurobiological basis of stress-induced amnesia, flashbulb and traumatic memories, and the Yerkes-Dodson law. *Neural Plasticity*, 2007, 1, 1-34.

Ma, F., Xu, S., Tang, Z., Li, Z., & Zhang, L. (2021). Use of antimicrobials in food animals and impact of transmission of antimicrobial resistance on humans. *Biosafety and Health*, 3(1), 32-38.

Manyahi, J., Kibwana, U., Mgimba, E., & Majigo, M. (2020). Multi-drug resistant bacteria predict mortality in bloodstream infection in a tertiary setting in Tanzania. *PLoS One*, 15(3), e0220424.

Marangu, D., & Zar, H. J. (2019). Childhood pneumonia in low-and-middle-income countries: An update. *Paediatric Respiratory Reviews*, 32, 3-9.

Mate, V. H., Gonarkar, S. B., & Dhamani, A. M. (2019). Drug utilization for common skin diseases: An outpatient based study. *International Journal of Basic & Clinical Pharmacology*, 8, 2604. https://doi.org/10.18203/2319-2003.ijbcp20195264

Kagashe, G. A., Minzi, O., & Matowe, L. (2011). An assessment of dispensing practices in private pharmacies in Dar-es-Salaam, Tanzania. *International Journal of Pharmacy Practice,* 19(1), 30-35.

Mbwasi, R., Mapunjo, S., Wittenauer, R., Valimba, R., Msovela, K., Werth, B. J., Khea, A. M., Nkiligi, E. A., Lusaya, E., Stergachis, A., & Konduri, N., (2020). National consumption of antimicrobials in Tanzania: 2017–2019. *Frontiers in Pharmacology,* 11, 585553.

McGregor, A. C., & Moore, D. A. (2015). Infectious causes of fever of unknown origin. *Clinical Medicine*, 15(3), 285.

Mdegela, R.H., Mwakapeje, E. R., Rubegwa, B., Gebeyehu, D. T., Niyigena, S., Msambichaka, V., Nonga, H. E., Antoine-Moussiaux, N., & Fasina, F. O. (2021). Antimicrobial use, residues, resistance and governance in the food and agriculture sectors, Tanzania. *Antibiotics*, 10(4), 454.

Mgaya, F. X., Matee, M. I., Muhairwa, A. P., & Hoza, A. S. (2021). Occurrence of multidrug resistant Escherichia coli in raw meat and cloaca swabs in poultry processed in slaughter slabs in Dar es Salaam, Tanzania. *Antibiotics,* 10(4), 343.

Ministry of Health. (2003). *National Health Policy*. In:https://www.healthresearchweb.org

Ministry of Health and Social Welfare-Tanzania. (2017). *Standard Treatment Guidelines and National Essential Medicines List*. In: https://www.who.int

Minzi, O. M., & Manyilizu, V. S. (2013). Application of basic pharmacology and dispensing practice of antibiotics in accredited drug-dispensing outlets in Tanzania. *Drug, Healthcare and Patient Safety*, 2013, 5-11.

MoH. (2023). *The National Action Plan on Antimicrobial Resistance 2023-2028.* https://scholar.google.com

MoHCGEC. (2017). *National Action Plan on Antimicrobial Resistance 2017 - 2022. Dodoma* https://scholar.google.com.

Moremi, N., Mushi, M. F., Fidelis, M., Chalya, P., Mirambo, M., & Mshana, S. E. (2014). Predominance of multi-resistant gram-negative bacteria colonizing chronic lower limb ulcers at Bugando Medical Center. *BMC Research Notes*, 7(1), 1-4.

Horumpende, P. G., Sonda, T. B., Van Zwetselaar, M., Antony, M. L., Tenu, F. F., Mwanziva, C. E., Shao, E. R., Mshana, S. E., Mmbaga, B. T., & Chilongola, J. O. (2018). Prescription and non-prescription antibiotic dispensing practices in part I and part II pharmacies in Moshi Municipality, Kilimanjaro Region in Tanzania: A simulated clients approach. *Plos One*, 13(11), e0207465.

Mshana, S. E., Falgenhauer, L., Mirambo, M. M., Mushi, M. F., Moremi, N., Julius, R., Seni, J., Imirzalioglu, C., Matee, M., & Chakraborty, T. (2016). Predictors of bla CTX-M-15 in varieties of Escherichia coli genotypes from humans in community settings in Mwanza, Tanzania. *BMC Infectious Diseases*, 2016, 16, 1-9.

Mshana, S. E., Hain, T., Domann, E., Lyamuya, E. F., Chakraborty, T., & Imirzalioglu, C. (2013). Predominance of Klebsiella pneumoniaeST14 carrying CTX-M-15 causing neonatal sepsis in Tanzania. *BMC Infectious Diseases*, 13(1), 1-8.

Mshana, S. E., Matee, M., & Rweyemamu, M. (2013). Antimicrobial resistance in human and animal pathogens in Zambia, Democratic Republic of Congo, Mozambique and Tanzania: an urgent need of a sustainable surveillance system. *Annals of Clinical Microbiology and Antimicrobials,* 12(1), 1-10.

Mushi, M. F., Mshana, S. E., Imirzalioglu, C., & Bwanga, F. (2014). Carbapenemase genes among multidrug resistant gram negative clinical isolates from a tertiary hospital in Mwanza, Tanzania. *Biomed Research International,* 2014, 1-7.

Mwambete, K. (2014). Antibacterial quality of some antibiotics available in five administrative areas along the national borders of Tanzania. *Integrated Pharmacy Research and Practice*, 2014, 3, 97-107.

Qiu, P. L., Liu, S.Y., Bradshaw, M., Rooney-Latham, S., Takamatsu, S., Bulgakov, T. S., Tang, S. R., Feng, J., Jin, D. N., Aroge, T., & Li, Y. (2020). Multi-locus phylogeny and taxonomy of an unresolved, heterogeneous species complex within the genus Golovinomyces (Ascomycota, Erysiphales), including *G. ambrosiae, G. circumfusus and G. spadiceus*. *BMC Microbiology*, 20, 1-16.

Nahar, P., Unicomb, L., Lucas, P. J., Uddin, M. R., Islam, M. A., Nizame, F. A., Khisa, N., Akter, S. M., & Rousham, E. K. (2020). What contributes to inappropriate antibiotic dispensing among qualified and unqualified healthcare providers in Bangladesh? A qualitative study. *BMC Health Services Research*, 20(1), 1-11.

Nate Goldfarb. (2022). *Expanding surveillance for "superbugs" in Tanzania*. https:// www. path. org

NBS. (2016). *The United Republic of Tanzania Dodoma Region Basic Demographic and Socio-Economic Profile 2012 Population and Housing Census*. Dodoma https:// scholar. google. com

Ndaki, P. M., Mushi, M. F., Mwanga, J. R., Konje, E. T., Ntinginya, N. E., Mmbaga, B. T., Keenan, K., Sabiiti, W., Kesby, M., Benitez-Paez, F., & Sandeman, A. (2021). Dispensing antibiotics without prescription at community pharmacies and accredited drug dispensing outlets in Tanzania: a cross-sectional study. *Antibiotics,* 10(8), 1025.

Ndhlovu, M., Nkhama, E., Miller, J. M., & Hamer, D. H. (2015). Antibiotic prescribing practices for patients with fever in the transition from presumptive treatment of malaria to 'confirm and treat'in Zambia: A cross-sectional study. *Tropical Medicine & International Health,* 20(12), 1696-1706.

Nelson, E., Kayega, J., Seni, J., Mushi, M. F., Kidenya, B. R., Hokororo, A., Zuechner, A., Kihunrwa, A., & Mshana, S. E. (2014). Evaluation of existence and transmission of extended spectrum beta lactamase producing bacteria from post-delivery women to neonates at Bugando Medical Center, Mwanza-Tanzania. *BMC Research Notes*, 7(1), 1-6.

Nepal, A., Hendrie, D., Robinson, S., & Selvey, L. A. (2019). Survey of the pattern of antibiotic dispensing in private pharmacies in Nepal. *BMJ Open,* 9(10), e032422.

Ngigi, C. K., Mwagiru, P., & Wala, J. (2016). *Self-Medication with Antibiotics Prior to Seeking Treatment among Adult Patients Attending Outpatient Department at Gatundu Sub-County hospital, Kiambu County, Kenya*. https://scholar.google.com

Nicolle, L. E. (2001). *Infection Control Programmes to Contain Antimicrobial Resistance.* World Health Organization. https://doi.org/WHO/CDS/CSR/DRS/2001.7

Myemba, D. T., Maganda, B. A., Kibwana, U. O., Nkinda, L., Ndayishimiye, P., Kilonzi, M., Mikomangwa, W. P., Njiro, B. J., Ndumwa, H. P., Mlyuka, H. J., & Felix, F. F. (2022). Profiling of antimicrobial dispensing practices in accredited drug dispensing outlets in Tanzania: A mixed-method cross-sectional study focusing on pediatric patients. *BMC Health Services Research,* 22(1), 1575.

Núñez, M., Tresierra-Ayala, M., & Gil-Olivares, F. (2016). Antibiotic self-medication in university students from Trujillo, Peru. *Medicina Universitaria,* 18(73), 205-209.

Obua, C., Talib, Z., & Haberer, J. E. (2023). Poverty and antibiotic misuse: A complex association. *The Lancet Global Health,* 11(1), e6-e7.

OIE. (2016). *The OIE Strategy on Antimicrobial Resistance and the Prudent Use of antimicrobials. Paris: OIE*. https://scholar.google.com

Okeke, I. N., Laxminarayan, R., Bhutta, Z. A., Duse, A. G., Jenkins, P., O'Brien, T. F., Pablos-Mendez, A., & Klugman, K. P. (2005). Antimicrobial resistance in developing countries. Part I: recent trends and current status. *The Lancet Infectious Diseases*, 5(8), 481-493.

PCT. (2015). *ADDO Medicines List*. https://www.pc.go.tz/regulation_guidelines.

Gotz, A., & Smalla, K. (1997). Manure enhances plasmid mobilization and survival of Pseudomonas putida introduced into field soil. *Applied and Environmental Microbiology*, 63(5), 1980-1986.

Perilla, M., Ajello, G., Bopp, C., Elliott, J., Facklam, R., Knapp, J., Popovic, T., Wells, J., Dowell, S., & CDC. (2003). *Manual* for the *Laboratory Identification* and *Antimicrobial Susceptibility Testing* of *Bacterial Pathogens* of *Public Health Importance* in the *Developing World*. https://scholar.google.com

Pharmacy Council of Tanzania. (2019). *The Pharmacy regulations*. https:// www. pc. go. tz/ regulation_ guidelines

Pharmacy Council of Tanzania. (2021). *Premises Register*. https://www.pc.go.tz

Pharmacy Council of Tanzania. (2015). *ADDO Medicines List*. https://www.pc.go.tz

Planta, M. B. (2007). The role of poverty in antimicrobial resistance. *Journal of the American Board of Family Medicine,* 20, 533–539.

Porter, G., Joshi, J., Bhullar, L., & Kotwani, A. (2020). Using 'smart regulation'to tackle antimicrobial resistance in low-income and middle-income countries. *BMJ Global Health*, 5(1), e001864.

Prestinaci, F., Pezzotti, P., & Pantosti, A. (2015). Antimicrobial resistance: A global multifaceted phenomenon. *Pathog Glob Health,* 109 (7), 309–18.

Rhee, C., Aol, G., Ouma, A., Audi, A., Muema, S., Auko, J., Omore, R., Odongo, G., Wiegand, R. E., Montgomery, J. M., & Widdowson, M. A. (2019). Inappropriate use of antibiotics for childhood diarrhea case management: Kenya, 2009–2016. *BMC Public Health*, 19, 1-12.

Rutta, E. (2014). Medicines in health Systems: advancing access, affordability, and appropriate use. *Alliance for Health Policy and Systems Research*, 2014, 1-20.

Elvidge, S. (2020). *AMR and Diagnostics: Pointing the Way to Better Infection Control.* https://scholar.google.com

Sangeda, R. Z., Saburi, H. A., Masatu, F. C., Aiko, B. G., Mboya, E. A., Mkumbwa, S., Bitegeko, A., Mwalwisi, Y. H., Nkiligi, E. A., Chambuso, M., & Sillo, H. B. (2021). National antibiotics utilization trends for human use in Tanzania from 2010 to 2016 inferred from Tanzania Medicines and Medical Devices Authority importation data. *Antibiotics,* 10(10), 1249.

Seni, J., Falgenhauer, L., Simeo, N., Mirambo, M. M., Imirzalioglu, C., Matee, M., Rweyemamu, M., Chakraborty, T., & Mshana, S. E. (2016). Multiple ESBL-producing Escherichia coli sequence types carrying quinolone and aminoglycoside resistance genes circulating in companion and domestic farm animals in Mwanza, Tanzania, harbor commonly occurring plasmids. *Frontiers In Microbiology,* 7, 142.

Seni, J., Mapunjo, S. G., Wittenauer, R., Valimba, R., Stergachis, A., Werth, B. J., Saitoti, S., Mhadu, N. H., Lusaya, E., & Konduri, N. (2020). Antimicrobial use across six referral hospitals in Tanzania: A point prevalence survey. *BMJ Open,* 10(12), e042819.

Sharma, P., & Dwivedi, S. (2017). Prospects of molecular biotechnology in diagnostics: step towards precision medicine. *Indian Journal of Clinical Biochemistry*, 32, 121-123.

Sié, A., Ouattara, M., Bountogo, M., Dah, C., Compaoré, G., Boudo, V., Lebas, E., Brogdon, J., Nyatigo, F., Arnold, B. F., & Lietman, T. M. (2021). Indication for antibiotic prescription among children attending primary healthcare services in rural Burkina Faso. *Clinical Infectious Diseases*, 73(7), 1288-1291.

Swaminathan, S., Prasad, J., Dhariwal, A. C., Guleria, R., Misra, M. C., Malhotra, R., Mathur, P., Walia, K., Gupta, S., Sharma, A., & Ohri, V. (2017). Strengthening infection prevention and control and systematic surveillance of healthcare associated infections in India. *Antimicrobial Resistance in South East Asia,* 2017, 358, j3768

Gilson, L., Jaffar, S., Mwankusye, S., & Teuscher, T. (1993). Assessing prescribing practice: A Tanzanian example. *The International Journal of Health Planning and Management*, 8(1), 37-58.

Thanner, S., Drissner, D., & Walsh, F. (2016). Antimicrobial resistance in agriculture. *MBio*, 7(2), e02227-15.

Todorovic Markovic, M., Gottfredsson, M., Todorovic-Mitic, M., & Gaini, S. (2019). Focus of infection and microbiological etiology in community-acquired infections in hospitalized adult patients in the Faroe Islands. *BMC Infectious Diseases*, 19(1), 1-11.

Tun, Z. M., Moorthy, M., Linster, M., Su, Y. C., Coker, R. J., Ooi, E. E., Low, J. G. H., Smith, G. J., & Tam, C. C. (2016). Patterns of medication use and factors associated with antibiotic use among adult fever patients at Singapore primary care clinics. *Antimicrobial Resistance & Infection Control*, 5, 1-8.

UN. (2016). *High-Level Meeting on Antimicrobial Resistance*. https://www.un.org

Van Boeckel, T. P., Brower, C., Gilbert, M., Grenfell, B. T., Levin, S. A., Robinson, T. P., Teillant, A., & Laxminarayan, R. (2015). Global trends in antimicrobial use in food animals. *Proceedings of the National Academy of Sciences*, 112(18), 5649-5654.

Kalyani, V., Bisht, M., Thapliyal, S., & Rohilla, K. K. (2020). Comparison of practice and attitude of self-treatment in rural and urban population in Uttarakhand, India: A comparative study. *National Journal of Physiology, Pharmacy and Pharmacology,* 10(12), 1052-1059.

Ventola, C. L. (2015). The antibiotic resistance crisis: Part 1: Causes and threats. *Pharmacy and Therapeutics*, 40(4), 277.

Vikesland, P., Garner, E., Gupta, S., Kang, S., Maile-Moskowitz, A., & Zhu, N. (2019). Differential drivers of antimicrobial resistance across the world. *Accounts of Chemical Research,* 52(4), 916-924.

Wall, B. A., Mateus, A. L. P., Marshall, L., Pfeiffer, D. U., Lubroth, J., Ormel, H. J., Otto, P., & Patriarchi, A. (2016). *Drivers, Dynamics and Epidemiology of Antimicrobial Resistance in Animal Production*. https://scholar.google.com

Wangai, F. K., Masika, M. M., Maritim, M. C., & Seaton, R. A. (2019). Methicillin-resistant Staphylococcus aureus (MRSA) in East Africa: Red alert or red herring? *BMC Infectious Diseases,* 19(1), 1-10.

WHO. (2021). *Antimicrobial Resistance.* https://www.who.int

WHO. (2014a). *Antimicrobial Resistance: Global Report on Surveillance*. https://apps.who.int

WHO. (2016). *WHO Report on Surveillance of Antibiotic Consumption.* https://apps.who.int

WHO. (2022). *WHO Supports Introduction to Antibiotic Stewardship in three Hospitals*. https://www.afro.who.int

WHO. (2015a). *Global Action Plan on Antimicrobial Resistance.* https://scholar.google.com

WHO. (2020). *Antibiotic Resistance*. https://www.who.int

WHO. (2019a). *Sanitation*. https://www.who.int

WHO. (2014b). *WHO Methodology for a Global Programme on Surveillance of Antimicrobial Consumption*. https://scholar.google.com

WHO. (2019b). *New Report Calls for Urgent Action to Avert Antimicrobial Resistance Crisis*. https://www.who.int

WHO. (2015b). *Global Antimicrobial Resistance Surveillance System*. Manual for Early Implementation. https://scholar.google.com

CDC. (2004). *Diseases of Poverty and the 10/90 Gap.* https://scholar.google.com

WHO. (2015c). *Prevention and Management of Wound Infection: Guidance from WHO's Department of Violence and Injury Prevention and Disability and the Department of Essential Health Technologies*. https://scholar.google.com

WHO. (2015d). *Prevention and Management of Wound Infection.* https://scholar.google.com

WHO. (2006). *Guidelines on Co-Trimoxazole Prophylaxis for HIV-Related Infections among Children, Adolescents and Adults: Recommendations for a Public Health Approach*. World Health Organization, Department of HIV/AIDS. https://scholar.google.com

Wiedenmayer, K., Ombaka, E., Kabudi, B., Canavan, R., Rajkumar, S., Chilunda, F., Sungi, S., & Stoermer, M. (2021). Adherence to standard treatment guidelines among prescribers in primary healthcare facilities in the Dodoma region of Tanzania. *BMC Health Services Research*, 21(1), 1-10.

Willms, I. M., Kamran, A., Aßmann, N. F., Krone, D., Bolz, S. H., Fiedler, F., & Nacke, H. (2019). Discovery of novel antibiotic resistance determinants in forest and grassland soil metagenomes. *Frontiers in Microbiology*, 10, 460.

Woolhouse, M., Ward, M., Van Bunnik, B., & Farrar, J. (2015). Antimicrobial resistance in humans, livestock and the wider environment. *Philosophical Transactions of the Royal Society B: Biological Sciences,* 370(1670), 20140083.

Worku, F., & Tewahido, D. (2018). Retrospective assessment of antibiotics prescribing at public primary healthcare facilities in Addis Ababa, Ethiopia. *Interdisciplinary Perspectives on Infectious Diseases*, 2018, 1-10.

World Bank. (2016). *Drug-resistant infections: A Threat to our Economic Future.* https://scholar.google.com

WTO. (1998). *Agreement on the Application of Sanitary and Phytosanitary Measures*. https:// www. wto. org

Wuijts, S., Van den Berg, H. H., Miller, J., Abebe, L., Sobsey, M., Andremont, A., Medlicott, K. O., van Passel, M.W., & De Roda Husman, A. M. (2017). Towards a research agenda for water, sanitation and antimicrobial resistance. *Journal of Water and Health,* 15(2), 175-184.

Xue, F., Xu, B., Shen, A., & Shen, K. (2021). Antibiotic prescriptions for children younger than 5 years with acute upper respiratory infections in China: A retrospective nationwide claims database study. *BMC Infectious Diseases,* 21(1), 1-10.

APPENDICES

Appendix 1: Data Collection Questionnaires

PART A: GENERAL INFORMATION		
District	*Ward*	*Village /Street*
Household number		
Date of Visit		
Name of data collector		

PART B: DEMOGRAPHIC INFORMATION			
S/N	Questions/Item	Response	Tick
1.	Age of respondent (Years)	A. 18 - 34	
		B. 35 - 49	
		C. 50 – 70	
		D. >70	
2.	Sex	A. Male	
		B. Female	
3.	Marital status	A. Single	
		B. Married	
		C. Divorced	
		D. Widow	
4.	What is the level of your education?	A. No formal education	
		B. Primary school education	
		C. Secondary School education	
		D. College education	
		E. Others (specify)	
5.	What is your occupation?	A. Farming	
		B. Livestock keeping	
		C. Farming and livestock keeping	
		D. Employed	
		E. Others (*specify*)	
6.	Between a health care facility and a community drug outlet, which one is closer to where you stay?	A. Health care facility	
		B. Community drug outlet	
PART C: SELF MEDICATION BEHAVIORS			
1.	Have you ever taken antibiotics?	A. Yes	
		B. No	
2.	Have you ever treated yourself (self-medicated) with antibiotics?	A. Yes	
		B. No	
3.	How many times did you treat yourself with antibiotics in the past one year?		
4.		A. Cost saving	

	What was (were) your reason(s) of self-medication with antibiotics? (check more than one if applicable)	B. Convenience	
		C. Lack of trust in prescribing doctor	
		D. Others (specify)	
	In which seasons of the year do you use antibiotics often?	A. Rainy seasons	
		B. Dry seasons	
5.	For which of the following complaint(s) did you use antibiotics? (check more than one if applicable)	A. Runny nose	
		B. Nasal congestion	
		C. Cough	
		D. Sore throat	
		E. Fever	
		F. Aches and pains	
		G. Vomiting	
		H. Diarrhea	
		I. Skin wounds	
		J. Others (specify)	
6.	Your selection of antibiotics was based on… (check more than one if applicable)	A. Recommendation by community pharmacists	
		B. Opinion of family members	
		C. Opinion of friends	
		D. My own experience	
		E. Recommendation by net citizens	
		F. Previous doctor's prescription	
7.	What did you consider when selecting antibiotics? (check more than one if applicable)	A. Type of antibiotics	
		B. Brand of antibiotics	
		C. Price of antibiotics	
		D. Indications for use	
		E. Adverse reactions	
		F. Others (specify)	
8.		A. Community pharmacies	

	Where did you usually obtain antibiotics from for self-medication? (check more than one if applicable)		
		B. Health facilities	
		C. Leftover from previous prescription	
		D. Online shopping/E-pharmacies	
		E. Others (specify)	
16.			
17.	When did you normally stop taking antibiotics? (check more than one if applicable)	A. After a few days regardless of the outcome	
		B. After symptoms disappeared	
		C. A few days after the recovery	
		D. After antibiotics ran out	
		E. At the completion of the course	
		F. After consulting a doctor/pharmacist	
		G. Others (specify)	
23.	Have you ever heard of AMR?	A. Yes	
		B. No	
24.	Please write down the names of antibiotics you have ever taken for SELF-MEDICATION:	1.	
		2.	
		3.	
		4.	
	How many different antibiotics did you take maximally during a single illness?		

PART D: HOUSEHOLD ECONOMIC STATUS			
	Indicators	Responses	
1.	1. How many household members are 18-years-old or younger?	A. Six or	
		B. Five	
		C. Four	
		D. Three	
		E. Two	
		F. One	
		G. None	
2.	Are all household members ages 6 to 18 currently in school?	A. No	
		B. Yes	
		C. No members ages 6 to 18	
3	What is the main building material used for the walls of the main building?	A. Baked bricks	
		B. Poles and mud, grass, sun-dried bricks, or other	

		C. Stones, cement bricks, or timber	
4.	What is the main building material used for the roof of the main building?	A. Grass/leaves, mud and leaves, or other	
		B. Iron sheets, tiles, concrete, or asbestos	
5	What is the main fuel used for cooking?	A. Firewood, coal, solar, gas (biogas), wood/farm residuals, or animal residuals	
		B. Charcoal, paraffin, gas (industrial), electricity, generator/private source, or other	
6.	Does your household have any televisions?	A. No	
		B. Yes	
7.	Does your household have any radios, cassette/tape recorders, or hi-fi systems?	A. No	
		B. Yes	
8.	Does your household have any lanterns?	A. No	
		B. Yes	
9.	Does your household have any tables?	A. No	
		B. Yes	
10.	If the household cultivated any crops in the last 12 months, does it currently own any bulls, cows, steers, heifers, male calves, female calves, or oxen?	A. No crops, and no cattle	
		B. No crops, and cattle	
		C. Crops, but no cattle	
		D. Crops, and cattle	

Appendix 2: Informed Consent Form

THE NELSON MANDELA
AFRICAN INSTITUTION OF SCIENCE AND TECHNOLOGY
(NM-AIST)

School of Life Sciences and Bioengineering

Direct Line: +255 272555070
Mobile Phone: +255272970005
Fax: +255 272555071
E-mail: deanlsbe@nm-aist.ac.tz

Tengeru
P.O. Box 447
Arusha, TANZANIA
Website: www.nm-aist.ac.tz

ID-No:

…………………………………………………………………………………………………...

Introduction

Greetings! My name is Richard James Mabilika, a PhD candidate in the department of Health and Biomedical Sciences (School of Life Sciences) at The Nelson Mandela African Institution of Science and Technology. I intend to conduct research on the "Community antibiotic usage and the characterization of resistance among common bacterial isolates in Dodoma region"

Purpose of the study

This study intends to explore the antibiotic usage and the trends of antibiotic resistance among commonly community acquired bacterial infections in patients visiting primary health care facilities in Chemba and Dodoma City Council as representatives of the rural and urban community settings respectively. The findings of this study will guide in determining the nature and accurate quantification of the AMR problem, implementation of "The Tanzanian National Action Plan on Antibiotic Resistance 2017 – 2022", development of new tools and policies and the allocation of resources to counter antibiotic resistance in the country. You are thus being asked to participate in this study for the reasons above.

What Participation Involves

Your consent to participate in this study means you voluntarily agree to respond to questions on the questionnaire forms (18 years <, excluding medics) or/and donate clinical samples for laboratory analysis (adults and children).

Confidentiality

All the information collected from you will be kept confidential and only people working in this research study will have access to such the information. Nothing traceable to you will be kept public.

Risks

You will either be asked questions about your antibiotic usage, purchases and knowledge on antibiotic resistance some of which you might find annoying; or asked to donate your clinical samples only for the purposes mentioned above. You may choose to decline from answering the questions or donating your clinical samples at any time during the interview or during sample collection.

Rights to Withdraw and Alternatives

Taking part in this study is completely your choice. If you choose to participate in the study or if you decide to decline you will not be subject to any losses or harm. You are free to stop participating in this study at any time, even when you have already given your consent. Refusal to participate or withdrawal from the study will not affect the quality of health care service that you are entitled from the health care facility.

Benefits

There will be no direct benefit to you; however, the information you provide and the samples collected will help in the quantification of the AMR problem and pave a way for policy makers and authorities to devise solutions for a healthier Tanzania and the Global community.

In Case of Injury

We do not anticipate that any harm will occur to you, your child or your family as a result of participation in this study.

Who to contact:

If you have questions about this study as a participant or any other study related questions, please do not hesitate to contact me by the following address:

Richard James Mabilika,

The Nelson Mandela African Institution of Science and Technology,

P.O. Box 447, Arusha,

Tanzania.

(Mobile. no. +255743368281/+255782358002).

Certification of consent

I have been invited to take part in the study on Community antibiotic usage and the characterization of resistance among common bacterial isolates in Dodoma region.

I have read (it has been read to me) the information and understood. My questions have been clearly answered to my satisfaction. On behalf of myself or my child, I agree to participate in this study.

Signature

Participant Agrees [__]

Participant disagree [__]

Signature (or thumbprint) of participant: ………………………. Date: ……………………….

Signature of witness (if participant cannot read): …………………. Date: ……………………….

Signature of principal investigator: …………………………………….. Date: ………………….

Appendix 3: Ethical Clearance

Kibong'oto Infectious Diseases Hospital- Nelson Mandela African Institution of Science and Technology- Centre for Educational Development in Health, Arusha (KIDH-NM-AIST-CEDHA) -KNCHREC

RESEARCH ETHICAL CLEARANCE CERTIFICATE

Research Proposal No: KNCHREC0020 **12th June 2019**

Study Title: **Community antibiotic usage and the characterization of resistance among common bacterial isolates in Dodoma region**

Study Area: THE NELSON MANDELA AFRICAN INSTITUTION OF SCIENCE AND TECHNOLOGY

PI Name: Richard James Mabilika

Co-Invigilator:

Institutions: SCHOOL OF LIFE SCIENCES AND BIO-ENGINEERING

The Proposal has been approved provisionally by KNCHREC on 12th June 2019

1. Subject to this approval you will be required to submit your progress report to the KNCHREC, National Institute of Research and Ministry of Health Community Development Gender Elderly and Children
2. Publication of your findings is subject to presentation to the KNCREC and NIMR Approval.
3. Copies of final publication should be made available to KNCHREC, National Institute of Research and Ministry of Health Community Development Gender Elderly and Children
4.

Duration of Study Renewal: Subject to Renewal within ONE YEAR

Span From: 12th June 2019 to 11th June 2020.

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Mr. Simon Njeya
Secretary
KNCHREC

....

Prof. Raymond Mosha
Chairperson
KNCHREC

RESEARCH UOTPUTS

(i) Publications

Mabilika, R. J., Shirima, G., & Mpolya, E. (2022). Prevalence and Predictors of Antibiotic Prescriptions at Primary Healthcare Facilities in the Dodoma Region, Central Tanzania: A Retrospective, Cross-Sectional Study. *Antibiotics*, *11*(8), 1- 11.

Mabilika, R. J., Mpolya, E., & Shirima, G. (2022). Prevalence and predictors of self-medication with antibiotics in selected urban and rural districts of the Dodoma region, Central Tanzania: A cross-sectional study. *Antimicrobial Resistance & Infection Control*, *11*(1), 1-9.

(ii) Poster Presentation