

The Burden of Antimicrobial Resistance in Zambia, a Sub-Saharan African Country: A One Health Review of the Current Situation, Risk Factors, and Solutions

Steward Mudenda^{1,2*}, Webrod Mufwambi¹, Shafiq Mohamed³

¹Department of Pharmacy, School of Health Sciences, University of Zambia, Lusaka, Zambia

²Surveillance and Research Technical Working Group, Antimicrobial Resistance Coordinating Committee, Zambia National Public Health Institute, Lusaka, Zambia

³York and Scarborough Teaching Hospitals, NHS Foundation Trust, York, UK

Email: *steward.mudenda@unza.zm

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Abstract

Background: Antimicrobial resistance (AMR) is a growing public health concern, with far-reaching consequences for modern medicine. Zambia, like many other low- and middle-income countries, faces significant challenges in addressing AMR. Further, high rates of resistance have been reported among various microorganisms in Zambia. This review paper aims to summarize the current situation of the burden of AMR in Zambia, including the prevalence, risk factors contributing to its emergence and spread, challenges in addressing this issue, and the required solutions to combat this growing public health threat. Additionally, the paper also outlines existing efforts to combat AMR and proposes required solutions and recommendations to address this threat to public health. **Materials and Methods:** This study employed a comprehensive narrative review design that included studies published from January 2000 to November 2024. The literature search was done using PubMed, Scopus, Web of Science, and Google Scholar. **Results:** In 2019, 1.27 million deaths were attributed to AMR of which 255,000 were from sub-Saharan Africa. Currently, the burden of AMR in Zambia is not well understood. This study found that the drug resistance index (DRI) in Zambia was 60.9%, demonstrating high resistance rates of pathogens to antimicrobials commonly used in humans and animals. The high DRI indicates the low effectiveness of antibiotics in treatment of infections. Most pathogens with high resistance to antimicrobials include *Klebsiella pneumoniae*, *Staphylococcus aureus*, *Streptococcus pneumoniae*, *Escherichia coli*, *Salmonella* species, *Enterococcus* species, *Mycobacterium*

tuberculosis, *Acinetobacter baumannii*, and *Pseudomonas aeruginosa*. Additionally, the study found that there was low awareness, knowledge, attitudes, and suboptimal practices regarding AMR in Zambia. The contributing factors to the emergence and spread of AMR include self-medication practices, overuse and misuse of antimicrobials in humans and animals, non-adherence to treatment guidelines, limited diagnostic capacity, substandard and falsified antimicrobials, and a lack of surveillance of AMR. There is a need to develop strategies to address the identified gaps in Zambia to successfully combat AMR. **Conclusion:** This study revealed high resistance of microbes to antimicrobials in Zambia. The high prevalence of AMR in Zambia indicates its burden on the country, thereby providing opportunities for further research to quantify this problem. The findings highlight the need for a One Health multi-sectoral approach to address AMR in Zambia, including strengthening surveillance and monitoring, improving antimicrobial stewardship and prescribing practices, enhancing infection prevention and control practices, increasing access to quality healthcare and diagnostic services, promoting public awareness and education, and encouraging research and development of new antimicrobial agents. The proposed solutions and recommendations can serve to strengthen the implementation of the Zambia National Action Plan (NAP) to combat AMR.

Keywords

Antimicrobial Resistance, Antimicrobial Stewardship, Burden, Infection Prevention and Control, Surveillance, Zambia

1. Introduction

Antimicrobial resistance (AMR) is a growing public health concern worldwide [1]-[4]. AMR occurs when microorganisms such as bacteria, viruses, and fungi develop resistance to antimicrobial agents, making them ineffective in treating infections [2] [3] [5]. This phenomenon has significant implications for public health, as it increases the risk of treatment failure, morbidity, and mortality [2] [6] [7]. Additionally, AMR has significant negative impacts on the global economy [8]-[11]. In 2019, AMR was linked to 4.95 million deaths globally, with 1.27 million of those directly attributed to AMR [2] [12]. Failure to address AMR will result in the death of 10 million people annually by the year 2050 [13]-[15]. Due to its impacts, AMR has been reported to be a silent pandemic and among the ten threats to public health [4] [7] [13] [16]-[21].

The problem of AMR is greater in low- and middle-income countries (LMICs), especially among African countries [22]-[31]. Studies have reported that the African region bears the major impacts of AMR due to many challenges faced in the healthcare system, poor regulation of antimicrobial use, and social and economic problems [22]-[26]. In Africa, there are many reports of self-medication, accessing antimicrobials without prescriptions, non-adherence to treatment

guidelines, poor to no diagnostic capacities, lack of awareness and knowledge about antimicrobial use (AMU) and AMR, and increased substandard and falsified antimicrobials [32]-[39]. Additionally, most countries have poor infection, prevention, and control measures, water, sanitation, and hygiene alongside the high burden of infectious diseases [25] [40]-[43]. Therefore, there is a need to develop and implement interventional strategies to address AMR globally [7] [44]-[48].

In Zambia, AMR is a major challenge, with high rates of resistance reported among various bacterial isolates [49]-[53]. This problem has been recognized as a One Health problem [50] [54]-[56]. The country's healthcare system faces significant challenges in addressing AMR, including limited diagnostic capacity, inadequate healthcare infrastructure, and knowledge gaps among healthcare professionals and the public [35] [36] [57] [58]. Several factors contribute to the development and spread of AMR in Zambia across humans, animals, plants, and the environment, including the overuse and misuse of antimicrobial agents, limited access to quality healthcare and diagnostic services, and poor infection prevention and control (IPC) practices [34]-[36] [57] [59] [60]. Non-adherence to treatment guidelines has also been reported to be very common in Zambia and a potential driver of AMR [61]-[65]. Further, the low capacity of laboratories and lack of effective surveillance and monitoring systems hinder the detection and response to AMR [35] [50] [58]. Furthermore, a lack of awareness, poor knowledge, attitudes, and practices have also contributed to the emergence and spread of AMR in Zambia [66]-[68].

Evidence has indicated that some of the resistant bacterial pathogens resistant to antibiotics in Zambia include *Escherichia coli* (*E. coli*) [69]-[78], Enterococcus species [79] [80], Staphylococcus species [81]-[83], Salmonella species [84] [85], and *Mycobacterium tuberculosis* [86]-[94]. There is also evidence that fungi are resistant to antifungal agents [95] [96]. Additionally, there are reports of viral resistance to antivirals making treatment of viral infections difficult or impossible [97] [98]. The drug-resistant pathogens have been isolated from humans, animals, and the environment, thereby demonstrating the need to instigate a One Health approach to address AMR [54]. For instance, ESBL-producing *E. coli* has been extensively isolated from humans, animals, and the environment, indicating its high resistance in the One Health ecosystem [70] [71] [75] [77] [99] [100]. Therefore, a holistic multidisciplinary One Health approach is required to combat AMR in Zambia [44] [54] [101].

The World Health Organization (WHO) identified AMR as a global health priority and developed a Global Action Plan (GAP) to address this threat to global health [102]. In response to the WHO recommendations, Zambia is committed to addressing this global issue through the development and implementation of a National Action Plan (NAP) on AMR [103] [104]. The NAP on AMR in Zambia is implemented by the Zambia National Public Health Institute (ZNPPI) through the Antimicrobial Resistance Coordinating Committee (AMRCC) [103] [105].

Many activities have been prioritized to effectively implement the NAP using a One Health approach [105]. However, there is still more that needs to be done to address the country's specific challenges and to ensure effective implementation of interventions and strategies to combat AMR.

Antimicrobial stewardship (AMS) programs are crucial in the fight against AMR as they focus on optimizing antimicrobial use [106]-[109]. Implementing an effective AMS program is a key strategy in addressing AMR [107] [110]-[112]. Research has shown that the introduction of AMR interventions leads to better antimicrobial prescribing practices, reduced antimicrobial use, and increased awareness and knowledge about AMR and AMS [113]-[121]. Therefore, all hospitals must establish and implement AMS programs to ensure the rational use of antimicrobials and prevent the development and spread of AMR [122]-[128]. However, there is a lack of published studies measuring the impact of AMS programs on reducing AMR [129] [130]. Another important approach to combating AMR is the promotion of surveillance programs, which are essential for monitoring the presence of pathogens and tracking AMR levels and trends [131] [132]. In Zambia, there is a need to enhance surveillance programs related to antimicrobial use (AMU) and AMR by adopting a One Health approach, taking into consideration the interconnectedness of humans, animals, plants, and the environment, as outlined in the Global Action Plan (GAP) and National Action Plan (NAP) on AMR [102] [103]. Many countries have developed and implemented NAPs on AMR to address AMR using a One Health approach [133]-[135]. Using a One Health approach promotes and strengthens collaboration between healthcare professionals, veterinarians, environmental scientists, and policymakers to develop effective strategies for preventing and controlling AMR [136] [137]. This would enable the effective detection of drug-resistant pathogens and support evidence-based decision-making in the fight against AMR.

Many strategies have been proposed to monitor antimicrobial use in the One Health sector including point prevalence surveys, WHO guidelines, monitoring of antimicrobial use in animals of human importance, prescription audits, and WHO Access, Watch, and Reserve (AWaRe) classification of antibiotics [138]-[147]. Monitoring antimicrobial use helps to come up with decisions to promote their rational use in the One Health sector [148]-[152]. There is a need to monitor antimicrobial consumption because a correlation exists between antimicrobial consumption and the occurrence and spread of AMR [153]-[162].

In the sub-Saharan African (SSA) region, approximately 255,000 human deaths were attributed to AMR in 2019 demonstrating the burden of this problem in the region [2] [12]. This also demonstrates that the problem of AMR affects Zambia too, a country located in the SSA region. Many strategies have been initiated and implemented by the Antimicrobial Resistance Coordinating Committee (AMRCC) of the Zambia National Public Health Institute (ZNPHI) and other partners to address AMR. The AMRCC addresses AMR through the implementation of the NAP on AMR [103] [104]. Therefore, this review paper aims to summarize the

current situation regarding AMR in Zambia, including the prevalence, risk factors, and proposed solutions to combat this public health problem.

2. Materials and Methods

This narrative review paper employed a comprehensive search of electronic databases to identify studies on AMR in Zambia. The following databases were searched: PubMed, Scopus, Web of Science, and Google Scholar. The search strategy included keywords such as “antimicrobial resistance”, “antimicrobial stewardship”, “One Health”, “factors”, “Zambia”, “bacteria”, “antibiotic resistance”, and “public health”. This study included studies that were published in English between January 2000 and November 2024. Further, the review included studies that were conducted in Zambia or involving Zambian populations. Furthermore, this review involved studies that focused on addressing antimicrobial resistance or antibiotic resistance across the One Health sector in Zambia. Alongside this, the review included original research articles, reviews, or meta-analyses. This narrative review paper excluded all the studies that did not meet the inclusion criteria, abstracts, and studies with incomplete or missing data. Relevant studies were selected based on the inclusion criteria and the data were extracted from each study using a standardized form. The data extracted included study characteristics (author, year, study design), population characteristics (sample size, demographics), and outcomes (prevalence of AMR, risk factors). The authors cross-checked all the included publications to ensure they met the inclusion criteria. A narrative synthesis of the data was conducted to summarize the findings. For instance, studies were grouped by theme (prevalence, risk factors, challenges, solutions and recommendations). The studies were reported based on their year of publication. Additionally, the findings were presented in a logical and coherent order to address the research questions.

3. Results

3.1. Prevalence and Burden of AMR in Zambia

This study found a high prevalence of AMR in Zambia across various bacterial isolates isolated from humans, food-producing animals, and the environment.

This review found that approximately 1.27 million deaths were attributed to bacterial AMR globally of which 255,000 were from the sub-Saharan African region where Zambia belongs. Based on the Mapping Antimicrobial Resistance and Antimicrobial Use Partnership (MAAP) Country Report for Zambia, the drug resistance index (DRI) was found to be 60.9% implying low antibiotic effectiveness. The prevalence of AMR in Zambia is as high as 70% to 80% across various bacterial isolates. The highest prevalence of ESBL-producing *E.coli* was 100% in children who had diarrhoea. In poultry, the prevalence of ESBL-producing *E.coli* was 20.1% and higher. The review further found that drug-resistant TB, HIV, plasmodium, and fungi were prevalent in Zambia. Furthermore, there are gaps in

awareness, knowledge, attitudes, and practices of healthcare workers, students, and community members regarding AMU, AMR, and AMS (Table 1).

Table 1. Prevalence and gaps identified regarding AMU, AMR, and AMS across the One Health Sector including humans, animals, agriculture, and the environment in Zambia.

Authors, year	Findings
MAAP Report for Zambia 2022 [58]	<ul style="list-style-type: none"> The Mapping Antimicrobial Resistance and Antimicrobial Use Partnership (MAAP) Country Reports for Zambia found a drug resistance index (DRI) of 60.9% implying low antibiotic effectiveness. High AMR rates were reported for penicillins, tetracyclines, folate pathway inhibitors, quinolones, and cephalosporins due to their high consumption and use.
Zambia National Public Health Institute (ZNPHI) 2022 [12]; Murray <i>et al.</i> , 2019 [2]	<ul style="list-style-type: none"> In 2019, it was estimated that approximately 1.27 million deaths were attributed to bacterial AMR of which 255,000 were from the sub-Saharan African region where Zambia belongs. A further 4.95 million deaths were associated with antimicrobial-resistant infections.
Chizimu <i>et al.</i> , 2024 [111]	<ul style="list-style-type: none"> An exploratory cross-sectional study was conducted from September to December 2023 using the WHO Periodic National and Healthcare Facility Assessment Tool to evaluate AMS activities in eight public hospitals across five Zambian provinces. Overall AMS score across core elements was 56%. Additionally, 62.5% (6/8) of the hospitals scored below 60% in AMS program implementation. Main challenges identified included reporting AMS feedback (average score: 46%), Functionality of Drugs and Therapeutics Committees (DTCs) (average score: 49%), AMS actions (average score: 50%), Education and training (average score: 54%), Leadership commitment to AMS (average score: 56%), none of the hospitals had a dedicated budget for AMS programs, and more than 50% of the hospitals lacked antibiograms and AMS-trained staff. AMS implementation in these hospitals was low, especially in facilities where DTCs were non-functional. Urgent actions are needed to address these challenges and establish sustainable multidisciplinary AMS programs.
Chizimu <i>et al.</i> , 2024 [163]	<ul style="list-style-type: none"> A cross-sectional study in December 2023 used the WHO Point Prevalence Survey (PPS) and AWaRe classification to assess antibiotic use among 1296 inpatients across 16 Zambian hospitals. Findings revealed a 70% overall antibiotic prevalence, with 52% receiving Watch group antibiotics—mainly ceftriaxone—and 48% receiving Access group antibiotics. Compliance with local guidelines was 53%, highlighting a high use of Watch antibiotics beyond recommended levels. This underscores the need for stronger antimicrobial stewardship programs to encourage rational antibiotic use in Zambian hospitals.
Mudenda <i>et al.</i> , 2024 [130]	<ul style="list-style-type: none"> A cross-sectional study conducted from October to December 2023 surveyed 64 healthcare workers (HCWs) using a semi-structured questionnaire. Of the participants, 59.4% were female, 60.9% were aged 25 - 34 years, with 37.5% being nurses, 18.7% pharmacists, 17.2% medical doctors, and one microbiologist. The study found that 75% of HCWs had good knowledge, 84% were highly aware, and 84% demonstrated good practices concerning AMU, AMR, and AMS. Additionally, 90.6% reported having a multidisciplinary AMS team at their hospitals and implementing the WHO AWaRe classification of antibiotics. Overall, the study highlighted good knowledge, high awareness, and strong practices related to AMU, AMR, and AMS among HCWs in Zambia involved in AMS activities.
Mufwambi <i>et al.</i> , 2024 [164]	<ul style="list-style-type: none"> In a 2022 cross-sectional study of 194 community pharmacists in Lusaka, 86% demonstrated good knowledge of antimicrobial stewardship (AMS), with 83.5% aware of AMS strategies and goals, and 89.2% recognizing its importance in their practice. About 66.7% practiced AMS strategies well, and 61.3% regularly avoided unnecessary broad-spectrum antimicrobials.

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- The study suggests a need for ongoing AMS training to improve practices further.
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- This study found a high prevalence of antibiotic resistant *E. coli* and Enterococcus species isolated from pregnant women and children under five years in Zambia.
 - Most prescribed antibiotics at the primary healthcare facilities belonged to the Access group of the WHO Access, Watch and Reserve (AWaRe) classification.
 - All the primary healthcare facilities adhered to the WHO AWaRe framework of $\geq 60\%$ prescribed antibiotics belonging to the Access group.
 - However, resistance was highest in the Access group of antibiotics. *E. coli* resistance to ampicillin ranged from 71% to 77% and to co-trimoxazole from 74% to 80%, while enterococcal resistance to tetracycline was 59% - 64%.
 - MDR was highest in *E. coli* (75%) isolates, while XDR was highest in enterococcal isolates (97%). The identified AMR genes in *E. coli* included blaCTX-M, sul2 and qnrA, while those of enterococci included erm(B), erm(C) and erm(A).
 - The study concluded that resistance was highest in the prescribed WHO Access group of antibiotics.
 - Therefore, these findings highlight the need to use local susceptibility data to formulate country-specific treatment guidelines in line with WHO AWaRe classification and enforce regulations that prohibit easy access to antibiotics.
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- Yamba *et al.*, 2024 [35]
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- Of the 335 participants in a multicenter cross-sectional study, 56.7% had good knowledge about antibiotics, but 77.3% exhibited low adherence to prescribed usage.
 - Additionally, 54.6% believed that antibiotics were effective against viral infections, while 43.9% accurately understood the concept of AMR.
 - Formal employment was significantly associated with better knowledge of antibiotics. Meanwhile, being divorced and possessing good knowledge were linked to higher adherence rates.
 - In terms of antibiotic use, 50.0% of respondents had used antibiotics in the past year, and 58.2% had taken them for a common cold. Furthermore, 74% reported purchasing antibiotics without a prescription.
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- Kampamba *et al.*, 2024 [165]
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- Out of 241 patient records reviewed, 77% were female. Among these patients, 44% were newly diagnosed with TB, 29% experienced a relapse, 10% were treated after treatment failure, and 8.3% were treated after loss to follow-up.
 - The study revealed that 65% of *M. tuberculosis* isolates were susceptible to both rifampicin and isoniazid, while 35% were resistant to either rifampicin or isoniazid, and 21.2% were MDR.
 - Treatment after failure and treatment after loss to follow-up were significantly associated with MDR-TB.
 - Unknown HIV status was significantly linked to isoniazid mono-resistance.
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- Kangongwe *et al.*, 2024 [94]
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- The study aimed to evaluate the quality of antiretroviral, antimalarial, and antituberculosis medicines provided in Zambia's public health sector.
 - A total of 198 samples were analyzed: 86 (43.43%) were antiretrovirals, 54 (27.27%) antimalarials, and 58 (29.29%) antituberculosis medicines.
 - The majority of the samples (86.36%) originated from Asia, followed by Africa (9.60%) and Europe (4.04%).
 - All the sampled medicines met their respective quality standards, including tests for appearance, identification, assay, uniformity of mass, weight variation, disintegration, dissolution, pH, and specific gravity, resulting in a 100% compliance rate.
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- Jere *et al.*, 2024 [166]
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- A cross-sectional study conducted from May to August 2020 surveyed 369 Mtendere residents using a structured questionnaire.
 - Of the participants, 50.9% were male, and 62.1% were aged between 18 and 29 years. The study revealed poor knowledge, attitudes, and practices (KAP) regarding AMU and AMR, with only 38% demonstrating good knowledge, 58% having positive attitudes, and 52% showing good practices.
 - While 66.7% had heard of antibiotics, only 33.6% were aware of AMR, and 23% knew about antimicrobial-resistant infections.
 - Additionally, 48.2% were unaware that AMR is a public health issue. The prevalence of self-medication with antibiotics was 47.2%.
 - The study concluded that Mtendere residents had poor KAP towards AMU and AMR.
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- Mudenda *et al.*, 2024 [66]
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- This retrospective cross-sectional study reviewed records of patients with confirmed drug-resistant
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- Chanda 2024 [92]
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- tuberculosis (DR-TB) who were treated at the MDR-TB Ward of Kabwe Central Hospital between 2017 and 2021.
- A total of 183 patients were managed during this period, and all were included in the study. The study found that the prevalence of DR-TB among registered TB patients in Central Province was 1.4%. The majority of affected individuals were adults aged 26 to 45 years (63.9%).
 - Most cases were from Kabwe District (60.7%), with significant numbers also reported from Kapiri Mposhi (10.4%), Chibombo (6.6%), Chisamba (5.5%), Mumbwa (3.8%), and Mkushi (3.8%).
 - The analysis revealed that 89.6% of patients had rifampicin-resistant TB (RR-TB), 9.3% had MDR-TB, 0.5% had isoniazid-resistant TB (IR-TB), and 0.5% had XDR-TB. RR-TB was found in 93.8% of new cases and 88.9% of relapse cases, while MDR-TB was present in 6.2% of new cases and 10% of relapse cases.
 - Regarding treatment outcomes, 16.9% of patients were declared cured, 45.9% completed treatment, 6% were lost to follow-up, and 21.3% died.
 - Risk factors for mortality identified through multivariate analysis included age 36 - 45 years and male gender.
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- Yamba *et al.*, 2024 [35]
- This cross-sectional study, conducted between August and December 2023, evaluated the AMR testing capacity of eight hospitals in Zambia using the Laboratory Assessment of Antibiotic Resistance Testing Capacity (LAARC) tool.
 - None of the hospitals had full AMR surveillance capacity, with performance ranging from moderate (63%) to low (38%).
 - Major barriers included the lack of an electronic laboratory information system (63%) and the absence of locally generated antibiograms (75%).
 - The lowest performing areas were quality control for antimicrobial susceptibility testing (14%), pathogen identification (20%), and media preparation (44%).
 - The strongest areas were specimen processing (79%), data management (78%), specimen collection and transport (71%), and safety (70%).
 - While most hospitals had general operating procedures, they lacked specimen-specific protocols.
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- Shempela *et al.*, 2024 [36]
- This multi-facility cross-sectional study, conducted from February to April 2024, assessed the antibiotic resistance testing capacity of laboratories in Zambia using the LAARC tool.
 - The results revealed an overall low capacity for AMR surveillance, with an average score of 39%. The highest laboratory score was 47%, and the lowest was 25%.
 - Only one hospital had full capacity (100%) to utilize a laboratory information system (LIS), while three hospitals demonstrated satisfactory data management capabilities with scores of 83%, 85%, and 95%.
 - Additionally, only one hospital had full capacity for specimen processing, and one met the safety standards for a microbiology laboratory (89%).
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- Ngoma *et al.*, 2024 [167]
- This cross-sectional study, conducted between December 2022 and January 2023, involved 2038 participants, of whom 53.4% were female and 51.5% had at least a secondary education.
 - Antibiotic use was found to be extremely high at 99.2%, but only 40.9% of this use was appropriate. Hospitals were the source of 79.1% of antibiotics, while 20.9% were taken from leftover supplies or obtained without prescriptions.
 - Factors associated with appropriate antibiotic use included being female, aged 35 and above, having a secondary or tertiary education, a monthly expenditure of at least \$195 USD, understanding that antibiotics are not painkillers, and confidence in hospital care effectiveness.
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- Mudenda *et al.*, 2024 [168]
- This cross-sectional study, conducted from August to October 2023 at St. Francis' Mission Hospital in Zambia, reviewed 800 medical records, revealing a total of 2003 prescribed medicines.
 - On average, each patient received 2.5 medications per prescription. Antibiotics were prescribed in 72.3% of cases, with 28.4% being injectable forms.
 - The most frequently prescribed antibiotics were amoxicillin (23.4%—Access), metronidazole (17.1%—Access), ciprofloxacin (8%—Watch), and ceftriaxone (7.4%—Watch), with 77.1% of all antibiotics coming from the Access list.
 - Additionally, 96.5% of medicines were prescribed by generic names, and 98% were sourced from the Zambia Essential Medicines List. The study highlights a high rate of antibiotic prescribing, including injectables, which requires attention.
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- Mukomena *et al.*, 2024 [169]
- A year-long cross-sectional study was conducted at two major tertiary hospitals in Zambia to screen patients with current or past hospital contact for nosocomial infections (Nis), specifically focusing on *Pseudomonas aeruginosa*.
 - A total of 841 patients were screened, and 116 (13.7%) were diagnosed with *P. aeruginosa* Nis. The patients' ages ranged from 15 to 98 years, with a mean age of 51.
 - The most common infections were catheter-associated urinary tract infections (57%), followed by pressure sores (38.7%).
 - *P. aeruginosa* showed the highest susceptibility to amikacin, but there was a high prevalence of MDR (73.6%), particularly linked to the presence of the carbapenem-hydrolyzing β -lactamase gene *blaOXA-51* and surgical care.
 - The study highlighted a significant prevalence of MDR *P. aeruginosa* in hospitals in Lusaka and Ndola, Zambia, indicating the need for enhanced infection control and AMS.
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- Kasanga *et al.*, 2024 [70]
- This cross-sectional study, conducted between February 2023 and June 2023, analyzed 450 samples using the VITEK® 2 Compact system for *E. coli* identification and antimicrobial susceptibility testing.
 - Among the 450 samples, 66.7% (n = 300) were clinical, and 33.3% (n = 150) were environmental. Overall, 47.8% (n = 215) tested positive for *E. coli*, with 37.8% of positive results from clinical samples and 10% from environmental samples.
 - Of the 215 *E. coli* isolates, 66.5% were identified as MDR, and 42.8% ESBL producers. The isolates showed high resistance to ampicillin (81.4%), sulfamethoxazole/trimethoprim (70.7%), ciprofloxacin (67.9%), levofloxacin (64.6%), ceftriaxone (62.3%), and cefuroxime (62%).
 - However, *E. coli* isolates were highly susceptible to amikacin (100%), imipenem (99.5%), nitrofurantoin (89.3%), ceftolozane/tazobactam (82%), and gentamicin (72.1%).
 - This study reveals a significant resistance of *E. coli* to several commonly used antibiotics in humans.
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- Siame *et al.*, 2024 [100]
- A cross-sectional study was conducted at a tertiary hospital in Lusaka, Zambia, to assess preoperative (preop) and postoperative (postop) carriage and antimicrobial susceptibility patterns of rectal ESBL-producing *E. coli* (ESBL-Ec) in elective surgery patients.
 - 120 participants were recruited, with 75 followed up at least 72 hours after surgery.
 - Of 195 rectal swabs, 177 (90.8%) were positive for *E. coli*; 53 (29.9%) were ESBL-Ec, with a significantly higher proportion in postop (47.9%) compared to preop (17.3%) participants.
 - Postop ESBL-Ec isolates showed higher resistance compared to preop for cefotaxime: 100% vs 88.9%, ampicillin: 100% vs 94.4%, ciprofloxacin: 88.3% vs 83.3%, amoxicillin/clavulanic acid: 80% vs 66.7%, and cefepime: 80% vs 77.8%.
 - MDR ESBL-Ec strains were more frequent in postop (91.4%) than preop (88.9%).
 - The study revealed a significantly higher rate of antimicrobial-resistant rectal *E. coli* in postop participants compared to preop.
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- Kasanga *et al.*, 2024 [78]
- A cross-sectional study of 58 ESBL-producing *E. coli* strains from hospital inpatients, outpatients, and non-hospital environments.
 - Genotypic analyses were performed using the Illumina NextSeq 2000 sequencing platform.
 - Phylogroup B2 was the most common among the isolates. Resistant MLST sequence types identified included ST131, ST167, ST156, and ST69.
 - ESBL genes detected: *blaTEM-1B*, *blaCTX-M*, *blaOXA-1*, *blaNDM-5*, *blaCMY*
 - ST131 and ST410 were the most common strains.
 - ST131 had a high prevalence of *blaCTX-M-15* and resistance to fluoroquinolones.
 - Both clinical and environmental isolates carried *blaNDM-5* (3.4%), with clinical isolates showing a higher risk of carbapenemase resistance genes.
 - *BlaCTX-M* and *blaTEM* variants, especially *blaCTX-M-15*, were frequent in ST131.
 - The study highlights the public health risks posed by *blaCTX-M-15* and *blaNDM-5*-carrying *E. coli* strains.
 - Strengthening AMS programs and continuous surveillance of AMR in clinical and environmental settings are essential to control the spread of resistant pathogens.
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- Chibuye *et al.*, 2023 [170]
- In a study conducted between 2020 and 2021, 86 *Shigella* isolates from children under five, both outpatients and hospitalized, were collected in Lusaka and Ndola as part of a surveillance effort. The majority of the isolates showed high resistance to trimethoprim/sulfamethoxazole (79.1%), ampicillin (56.9%),
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- amoxicillin-clavulanate (49.4%), cefuroxime (55.8%), and gentamicin (49.4%).
 - Only two isolates were resistant to ciprofloxacin. Overall, 83.7% (72/86) of the isolates were resistant to at least one class of antibiotics, with 59.3% resistant to cephalosporins, 79.1% to sulfonamides, 57% to penicillins, 48.8% to aminoglycosides, and 25.6% to beta-lactams.
 - MDR was found in 62.8% (54/86) of the isolates. In-patient isolates exhibited higher MDR rates (71.4%) compared to outpatient isolates (61.1%).
 - MDR was particularly prevalent among *Shigella sonnei* (25/29) and *Shigella flexneri* (24/33) isolates.
 - The high levels of AMR, especially MDR, in *Shigella* isolates from young children present a significant challenge for effective treatment and management of *Shigella* infections in Zambia.
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- This study was conducted to isolate pathogens that cause blood stream infections and reported that 88 Gram-negative bacteria were isolated including 76% Enterobacterales, 14% *Acinetobacter baumannii* and 8% *P. aeruginosa*.
 - Resistance to third and fourth-generation cephalosporins was 75% and 32%, respectively. Further, the study found a high prevalence (68%) of inappropriate empirical treatment, carbapenem resistance (7%), MDR (83%) and ESBL-producers (76%).
- Yamba *et al.*, 2023 [171]
- In comparison to *E. coli* as a causative agent of BSI, the odds of death were significantly higher among patients infected with *Acinetobacter baumannii* (OR = 3.8).
 - The odds of death were also higher in patients that received third-generation cephalosporins as empiric treatment than in those that received fourth-generation cephalosporins or other (none cephalosporin) treatment options.
 - The study concluded that a structured surveillance, yearly antibiogram updates, improved infection prevention and control measures, and a well-functioning AMS program, are of utmost importance in improving appropriate antimicrobial treatment selection and favourable patient outcomes.
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- This study focused on characterizing 63 drug-resistant *M. tuberculosis* strains collected from the University Teaching Hospital between 2018 and 2019, using targeted gene sequencing.
 - Of these, 50 strains were conveniently selected for whole genome sequencing. The results showed that 60 strains had resistance mutations associated with MDR, one was poly-resistant, and two were rifampicin-resistant.
 - Among the MDR strains, 7% (4/60) exhibited mutations linked to pre-XDR-TB. Additionally, mutations associated with resistance to ethionamide, para-aminosalicylic acid, and streptomycin were found in four, one, and nine strains, respectively.
 - All 50 strains belonged to lineage 4, with the predominant sub-lineage being 4.3.4.2.1, which accounted for 38% of the strains.
 - Notably, three out of the four pre-XDR strains were part of this sub-lineage. When comparing the clustering of strains based on single nucleotide polymorphism differences, sub-lineage 4.3.4.2.1 was less clustered compared to sub-lineages L4.9.1 and L4.3.4.1.
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- Chizimu *et al.*, 2023 [93]
- This cross-sectional study, conducted from April 2022 to August 2022, analyzed 980 samples collected from both clinical and environmental settings.
 - Of the total samples, 51% were from environmental sources. Overall, 64.5% of the samples tested positive for *E. coli*, with 52.5% of these isolates originating from clinical sources.
 - Additionally, 31.8% of the *E. coli* isolates were identified as ESBL producers, with 70.1% of these being clinical isolates.
 - Among the 632 isolates, 48.3% were classified as MDR. Clinical isolates showed high resistance to ampicillin (83.4%), sulfamethoxazole/trimethoprim (73.8%), and ciprofloxacin (65.7%).
 - In contrast, all environmental isolates were resistant to sulfamethoxazole/trimethoprim (100%), and a portion also showed resistance to levofloxacin (30.6%). The study identified key factors driving MDR in the isolates, including pus samples, male sex, and water samples.
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- Kasanga *et al.*, 2023 [71]
- This facility-based cross-sectional study, conducted from July to December 2021 at the University Teaching Hospital (UTH) in Lusaka, investigated the presence and resistance patterns of *Acinetobacter* species in clinical and environmental samples.
 - A total of 60 *Acinetobacter* isolates were collected—40 (66.7%) from clinical specimens and 20 (33.3%) from environmental sources. The highest rate of clinical isolates (21.7%) came from the admission ward, while
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- Mwanamoonga *et al.*, 2023 [172]

the lowest (1.7%) were from the main ICU. Environmental samples from taps and sinks had the highest isolation rates (25% and 20%, respectively).

- *Acinetobacter baumannii* was the most prevalent species (43 isolates). Resistance patterns showed the highest resistance to tetracycline (98%) and co-trimoxazole (70%), with the lowest resistance to imipenem (17%), tobramycin (20%), and cefotaxime (22%).
- The AdeB gene, linked to drug resistance, was found in 82.5% of clinical isolates. Among the clinical isolates, 75% were MDR, and 52.5% of MDR isolates were XDR.
- These results emphasize the importance of ongoing AMR surveillance to inform treatment and improve infection control in healthcare settings.

Shivangi *et al.*,
2023 [173]

- A cross-sectional study was conducted by swabbing trolley and basket handles, and standard microbiological methods were used to identify bacteria. Of the 200 samples collected, 28% were culture-positive.
- The predominant isolates were *S. aureus* (17.3%), *Pseudomonas* species (4.5%), *E. coli* (2%), *Corynebacterium* species (2%), *Staphylococcus* species (1.5%), and *Enterobacter aerogenes* (0.5%). *S. aureus* exhibited the highest resistance to azithromycin (17%), followed by ciprofloxacin (2.8%), nitrofurantoin (2.8%), and chloramphenicol (2.8%).
- *E. coli* showed 100% resistance to amoxicillin, cloxacillin, and ampicillin, 75% resistance to ciprofloxacin, and 25% resistance to azithromycin, but was susceptible to nitrofurantoin.
- Other bacteria, including *Staphylococcus* species, *Corynebacterium* species, *Enterobacter aerogenes*, and *Pseudomonas* species, showed no resistance to any tested panel of antibiotics.

Monde *et al.*, 2023
[90]

- Overall, the prevalence of resistance to one or more anti-TB drugs was 23.5%. Among the patients, 9.8% had MDR-TB, with 1.2% being new cases and 25.5% having a history of previous TB treatment.
- Isoniazid (INH) resistance was the most common among mono-resistant TB strains, occurring in 9.8% of cases.
- Two cases of XDR-TB (6.5%, 2/31) and one case of pre-XDR-TB (3.2%, 1/31) were identified among the MDR-TB patients.
- Notably, patients with a history of previous TB treatment were 40 times more likely (OR: 40.3, 95% CI: 11.1% - 146.5%) to have drug-resistant TB compared to those with no prior treatment history.
- This study reveals a high rate of MDR-TB and has also identified cases of both pre-XDR and XDR-TB, highlighting the significant challenge of drug-resistant TB in this population.

Sikwewa *et al.*,
2023 [95]

- This cross-sectional, laboratory-based study included 101 participants with pus swab specimens collected from burn wounds and 50 environmental swabs from strategic locations.
- The median age of participants with burn wound fungal infections was 3 years, with a median burn surface area of 18% TBSA. The study group comprised 3 males and 6 females.
- Fungal organisms isolated included *Candida albicans* from 8 (7.9%) participants and 2 (4%) of the environmental swabs. Additionally, 1 (1%) *Candida* spp. was found in pus swabs.
- Among the 11 *Candida* isolates, 4 (36.4%) were susceptible to fluconazole, while 7 (63.6%) were resistant.
- The presence of *Candida albicans* and other *Candida* species in both burn wound patients and hospital environments indicates fungal contamination.

Mudenda *et al.*,
2023 [174]

- A cross-sectional study conducted among 412 pharmacy students from June to July 2023 used a structured questionnaire to assess their knowledge, attitudes, and practices regarding antifungal resistance (AFR) and antifungal stewardship (AFS).
- Of the participants, 55.8% were female, and 81.6% were aged between 18 and 25 years. While most students demonstrated good knowledge (85.9%) and positive attitudes (86.7%), 65.8% had suboptimal practices related to AFR and AFS.
- Notably, 30.2% of students accessed antifungals without a prescription. Male students were less likely to have good knowledge of AFR (AOR = 0.55), and urban residents were less likely to have a positive attitude (AOR = 0.35).
- Additionally, fourth-year students showed poorer practices compared to second-year students (AOR = 0.48).
- The study highlights gaps in practices among pharmacy students, despite their strong knowledge and attitudes, indicating a need for targeted interventions to improve practices related to AFR and AFS.

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- Nowbuth *et al.*, 2023 [175]
- A cross-sectional anonymous survey was conducted among students from six accredited medical schools in Zambia using a self-administered Qualtrics questionnaire.
 - A total of 180 student responses were analyzed. Fifty-six percent rated their education on antibiotic use as useful or very useful.
 - While 91% believed antibiotics are overused, and 88% recognized antibiotic resistance as a problem in Zambia, only 47% felt adequately trained on antibiotic prescribing, and 43% were confident in selecting the correct antibiotic for infections.
 - Worryingly, only 2% felt prepared to interpret antibiograms, and few students were trained in key prescribing practices, such as de-escalation to narrow-spectrum antibiotics (3%), transitioning from IV to oral antibiotics (6%), or understanding dosing and duration (12%). Additionally, 47% thought hand hygiene was unimportant.
 - The survey highlighted that while Zambian medical students possess good knowledge about antibiotics and resistance, they lack sufficient training and confidence in key antimicrobial prescribing practices.
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- Gannon *et al.*, 2023 [176]
- A study measured antibiotic usage in clinics at three intervals over 16 months (April 2021, March 2022, and August 2022) through chart reviews to assess compliance with national prescribing guidelines.
 - A total of 340 consultations were reviewed across the three audits (240, 50, and 50 consultations).
 - Overprescription of antibiotics decreased from a ratio of 3.59:1 (212 prescribed vs. 59 indicated) to 3:1 (33 prescribed vs. 11 indicated), and finally to 2.78:1 (25 prescribed vs. 9 indicated).
 - The correct choice of antibiotics fluctuated, with rates of 25.9% (14/59), 9% (1/11), and 33% (3/9) across the three audits.
 - Antibiotic overuse declined steadily after mentoring and educational interventions. However, incorrect antibiotic selection was primarily due to limited medication availability.
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- Bumbangi *et al.*, 2022 [73]
- This hospital-based cross-sectional study collected rectal swabs 565 and 455 diarrhoeic and healthy children, respectively, from which 1020 *E. coli* were cultured and subjected to antibiotic susceptibility testing.
 - The study found that 96.9% of *E. coli* isolates were resistant to at least one antimicrobial agent tested.
 - Further, 700 isolates were MDR, 136 were possibly XDR and nine were PDR.
 - Furthermore, 40% of the isolates were imipenem-resistant, mostly from healthy children.
 - This study revealed AMR was prevalent in children and emphasised the need for a community-specific-risk-based approach to implementing mitigating measures to curb the problem.
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- Samutela *et al.*, 2022 [82]
- This study examined the prevalence and characteristics, both phenotypic and genotypic, of *S. aureus* from pigs and workers at farms and abattoirs in Lusaka Province, Zambia.
 - A total of 492 nasal swabs from pigs, along with 53 hand and 53 nasal swabs from human workers, were collected across selected districts.
 - The overall prevalence of *S. aureus* was 33.1%, with 37.8% in pigs and 11.8% in humans.
 - The isolates exhibited resistance to several antibiotics, with resistance rates ranging from 18% to 98%, though all were susceptible to vancomycin.
 - Typical livestock-associated *S. aureus* (LA-SA) spa types were identified. The detection of plasmid-mediated resistance genes, such as tetM (12.8%), along with other resistance determinants and immune evasion cluster genes, raises significant public health concerns.
 - Continuous surveillance of *S. aureus* using a “One Health” approach is essential to monitor infections and the spread of AMR.
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- Sarenje *et al.*, 2022 [177]
- A prospective cross-sectional study was conducted from 2019 to 2020 on 630 patients with sexually transmitted infections (STIs) presenting with urethral or vaginal discharge.
 - Of the 630 participants, 46% were male, with a median age of 29 years (IQR: 19 - 39), while females had a median age of 26 years.
 - *N. gonorrhoeae* was isolated from 19.4% of patients (122/630), with males accounting for 72.9% of infections.
 - High resistance was observed to penicillin (85.2%), tetracycline (68.9%), and ciprofloxacin (59.8%), while reduced susceptibility was noted to cefixime (1.6%), spectinomycin (4.9%), and azithromycin (4.9%).
 - No resistance was found to ceftriaxone.
 - Risk factors for AMR included female gender, HIV-positivity, douching, unprotected sex, sex trading, and over-the-counter ciprofloxacin use.
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- High resistance to penicillin, tetracycline, and ciprofloxacin suggests a need for updated treatment guidelines.
 - However, ceftriaxone remains fully effective against *N. gonorrhoeae*.
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- Sarenje *et al.*, 2022 [96]
- A prospective cross-sectional study was conducted from 2019 to 2020 involving 630 patients with urethral or vaginal discharge due to STIs.
 - A study of 630 patients with a median age of 29 years (IQR 19 - 39) found that 46% (290/630) were male. Among females, the median age was 26 years.
 - *N. gonorrhoeae* was isolated in 19.4% (122/630) of patients, with 72.9% of these cases (89/122) being male, predominantly in the 25 - 34 age group.
 - High resistance was observed to penicillin (85.2%), tetracycline (68.9%), and ciprofloxacin (59.8%), while reduced susceptibility was noted for cefixime (1.6%), spectinomycin (4.9%), and azithromycin (4.9%).
 - All isolates were susceptible to ceftriaxone. Risk factors for AMR included douching in females (AOR 6.69), female gender (AOR 7.64), HIV positivity (AOR 26.59), unprotected sex (AOR 5.48), sex trading (AOR 4.19), and over-the-counter ciprofloxacin use (AOR 3.44).
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- Mwansa *et al.*, 2022 [51]
- Out of 765 specimens processed, only 500 (65.4%) met the inclusion criteria. Among these, 291 (58.2%) were from female patients, with the majority belonging to the 17 - 39 years age group (253, 50.6%) and the 40 - 80 years group (145, 29%).
 - The specimens were primarily blood (331, 66.2%), urine (165, 33%), and sputum (4, 0.8%).
 - The most frequently identified bacterial isolate was *S. aureus* (142, 28.4%), followed by *E. coli* (91, 18.2%), *Enterobacter agglomerans* (76, 15.2%), and *K. pneumoniae* (43, 8.6%).
 - The AMR pattern revealed high resistance rates to ampicillin (93%), oxacillin (88%), penicillin (85.6%), co-trimoxazole (81.5%), erythromycin (71.9%), nalidixic acid (68%), and ceftazidime (60%).
 - In contrast, the most effective antibiotics were imipenem (14.5% resistance) and piperacillin/tazobactam (16.7% resistance). Screening for MRSA using ceftoxitin showed a 23.7% (9/38) resistance rate.
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- Mudenda *et al.*, 2022 [178]
- This cross-sectional study surveyed 172 randomly selected participants using a structured questionnaire. Of the total participants, 55.2% (n = 95) were male, and the majority (64%) were aged between 21 and 25 years (n = 110).
 - Most pharmacy students demonstrated good knowledge (90% average score, n = 155) and a positive attitude (84% average score, n = 145) regarding AMU and AMR, but their practices were suboptimal (64% average score, n = 110).
 - Despite high knowledge and attitude scores, self-medication with antibiotics was prevalent in 41% (n = 70) of participants.
 - The suboptimal practice score raises concerns, highlighting the need for urgent improvements in the undergraduate pharmacy curriculum, particularly regarding AMU, AMR, and AMS programs.
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- Mudenda *et al.*, 2022 [179]
- A cross-sectional study conducted between February and April 2022 assessed the knowledge, attitudes, and practices of 178 community pharmacy professionals regarding poultry antibiotic dispensing, usage, and bacterial AMR in Lusaka, Zambia.
 - The most commonly dispensed antibiotic was oxytetracycline, a Watch antibiotic, often given without prescriptions.
 - Good knowledge of antibiotic use (ABU) and AMR was significantly associated with more than one year of work experience (p = 0.016), while good practices were linked to being male (p = 0.039) and having over one year of experience (p = 0.011).
 - The study found moderate levels of knowledge and practices, along with positive attitudes among pharmacy professionals regarding poultry ABU and AMR.
 - However, the high rate of dispensing antibiotics without prescriptions highlights the need for stricter antimicrobial stewardship and surveillance programs in poultry production to combat AMR in Zambia.
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- Chabalenge *et al.*, 2022 [180]
- This study conducted a descriptive cross-sectional review of product recalls issued by the Zambia Medicines Regulatory Authority (ZAMRA) from January 2018 to December 2021.
 - A search was performed for all medical product alerts and recalls by reviewing the internal post-marketing surveillance database at ZAMRA headquarters.
 - During the review period, 119 alerts were issued, with 83 (69.7%) being product recalls. Oral solid dosage forms accounted for the majority (53%) of recalls.
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- The number of recalls saw an increase in 2020 (44.6%) and 2021 (22.9%), largely due to a rise in substandard antiseptics and disinfectants during the COVID-19 pandemic.
 - Manufacturing and laboratory control issues were responsible for nearly half (47.4%) of the recalls. Most recalled products originated from India (38.6%), followed by Zambia (25.3%).
 - Only one suspected falsified product was recalled between 2018 and 2021. Out of the 83 recalls, 66 were initiated by ZAMRA, while 17 were voluntary recalls by foreign Marketing Authorization Holders (MAHs).
 - Notably, no product recalls were initiated by local representatives of foreign manufacturers or MAHs.
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- This study aimed to explore the genetic diversity and transmission patterns of MDR M. tuberculosis strains in Lusaka, Zambia.
 - Eighty-five MDR MTB samples collected between 2013 and 2017 from the University Teaching Hospital were analyzed.
 - Techniques used included drug-resistance gene sequencing, spoligotyping, 24-loci mycobacterial interspersed repetitive units-variable number of tandem repeats (MIRU-VNTR), and multiplex PCR for RD-Rio sub-lineage identification.
- Chizimu *et al.*, 2022 [86]
- The study identified the following clades: LAM (48%), CAS (29%), T (14%), X (6%), and Harlem (2%). The dominant clonal complexes were SIT21/CAS1-Kili and SIT20/LAM1.
 - Combining spoligotyping with 24-loci MIRU-VNTR identified 47 distinct genotypic patterns, with a clustering rate of 63%. Additionally, 95% of LAM strains belonged to the RD-Rio sub-lineage.
 - The high clustering rate indicates that recent transmission rather than independent MDR acquisition is a major factor in the spread of MDR-TB.
 - This spread is primarily due to the clonal expansion of SIT21/CAS1-Kili and SIT20/LAM1 strains.
 - Genotyping combined with conventional epidemiological methods could enhance TB control programs by providing insights to curb MDR-TB transmission effectively.
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- A descriptive cross-sectional study involving 263 participants was conducted using a structured questionnaire.
 - Of the 263 participants, 225 (85.6%) were nurses and 38 (14.4%) were pharmacy personnel.
 - Pharmacy personnel had significantly better knowledge of the transmission of resistant bacteria ($P = 0.001$) and the role of antibiotics in livestock in contributing to AMR ($P = 0.01$) compared to nurses.
 - They also exhibited more positive attitudes towards AMR as a public health issue ($P = 0.001$) and the impact of antibiotics in livestock ($P = 0.001$).
 - Additionally, a higher proportion of pharmacy personnel participated in awareness campaigns ($P = 0.029$), continued professional development ($P = 0.001$), and courses on antibiotics and AMR ($P = 0.028$).
 - Overall, pharmacy personnel demonstrated superior knowledge and attitudes regarding AMR and were more engaged in related professional activities compared to nurses.
- Tembo *et al.*, 2022 [181]
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- This retrospective cross-sectional study analyzed 388 patient medical files from five primary healthcare hospitals in Zambia (Chawama, Matero, Chilenje, Kanyama, and Chipata) between September and November 2021.
 - Of the patients, 52.3% were male. Antibiotic use was significantly high at 82.5%, far surpassing the WHO's recommended threshold of 30%.
 - The most prescribed antibiotic was ceftriaxone (20.3%), a Watch group antibiotic, followed by metronidazole (17.8%) and sulfamethoxazole/trimethoprim (16.3%), both from the Access group.
 - Alarming, 41.9% of prescriptions did not follow standard treatment guidelines, highlighting excessive antibiotic use and poor guideline adherence in these healthcare facilities.
- Mudenda *et al.*, 2022 [64]
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- A 2020 retrospective study at two Lusaka hospitals reviewed 838 women who delivered via C-section, with 55% aged 21 - 25, 56.3% from low-cost areas, and 57% undergoing emergency procedures.
 - The prevalence of surgical site infections (SSIs) was 6%, with key predictors including education level, type of C-section, post-C-section oral antibiotics, and IV antibiotic duration.
 - Nearly all women (99.8%) received antibiotics, primarily a benzylpenicillin, gentamicin, and metronidazole combination, followed by ceftriaxone.
 - This highlights the common use of triple therapy and third-generation cephalosporins in managing infection risks post-C-section.
- Kasanga *et al.*, 2022 [182]
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- This cross-sectional study focused on *S. aureus* and *Enterococcus* species isolated from skin, soft tissue, and
- Mutalange *et al.*,
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- 2021 [183] bloodstream infections.
- Out of 59 *S. aureus* isolates, 37 were from skin and soft tissue infections, while 22 were from blood cultures.
 - Among these, 26 isolates (44.1%) were identified as Methicillin-resistant *S. aureus* (MRSA).
 - Additionally, 39 *Enterococcus* isolates were obtained from blood cultures. Vancomycin resistance was not detected in any of the *S. aureus* or *Enterococcus* isolates tested.
 - However, 12.5% of *S. aureus* and 14.3% of *Enterococcus* showed intermediate susceptibility to vancomycin. *S. aureus* exhibited high resistance to penicillin (93.2%), erythromycin (52.5%), and tetracycline (50.8%).
 - *Enterococcus* showed resistance to penicillin (83%) and tetracycline (84.6%).
 - The absence of vancomycin resistance among *S. aureus* and *Enterococcus* isolates indicates that vancomycin remains an effective treatment option for invasive infections caused by these organisms.
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- Yeta *et al.*, 2021 [184]
- In this study (n = 203), the prevalence of urinary tract infections (UTIs) was found to be 60% (95% CI: 53.3% - 66.7%). The most commonly isolated bacteria were *E. coli* (59%) and *Klebsiella* species (21%).
 - AMR was detected in 53% of the cases. The highest resistance rates were against nalidixic acid (88.3%), ampicillin (77.8%), and norfloxacin (58.5%), while chloramphenicol exhibited the lowest resistance rate (20%).
 - No significant predictors of AMR were identified among the pregnant women in this study.
 - The findings highlight a high burden of AMR, which is closely linked to the elevated prevalence of UTIs in this population.
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- Monde *et al.*, 2021 [91]
- Out of 232 samples with available drug susceptibility testing (DST) results, 211 (90.9%) were identified as drug-resistant TB, while 21 (9%) were drug-susceptible.
 - Among these, 53% (124/232) were cases of MDR-TB, and 32.3% (75/232) were confirmed as having rifampicin mono-resistance. Only 1.7% (4/232) of the MDR-TB patients were classified as pre-extensively drug-resistant tuberculosis (pre-XDR TB).
 - The Copperbelt province had the highest proportion of MDR-TB cases at 56%, followed by Luapula at 48% and North-Western at 30%.
 - The proportion of MDR-TB was 41.7% (88/211) in previously treated patients and 12.7% (27/211) in new patients.
 - There has been a slight increase in the incidence of MDR-TB over the four years under review, with the highest rates observed in the Copperbelt Province.
 - We recommend strengthening routine laboratory surveillance and enhancing the management of MDR-TB cases in the region to address this growing challenge.
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- Kasanga *et al.*, 2021 [52]
- This study determined the AMR patterns of bacterial pathogens from urine, blood and wound infections and their distribution by age, sex and location, and found MDR in almost all bacterial pathogens in blood urine and wound swabs.
 - In urine and females odds ratio (OR) = 0.864, p = 0.023, OR = 0.909, p = 0.013 urine and neonates were susceptible to antibiotics OR = 0.859, p = 0.003, OR = 0.741, p < 0.001.
 - Ampicillin resistance was above 90% for *E. coli* isolates in blood, urine and wound swabs.
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- Mufwambi *et al.*, 2021 [185]
- A cross-sectional study of 304 healthcare professionals at tertiary hospitals in Lusaka, Zambia, found that overall knowledge about AMR was 60.4%. Knowledge of pharmacogenetics (PGx) was lower, at 38%.
 - Structural Equation Modeling (SEM) showed that a higher AMR knowledge score was linked to a positive attitude toward combating AMR (p < 0.001).
 - Pharmacists had the highest AMR knowledge scores, while nurses scored lower. Only 31.5% of respondents believed that poor access to local antibiogram data contributed to AMR, while 56.5% felt that poor adherence to prescribed antimicrobials was a major factor.
 - Pharmacists also had the most positive attitudes toward AMR, while nurses had the least. The study concluded that suboptimal knowledge of AMR and PGx among healthcare professionals in Zambia could hinder the adoption of precision medicine approaches to combat AMR.
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- Mudenda *et al.*, 2021 [186]
- This descriptive cross-sectional study surveyed 144 randomly selected community pharmacists, achieving a 91% response rate.
 - The study found that 93.8% of pharmacists had good knowledge of AMR and AMS, and 67% held positive attitudes. However, 75% exhibited poor practices related to AMR and AMS.
 - While 69.4% acknowledged AMR as a public health issue and 57.6% agreed that proper antibiotic use
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- improves patient care, 32.6% rarely collaborated with other healthcare professionals on infection control.
- Furthermore, over 80% regularly dispensed antibiotics without prescriptions, and few participated in public education campaigns on antibiotic use.
 - Despite good knowledge and attitudes, the poor practices observed highlight the need for urgent educational interventions and stronger government policies to promote AMS and curb non-prescription antibiotic dispensing.
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- Kaluba *et al.*, 2021 [187]
- This retrospective study analyzed samples from the University Teaching Hospital in Lusaka, Zambia, to assess carbapenem resistance and antimicrobial susceptibility in *Pseudomonas aeruginosa* and *Acinetobacter* species, collected between March 2018 and June 2019.
 - Among 384 samples, 84 *P. aeruginosa* and 11 *Acinetobacter* species were isolated. *P. aeruginosa* showed high susceptibility to imipenem (94%), piperacillin-tazobactam (95.2%), and amikacin (91%), but lower for ciprofloxacin (69%) and gentamicin (63.1%).
 - *Acinetobacter* had high susceptibility to amikacin (90.9%) and imipenem (82.9%), but very low susceptibility to gentamicin (9.1%) and cefotaxime (9.1%).
 - Carbapenem resistance was low, with 6% of *P. aeruginosa* and 18.2% of *Acinetobacter* isolates being resistant, and carbapenemase production confirmed in all resistant *P. aeruginosa* cases.
 - These results indicate that imipenem remains an effective treatment for invasive infections.
 - Enhanced AMR surveillance, AMS, and IPC measures are recommended to reduce hospital-acquired infections and improve patient outcomes.
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- Mtonga *et al.*, 2021 [188]
- The study aimed to isolate and analyze the AMR patterns of pathogenic *E. coli* from chickens in Chisamba and Lusaka districts.
 - A total of 417 samples were collected and processed microbiologically, with *E. coli* isolated from 333 samples (79.9%).
 - The majority of isolates came from cloacal swabs (313; 75.1%; 95% CI: 70.2% - 78.5%), followed by 18 isolates from litter in poultry houses (4.3%), and one each from eggs and environmental swabs (0.2%).
 - Of the 333 *E. coli* isolates, 62 (18.6%) were identified as pathogenic.
 - The bacteria showed 100% resistance to tetracycline and 92% resistance to cephalixin, while 77% were susceptible to gentamicin.
 - MDR was observed in 4.8% of pathogenic isolates, which were resistant to all six antibiotics tested, and 17.7% were resistant to five antibiotics.
 - The presence of antimicrobial-resistant pathogenic *E. coli* suggests prior exposure to these antibiotics.
 - This resistance poses a significant public health threat, as it complicates treatment options. There is an urgent need to enhance education on biosecurity and good hygiene practices to address this issue.
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- Shawa *et al.*, 2021 [189]
- A total of 58 AMR genes were identified, including four blaCTX-M alleles: blaCTX-M-14, blaCTX-M-15, blaCTX-M-27, and blaCTX-M-55.
 - Hierarchical clustering suggested clonal dissemination of the blaCTX-M genes among the isolates. Out of the 45 strains carrying blaCTX-M genes, seven had these genes integrated into their chromosomes.
 - In particular, one *E. cloacae* and three *E. coli* strains had chromosomal blaCTX-M-15 genes located within large insertions exceeding 10 kilobases.
 - These insertions, flanked by the ISEcp1 element, were highly similar to previously reported plasmids and carried multiple AMR genes corresponding to the observed AMR.
 - The study highlights the role of the ISEcp1 element in transferring AMR genes from plasmids to bacterial chromosomes, facilitating the stable integration and spread of MDR clones within Enterobacteriaceae.
 - This study emphasizes the need for monitoring such genetic changes, as they can lead to the persistent and widespread dissemination of antibiotic-resistant bacteria.
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- Sitali *et al.*, 2021 [190]
- Blood samples were collected during a cross-sectional household survey at the peak of malaria transmission, from April to May 2017.
 - Dried blood spots were transported to a laboratory for analysis. PCR followed by high-resolution melt (HRM) was used to detect mutations linked to sulfadoxine-pyrimethamine resistance in *Plasmodium falciparum* genes Pfdhfr and Pfdhps.
 - Mutations related to artemether-lumefantrine resistance in the Pfmdr1 gene were also analyzed using PCR and HRM. Additionally, nested PCR and amplicon sequencing were employed to assess mutations in the
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	PfK13 gene.
Kasanga <i>et al.</i> , 2020 [191]	<ul style="list-style-type: none"> • A retrospective cross-sectional among bacteria that causes bacteremia found that <i>K. pneumoniae</i> was the most commonly isolated bacteria. • This study further found that <i>K. pneumoniae</i>, <i>E. coli</i>, <i>Pantoea agglomerans</i>, and <i>Enterococcus</i> species have developed high resistance levels against ampicillin, cefotaxime, ciprofloxacin, gentamicin and trimethoprim/sulfamethoxazole but a very low resistance levels against imipenem and amikacin.
Mwape <i>et al.</i> , 2020 [192]	<ul style="list-style-type: none"> • <i>Vibrio cholerae</i> isolates from patients during the 2009 and 2010 outbreaks were found to be 100% resistant to nalidixic acid and cotrimoxazole, yet fully sensitive to ampicillin and azithromycin. • Notably, reduced sensitivity to tetracycline was observed in both years, with 67% of the 2009 isolates and 64% of the 2010 isolates showing intermediate resistance. • During the 2016 outbreak, 98% (51/52) of the isolates were resistant to nalidixic acid, but the majority were highly sensitive to cotrimoxazole (90%), tetracycline (98%), and azithromycin (98%). • However, reduced sensitivity to ciprofloxacin was noted in 6% (3/52) of the isolates, with 83% (43/52) showing intermediate resistance. • In profiling AMR patterns, it was evident that AMR was present in all outbreak isolates, though MDR was rare. • None of the isolates from 2009 (0/6) or 2010 (0/25) were MDR, while only one isolate from the 2016 outbreak (1.9%, 1/52) exhibited an MDR pattern, resistant to tetracycline, trimethoprim-sulfamethoxazole, ampicillin, and azithromycin.
Zulu <i>et al.</i> , 2020 [193]	<ul style="list-style-type: none"> • A cross-sectional study at the University of Zambia Ridgeway Campus surveyed 260 randomly selected undergraduate medical students using a structured questionnaire. • The results showed that 87.3% (227/260) had good knowledge of antibiotic use and resistance, 96.9% (252/260) had positive attitudes, and 75% (195/260) demonstrated good practices regarding AMR. • A significant relationship was found between the year of study and knowledge levels ($\chi^2 = 16.333$, $p = 0.003$) and practices ($\chi^2 = 10.926$, $p = 0.027$), but no significant link was observed between year of study and attitudes ($\chi^2 = 4.061$, $p = 0.398$).
Miti <i>et al.</i> , 2020 [98]	<ul style="list-style-type: none"> • Out of 273 participants receiving ART, 99 experienced viral load (VL) failure. Among these, 77 underwent successful HIV drug resistance (HIVDR) testing. Of the 77 tested, 75% (58 individuals) had at least one drug-resistant mutation, with 83% (48 of 58) needing a change in their medication regimen. • The prevalence of resistance mutations among these 58 patients was as follows: 81% to nucleoside reverse transcriptase inhibitors (NRTIs), 65.5% to non-nucleoside reverse transcriptase inhibitors (NNRTIs), and 1.7% to protease inhibitors (PIs). • The most common NRTI-associated mutation was M184V, found in 81% of cases, which confers resistance to lamivudine (3TC) and emtricitabine (FTC). • This was followed by K65R, present in 34.5% of cases, which affects resistance to tenofovir disoproxil fumarate (TDF) and tenofovir alafenamide fumarate (TAF). • Thymidine analogue mutations (TAMs), primarily associated with resistance to zidovudine (AZT), stavudine (d4T), and other NRTIs, were observed in 32.8% of patients. • Common TAMs included K70RTQNE (32.8%), K219QE (22.4%), D67N (17.2%), and T215IT (15.5%). • For NNRTIs, the most frequent mutation was K103N (65.5%), which impairs efficacy of efavirenz (EFV) and nevirapine (NVP). • Additionally, mutations such as V106A, Y188C, and Y181C, each present in 36.2% of cases, were noted, affecting resistance to etravirine.
Bennett <i>et al.</i> , 2020 [97]	<ul style="list-style-type: none"> • In this study, drug resistance mutations (DRMs) were detected in 45% (44/97) of the samples, with these samples showing resistance to at least two antiretrovirals. • The prevalence of non-nucleoside reverse transcriptase inhibitor resistance was significantly higher than that of other antiretroviral classes. • DRMs were detected disproportionately in infants (67%; 33/49) compared to mothers (23%; 11/48); however, the extent of resistance was similar when present. • The disparity in drug resistance profiles was further highlighted in pairwise comparisons of resistance profiles between mother-infant pairs.

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- Kalonga *et al.*, 2020 [194]
- This cross-sectional study, conducted from April to July 2019, reviewed 357 medical files of in-patients and outpatients aged 1 month to 18 years. The majority of files (64.4%) were for pediatric patients aged 1 month to 5 years.
 - The study found an overall antibiotic prescribing rate of 78.7%. Of the patients, 33.3% needed antibiotics and were receiving treatment, while 12.9% received antibiotics despite not needing them.
 - Respiratory system diseases were the most common (41.2%). Penicillins were the most frequently prescribed antibiotics (54.8%), followed by cephalosporins (31.3%).
 - Significant associations were found between age, white blood cell count, and the system of illness with antibiotic use.
 - The study highlighted a high frequency of antibiotic use among pediatric patients, exceeding the World Health Organization's prescribing indicators.
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- Chakolwa *et al.*, 2019 [81]
- The study aimed to evaluate the carriage rate, antimicrobial susceptibility, and spa typing of *S. aureus* among healthcare workers at a major tertiary hospital in Lusaka, Zambia.
 - Conducted between May and July 2017 at the University Teaching Hospital, this cross-sectional study involved collecting nasal and hand swabs from 140 healthcare workers, including nurses, doctors, and laboratory scientists.
 - The overall carriage rate of *S. aureus* among healthcare workers was 17.1%, with 13.6% being nasal carriers and 8.6% hand carriers.
 - Carriage rates were highest among doctors (17.9%), followed by nurses (17.5%) and laboratory scientists (11.1%).
 - MRSA was detected in 25.8% of the isolates, with these strains showing resistance to more than four antibiotics.
 - Spa typing revealed that 25.8% of the isolates were positive for the spa gene, with identified types including t015 (42.8%) and t069 (14.3%), while 42.8% of the spa types remained unknown.
 - The study's findings indicate a significant carriage rate of *S. aureus* and a notable presence of MRSA among healthcare workers, underscoring the importance of regular screening and decolonization efforts to mitigate the spread of this pathogen in healthcare environments.
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- Chanda *et al.*, 2019 [195]
- This study retrospectively analyzed 693 laboratory specimens from Ndola Teaching Hospital to assess the prevalence of bacterial pathogens and their antibiotic resistance patterns.
 - The majority of the specimens (65.9%) were from inpatient departments, and nearly half (49.1%) were from female patients.
 - The most common types of samples were urine (58.6%), followed by blood (12.7%) and wound swabs (8.5%).
 - The primary bacteria identified included coliforms (29.3%), *S. aureus* (15.4%), coagulase-negative staphylococci (CoNS, 13.4%), and *E. coli* (13%).
 - The analysis revealed significant AMR, with the highest rates observed for co-trimoxazole (91.7%), nalidixic acid (75.2%), norfloxacin (69.0%), ceftazidime (55.7%), nitrofurantoin (46.6%), chloramphenicol (43%), and ciprofloxacin (8.6%).
 - The study also found that patient location within the hospital and gender significantly influenced resistance patterns.
 - Coliforms showed varying resistance to nitrofurantoin based on patient location, while gender influenced resistance in *Enterobacter* and *Proteus* species to certain antibiotics.
 - The study highlights the need to consider patient-specific factors, such as location and gender, when selecting antibiotics for treatment, as these can significantly impact bacterial resistance.
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- Kalungia *et al.*, 2019 [129]
- This descriptive cross-sectional study surveyed 137 physicians and 61 pharmacists, revealing low knowledge of AMS, with only 51% of physicians and 39% of pharmacists demonstrating adequate understanding.
 - A small proportion—9% of physicians and 20% of pharmacists—showed sufficient knowledge of AMS principles.
 - Knowledge levels were significantly linked to years of practice, job position, and previous AMS training.
 - Most respondents (95%) recognized AMR as a current issue, but the majority (92% of physicians and 86% of pharmacists) had never received AMS training.
 - All participants emphasized the need for context-specific educational interventions to improve AMS
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- awareness in Zambia.
- Despite positive attitudes, there is a significant gap in AMS knowledge, highlighting the need for tailored educational efforts and capacity building.
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- Mudenda *et al.*, 2019 [196]
- This descriptive cross-sectional study, conducted between November 2018 and February 2019, surveyed 46 randomly selected hospital pharmacists.
 - Of the participants, 52% were male, and 48% were female. Most were aged 26 - 30 years, with ages ranging from 23 to 47 years (mean age: 32.11, SD: 6.533).
 - A majority (61%) were married, and 52% had worked for 1 - 5 years. The results revealed that the pharmacists had adequate knowledge, positive attitudes, and good practices regarding AMR.
 - Statistical tests showed no significant associations between knowledge and attitude ($p = 0.693$), knowledge and practices ($p = 0.409$), or attitude and practices ($p = 0.226$).
 - Overall, pharmacists at the University Teaching Hospital in Lusaka demonstrated strong knowledge, attitudes, and practices towards AMR.
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- Samutela *et al.*, 2017 [83]
- This study analyzed 32 clinical isolates of *S. aureus* collected from a major referral hospital in Lusaka, Zambia, between June 2009 and December 2012.
 - The analysis involved Staphylococcal cassette chromosome *mec* (SCC*mec*) typing, Staphylococcus protein A gene typing (*spa*), and detection of the Panton-Valentine Leucocidin (*pvl*) genes.
 - The study identified three SCC*mec* types among the isolates: SCC*mec* type IV (65.6%), SCC*mec* type III (21.9%), and SCC*mec* type I (3.1%).
 - Additionally, 9.4% of the isolates were untypable. Five different *spa* types were detected, including a novel type, with *spa* type t064 being the most prevalent (40.6%).
 - Other *spa* types identified were t2104 (31.3%), t355 (3.1%), and t1257 (21.9%).
 - The *pvl* genes were present in 3 out of the 32 isolates.
 - The study revealed a diverse population of MRSA strains in Lusaka.
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- Nagelkerke *et al.*, 2017 [197]
- A study conducted at a secondary care hospital in Zambia found that 14% of inpatients and 18% of outpatients carried *S. aureus*, with no cases of MRSA detected.
 - Among inpatients, 90% carried at least one strain of Enterobacteriaceae, primarily *E. coli* and *K. pneumoniae* that were resistant to gentamicin, ciprofloxacin, and/or ceftriaxone, compared to 48% of outpatients.
 - Gentamicin resistance was most common among inpatients (78%), while ciprofloxacin resistance was more prevalent among outpatients (38%).
 - All ceftriaxone-resistant Enterobacteriaceae were ESBL-positive, with a significantly higher presence in inpatients (52%) than outpatients (12%).
 - The study demonstrated the feasibility of performing basic microbiological procedures in a low-income hospital setting, generating essential data on antimicrobial susceptibility.
 - The high prevalence of drug-resistant Enterobacteriaceae among both inpatients and outpatients is concerning.
 - The findings underscore the importance of local surveillance data to develop antimicrobial therapy guidelines, guide individual patient treatment, and support the implementation of infection control measures in hospitals.
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- Masenga *et al.*, 2017 [88]
- This cross-sectional study investigated rifampicin resistance in *Mycobacterium tuberculosis* patients at Livingstone Central Hospital in 2015, utilizing GeneXpert technology.
 - Participants' ages ranged from 8 months to 73 years, with a median age of 34. Of those with complete gender data, 66% were male and 34% were female.
 - The study found a high prevalence of TB co-infection with HIV at 98.3% ($p < 0.001$).
 - Rifampicin resistance was identified in 5.9% of the cases, with no statistically significant difference in resistance rates between males and females ($p = 0.721$).
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- Chiyangi *et al.*, 2017 [74]
- This study found a high resistance of enteropathogens isolated from children.
 - Of the 271 stool samples analysed *Vibrio cholerae* 01 subtype and Ogawa serotype were the most isolated pathogens (40.8%), followed by *Salmonella* species (25.5%), diarrhoeagenic *E. coli* (18%), *Shigella* species (14.4%) and *Campylobacter* species (3.5%).
 - Additionally, most of the pathogens were resistant to two or more antibiotics, especially ampicillin and
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- co-trimoxazole.
- All (100%) diarrhoeagenic *E. coli* were ESBL-producers.
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- Chibwe *et al.*, 2017 [198]
- In this cross-sectional study, samples were collected from healthcare workers' hands, touch surfaces, and disinfectant buckets across delivery rooms, post-natal and pediatric wards, operating theatres, post-op wards, and outpatient departments.
 - A total of 132 swabs led to the isolation of 275 bacteria, with 65 successfully identified, including *Acinetobacter*, *Enterobacter*, *Klebsiella*, *Pseudomonas*, *Staphylococcus*, and *Streptococcus* species.
 - Drug resistance testing revealed high resistance levels, particularly among *Pseudomonas* spp., with 70%, 90%, and 60% resistance to cephalosporins, amoxicillin, and carbenicillin, respectively.
 - *Staphylococcus* spp. showed resistance to penicillin (86%), ampicillin (76%), azithromycin (57%), and cephalosporins (95%), with 19% resistant to vancomycin.
 - The study highlights high drug resistance levels among pathogens in Zambian healthcare facilities, reflecting the prolonged empiric use of antibiotics.
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- Sarenje *et al.*, 2017 [96]
- A study was conducted to identify fungi in immunocompromised patients and found that *Candida albicans* were the predominant species (66.7%), followed by *C. lusitaniae* (12.2%), *C. glabrata* (6.7%), *C. tropicalis* (5.6%), *C. parapsilosis* (3.3%), *C. quilliermondii* (3.3%), *C. pelliculosa* (1.1%) and *C. keyr* (1.1%).
 - Majority of the *Candida* species were highly resistant to fluconazole and amphotericin B, but were highly sensitive to caspofungin and flucytosine.
 - *C. albicans* was resistant to fluconazole (18.3%,) with an MIC₉₀ of 256 µg/ml and amphotericin B (10%) with MIC₉₀ of 1.5 µg/ml.
 - *C. glabrata* was the most resistant species against amphotericin B (66.6%) with an MIC₉₀ of 2 µg/ml. *C. albicans* and most of the non-*albicans* species were MDR.
 - This shows that fungal infections and resistance are prevalent among immunocompromised patients with pulmonary fungal infections in Zambia.
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- Matundwelo and Mwansasu, 2016 [199]
- Samples collected from children with suppurative otitis media at Arthur Davidson Children's Hospital revealed the isolation of *Staphylococcus* species (36%), *Proteus vulgaris* (35%), *Pseudomonas* species (15%), *Streptococcus* species (7%), *E. coli* species (3%), *Enterobacter* species (2%), and *Serratia marcescens* species (2%).
 - Antimicrobial sensitivity testing indicated that ciprofloxacin was the most effective against the majority of these isolates.
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- Kalungia *et al.* 2016 [34]
- A study assessing the non-prescription sale and dispensing of antibiotics was conducted in 73 randomly selected community retail pharmacies using a structured interviewer-administered questionnaire with simulated case scenarios.
 - The majority (97%) of pharmacists reported frequent client requests for non-prescribed antibiotics. Most respondents asked about client symptoms (94%), provided dosing advice (96%), and suggested alternative antibiotics (97%).
 - However, all pharmacies (100%) dispensed antibiotics without prescriptions.
 - The most commonly dispensed antibiotics were amoxicillin (52%), cotrimoxazole (25%), and metronidazole (23%).
 - The sale of non-prescribed antibiotics was significantly linked to the professional qualifications of the pharmacists in four out of five simulated cases.
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- Songe *et al.*, 2016 [200]
- Semi-structured interviews were conducted with two groups: 1) traders, which included a random selection of both males and females, and 2) consumers, also randomly selected males and females.
 - Following the interviews, we collected flies found on fish in markets located in Mongu and Lusaka districts of Zambia.
 - A total of 418 fly samples were analyzed in the laboratory. *Salmonella* spp. and enteropathogenic *E. coli* were isolated from houseflies.
 - Further laboratory screening revealed that 17.2% (72/418) of the samples contained ESBL-producing *E. coli*.
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- Kapata *et al.*, 2016 [201]
- A cross-sectional population-based survey conducted in Zambia from 2013-2014 aimed to estimate TB prevalence among adults aged 15 and older.
 - The survey covered 66 clusters across all 10 provinces, screening participants for TB symptoms, chest x-rays (CXR), and offering HIV tests.
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- Out of 98,458 enumerated individuals, 46,099 participated (84.1%), with 99% undergoing both symptom assessment and CXR. Sputum samples were collected from 6708 eligible participants, yielding 265 cases of MTB from 6123 specimens (4.3%).
 - The estimated TB prevalence was 638 per 100,000 for bacteriologically confirmed TB and 455 per 100,000 for all forms.
 - HIV-positive individuals were five times more likely to have TB than HIV-negative individuals.
 - The study revealed a higher-than-expected TB prevalence, highlighting the need for innovative strategies to improve TB control in Zambia.
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- Mudenda *et al.*, 2016 [65]
- This cross-sectional, descriptive, retrospective study analyzed prescription encounters at the adult and pediatric outpatient departments of the University Teaching Hospital (UTH) in 2015.
 - A total of 1486 drug encounters were reviewed, with an average of 2.5 drugs prescribed per patient (ranging from 1 to 7 drugs).
 - The antibiotic prescribing rate was 53.7%, while injections were prescribed in 11.8% of encounters.
 - Generic prescribing was noted in 56.1% of cases, and 98.1% of drugs were from the Zambia Essential Medicines List (ZEML).
 - The average consultation time was 9.5 minutes, with a dispensing time of 1.3 minutes.
 - About 78.9% of patients demonstrated correct knowledge of their dosing schedule.
 - However, none of the consultation rooms had Standard Treatment Guidelines (STGs) or access to reference literature or the internet.
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- Mwamungule *et al.*, 2015 [202]
- This prospective cross-sectional study was conducted from October 2013 to May 2014 at the University Teaching Hospital (UTH) in Lusaka.
 - A total of 107 white coats worn by healthcare workers at UTH were sampled to assess bacteriological contamination.
 - Of the 107 white coats screened, 94 (72.8%) were found to be contaminated with bacteria.
 - Contamination levels did not differ significantly between white coats worn for more than 60 minutes (47.8%) and those worn for 30 - 60 minutes (46.7%) ($p = 0.612$).
 - Antibiotic sensitivity tests revealed that the bacterial isolates were resistant to several of the antibiotics tested.
 - Notably, isolates of *S. aureus* and *K. pneumoniae* showed the highest levels of resistance.
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- Hendriksen *et al.*, 2015 [203]
- The genomic analysis of MDR *Salmonella enterica* serovar Typhi from a significant outbreak in Zambia (2010-2012) provided new insights.
 - The outbreak affected 2040 patients with a 0.5% fatality rate, and 83% of isolates were MDR.
 - These MDR isolates were identified as MLST ST1 and a new variant of the H58B haplotype.
 - A chromosomally translocated region with seven resistance genes—*catA1*, *blaTEM-1*, *dfrA7*, *sul1*, *sul2*, *strA*, and *strB*—was found in most isolates, along with fragments of the IncQ1 plasmid replicon, class 1 integron, and *mer* operon.
 - Whole-genome sequencing of 33 isolates showed 415 SNPs and 35 deletions, indicating a distinct clonal group from other H58 genomes in Central Africa and India.
 - The small number of SNPs suggests short-term transmission during the outbreak. Phylogenetic analysis and deletions point to a single MDR clone as the main cause of the outbreak, though other *S. Typhi* lineages, including sensitive ones, were also present.
 - This study challenges the view that the H58B haplotype with the MDR IncHI1 plasmid is the primary cause of typhoid in Asia and sub-Saharan Africa.
 - It suggests that a new H58B variant with chromosomally translocated MDR regions is emerging in Zambia, potentially altering the understanding of MDR typhoid and indicating that such variants may be more widespread than previously recognized.
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- Kapata *et al.*, 2015 [204]
- In a study involving 917 TB patients, 883 (96.3%) were analyzed. Of these, 574 (65%) had results from the Löwenstein-Jensen (LJ) method, and 824 (93.3%) had results from the MTBDRplus assay.
 - The median age of participants was 32 years, with 63.3% being male. MDR-TB prevalence was found to be 1.1% using LJ-based drug susceptibility testing (DST) and 1.6% using the MTBDRplus assay.
 - Isoniazid monoresistance in new TB cases was 2.4% based on LJ results and 5.0% using MTBDRplus.
 - For retreatment cases, isoniazid monoresistance was 4.4% on LJ and 2.4% on MTBDRplus.
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- Rifampicin mono-resistance in new cases was 0.1% on LJ and 0.6% using MTBDRplus.
 - In retreatment cases, rifampicin mono-resistance was 0% on LJ and 1.8% using MTBDRplus.
 - No cases of XDR-TB were detected, and no significant association was found between MDR-TB and HIV.
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- Kapata *et al.*, 2013 [89]
- Over an 11-year period, a total of 2038 drug susceptibility tests (DSTs) were conducted, representing 2.6% of all retreatment cases reported (2038 out of 78,639).
 - During this time, 446 cases of MDR-TB were diagnosed. Of these, 56.3% were male (251/446) and 41.7% were female (186/446), with only one case in a child.
 - Poly-drug resistance was observed in 18.9% of drug-resistant TB (DR-TB) cases (172/911) and 8.8% of DSTs. Additionally, 8.8% of DR-TB cases exhibited rifampicin mono- or poly-resistance without MDR-TB.
 - No cases of extensively drug-resistant TB (XDR-TB) were reported.
 - Data on DR-TB and HIV co-infection were not available. Only 65 MDR-TB patients were notified and started on second-line treatment per WHO guidelines.
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- Kapata *et al.*, 2011 [205]
- The study reviewed TB notification records and program reports from 1990 to 2010, revealing two distinct trends: an increase in TB cases until 2004, followed by a moderate decline from 2004 to 2010.
 - Treatment outcomes improved over time. However, data on pediatric TB, TB in prisoners, and TB in pregnant women were limited due to poor diagnostics. There was also no data on drug-resistant TB due to the lack of drug sensitivity testing. The rise in TB cases from 1990 to 2000 was closely linked to the HIV/AIDS epidemic.
 - The slight decline in cases between 2004 and 2010 was attributed to better TB care, sustained DOTS implementation, and improved diagnostics.
 - To enhance TB control, newer diagnostic technologies and drug-resistance testing should be integrated into national TB programs, and TB-HIV services should be aligned for better outcomes.
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- Kapatamoyo *et al.*, 2010 [206]
- In this study, samples were collected from breast abscesses in both HIV-positive and HIV-negative women.
 - *S. aureus* was identified as the primary causative agent in 91.8% of the isolates. Among the *S. aureus* isolates, 69.3% (70 out of 101) were susceptible to oxacillin.
 - However, in HIV-positive patients, 86.0% (43 out of 50) of the specimens were resistant to trimethoprim/sulphamethoxazole.
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- Mulenga *et al.*, 2010 [207]
- In an urban setting in Zambia with a long-standing DOTS program, the prevalence of tuberculosis (TB) drug resistance among pulmonary TB patients was assessed.
 - Among 156 new cases, 7.7% showed any drug resistance, with 4.5% exhibiting mono-resistance to isoniazid and 1.3% to rifampicin.
 - Of 31 retreatment cases, 16.1% had drug resistance, with mono-resistance to isoniazid and rifampicin at 3.3% each and one case of multidrug resistance (both isoniazid and rifampicin).
 - No resistance was found to kanamycin or ofloxacin. While these results may not represent the entire country, they indicate low levels of drug resistance in a community with effective DOTS implementation.
 - Resource-limited countries could potentially reduce TB drug resistance by adopting community-based strategies that ensure treatment completion.
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- Gill *et al.*, 2008 [208]
- Among 260 infants followed over 3096 patient-months, pneumococci were detected in 360 out of 1394 samples (25.8%).
 - HIV-exposed infants were more frequently colonized than HIV-unexposed infants. Co-trimoxazole prophylaxis reduced colonization by approximately 7%, but it increased the risk of colonization with co-trimoxazole-resistant pneumococci within six weeks of starting prophylaxis.
 - The prophylaxis led to a small but statistically significant increase in nasopharyngeal colonization with pneumococci that were not susceptible to clindamycin, but it did not increase the risk of non-susceptibility to penicillin, erythromycin, tetracycline, or chloramphenicol.
 - Co-trimoxazole prophylaxis did not alter the prevalence of pneumococcal serotypes targeted by the 7-valent conjugate pneumococcal vaccine.
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- Habeenzu *et al.*, 2007 [87]
- A study was conducted involving 1080 prisoners in Zambia, comprising 1055 males and 25 females. Sputum samples from 245 prisoners (22.7%) tested positive for MTB, including 168 (15.6%) with smear-positive TB.
 - With a total prison population of 6118, the minimal prevalence of TB was estimated at 4.0%.
 - However, a linear relationship between the number of prisoners evaluated and the prevalence of TB ($R^2 = 0.9366$) across facilities suggests that the true prevalence of TB could be as high as 15% - 20%.
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- Drug resistance testing revealed that 40 isolates (23.8%) showed resistance to at least one anti-tuberculosis drug, and 16 isolates (9.5%) were identified as MDR-TB.
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- Bijl *et al.*, 2000 [209]
- This pilot study investigated resistance to chloroquine (CQ) and sulfadoxine-pyrimethamine (SP) in *Falciparum malaria* in rural Zambia.
 - The combined prevalence of CQ resistance, including both R-II and R-III categories, was 58%, with a higher rate of 60% observed in children under five years old.
 - This level of resistance aligns with previously reported figures from Zambia.
 - In contrast, SP resistance (R-II and R-III) was significantly higher at 26%, compared to earlier reports of 3% to 17%.
 - The study found a strong correlation between prior CQ use and resistance levels, as indicated by the Dill-Glazko test, but did not find evidence of prior SP use to explain the high levels of SP resistance.
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- Chileshe *et al.*, 2024 [99]
- This cross-sectional study aimed to identify the bacterial pathogens in diseased chickens in Lusaka and to detect the presence of extended-spectrum beta-lactamase (ESBL)-encoding genes.
 - A total of 215 samples were collected from 91 diseased chickens at three post-mortem facilities and screened for Gram-negative bacteria.
 - Among these, 103 samples tested positive for various clinically significant Enterobacteriaceae including *Enterobacter* (41.7%, 43/103), *E. coli* (19.4%, 20/103), *Salmonella* species (9.7%, 10/103), and *Shigella* species (7.8%, 8/103).
 - Other bacteria isolated included *Yersinia*, *Morganella*, *Proteus*, and *Klebsiella*, accounting for 21.4%.
 - The study revealed that *E. coli*, *Enterobacter*, and *Shigella* exhibited high resistance to tetracycline, ampicillin, amoxicillin, and trimethoprim-sulfamethoxazole.
 - Conversely, *Salmonella* showed complete susceptibility to all tested antibiotics.
 - The observed resistance patterns corresponded with antimicrobial usage data obtained from a major wholesale and retail company.
 - Furthermore, 42.9% (6/14) of *E. coli* isolates tested positive for the blaCTX-M gene, while 57.1% (8/14) of *Enterobacter* isolates carried the blaTEM gene. Notably, 66.7% (4/6) of the blaCTX-M-positive *E. coli* strains were also positive for blaTEM.
 - Sanger sequencing revealed that 83.3% (5/6) of the blaCTX-M-positive isolates harbored the blaCTX-M-15 allele.
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- Sinyawa *et al.*, 2024 [77]
- The cross-sectional survey indicated that medium- and small-scale poultry farmers were more likely to use antimicrobials compared to commercial farmers. However, they issued fewer prescriptions.
 - Susceptibility testing revealed the highest resistance to ampicillin (86.5%, 128/148) and tetracycline (74.3%, 101/136).
 - MDR was also notably high, found in 93.3% (28/30) of isolates. Whole-genome sequencing (WGS) of 26.7% (8/30) of isolates with a CTX Minimum Inhibitory Concentration (MIC) ≥ 4 $\mu\text{g/mL}$ identified ESBL-encoding genes, including blaCTX-M-14, blaCTX-M-55, and blaTEM.
 - WGS further revealed resistance genes for quinolones, aminoglycosides, phenicols, tetracycline, macrolides, and folate-pathway antagonists.
 - The survey results underscored a higher level of antimicrobial use and lower prescription frequency among medium- and small-scale poultry farmers compared to their commercial counterparts.
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- Mudenda *et al.*, 2024 [33]
- This cross-sectional study was conducted from August 2023 to October 2023 among 200 veterinary medicine dispensers in the Lusaka District of Zambia using a simulated farmer or mystery shopper approach.
 - Out of the 200 medicine outlets investigated, 23 (11.5%) were agro-veterinary shops, while 177 (88.5%) were community pharmacies.
 - A total of 165 community pharmacies and agro-veterinary shops provided veterinary services in the Lusaka District and sold medicines without prescription giving a 100% non-prescription sale.
 - Of the 178 medicines dispensed for prophylaxis, 88.5% were antibiotics, while 13.5% were vitamins.
 - The most dispensed antibiotic drug for prophylaxis in broiler chickens was oxytetracycline (30.34%), amoxicillin (17.98%) and gentamicin/doxycycline (10.67%).
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- Mwikuma *et al.*, 2023 [80]
- This cross-sectional study in poultry found a prevalence of enterococci to be 31.1% of which *Enterococcus faecalis* contributed 37.9% while *E. faecium* was 10.5%.
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- Most of the *E. faecalis* and *E. faecium* isolates were resistant to tetracycline (66/74, 89.2%) and ampicillin and erythromycin (51/74, 68.9%).
 - Conversely, enterococci isolates were susceptible to vancomycin (72/74, 97.3%).
 - Therefore, the results demonstrate that poultry are a potential source of MDR *E. faecalis* and *E. faecium* strains, which can be transmitted to humans.
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- Mudenda et al., 2023 [69]
- This cross-sectional study found a high prevalence of antibiotic resistant *E. coli* isolated from laying hens.
 - Of the 365 samples, *E. coli* was isolated from 92.9% (n = 339).
 - The AMR was detected in 96.5% (n = 327) of the isolates, of which 64.6% (n = 219) were MDR.
 - *E. coli* was highly resistant to tetracycline (54.6%) and ampicillin (54%) but showed low resistance to meropenem (0.9%), ceftazidime (6.2%) and chloramphenicol (8.8%).
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- Mwasinga et al., 2023 [72]
- This cross-sectional study was conducted using 418 pooled raw cow milk samples and analysed using standard culture methods to isolate *E. coli*.
 - The prevalence of *E. coli* was found to be 51.2% (214/418) of which 21% (45/214) were MDR.
 - A high resistance was observed towards ampicillin (107/214, 50%), tetracycline (86/214, 40.1%), trimethoprim/sulfamethoxazole (61/214, 28.5%), and amoxicillin/clavulanic acid (50/214, 23.4%).
 - A low resistance was observed towards CTX (32/214, 15%) and imipenem (27/214, 12.6%). The blaCTX-M and blaTEM genes were detected in CTX-resistant isolates.
 - The study concluded that MDR *E. coli* that harbour blaCTX-M and blaTEM genes in raw cow's milk demonstrate serious public health risks for consumers.
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- Mwansa et al., 2023 [76]
- This was a cross-sectional study that was conducted in four districts of Lusaka Province in Zambia to determine the AMR patterns, ESBL production of *E. coli* isolated from stool samples of broiler poultry farm workers, and to assess poultry farmers' awareness of AMR.
 - Sixty-six human stool samples were collected and processed for *E. coli* isolation, performed AST, and screened for ESBL production.
 - Further, 80 farmers were assessed for their level of awareness on AMR. A total of 58 single *E. coli* isolates were isolated and demonstrated high resistance to tetracycline (87.9%), trimethoprim/sulfamethoxazole (48.3%), and ampicillin (46.8%); nalidixic acid (19.0%), ciprofloxacin (12.1%), cefotaxime (8.6%) and chloramphenicol (5.2%).
 - The prevalence of AMR *E. coli* was 67.2% and 29.3% were found to be MDR. Two (3.4%) isolates were identified to be ESBL producers, harboring the CTX-M gene.
 - The study concluded that broiler farmers were aware and knowledgeable of AMR, although their knowledge about its impact on human health was low.
 - This study demonstrated the presence of resistant and ESBL-producing *E. coli* among poultry farm workers indicated a potential transmission of AMR between humans and poultry and vice-versa.
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- Mudenda et al., 2022 [79]
- A cross-sectional study found a high prevalence (99.4%) of antibiotic-resistant Enterococcus species isolated from laying hens.
 - A total of 308 (83%) single Enterococcus species isolates were obtained and showed resistance to tetracycline (80.5%), erythromycin (53.6%), quinupristin/dalfopristin (53.2%), ampicillin (36.72%), vancomycin (32.8%), linezolid (30.2%), ciprofloxacin (11.0%), nitrofurantoin (6.5%) and chloramphenicol (3.9%).
 - The prevalence of enterococci resistant to at least one antibiotic was 99.4% (n = 306), of which 86% (n = 265) were MDR.
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- Chilawa et al., 2022 [210]
- This was a cross-sectional study conducted among 106 poultry farmers from November to December 2021 using a structured questionnaire.
 - Overall, of the 106 participants, 90.6% knew what antimicrobials were, but only 29.2% were aware of AMR.
 - The study showed that 46.2% of the participants had low knowledge, 71.7% had negative attitudes, and 61.3% had poor practices regarding AMR.
 - The prevalence of antibiotic use in poultry production was 83%. The most used antimicrobials were tetracycline (84%) and gentamicin (35.2%).
 - The commonly reported reason for the use of antimicrobials was for the treatment (93.2%) and prevention (89.8%) of diseases.
 - Further, 76.9% of the administered antimicrobials were usually done without veterinarian consultation or
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- prescription.
- The study shows that there was high AMU in poultry farms in Kitwe. However, there was low knowledge, negative attitude, and poor practices towards AMU and AMR.
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- Mudenda *et al.*, 2022 [67]
- This study assessed the awareness of AMR and associated factors among layer poultry farmers in Zambia. A cross-sectional study was conducted among 77 participants from September 2020 to April 2021.
 - Overall awareness of AMR among the farmers was 47% (n = 36). The usage of antibiotics in layer poultry production was high at 86% (n = 66).
 - Most antibiotics were accessed from agrovets (31%, n = 24) and pharmacies (21%, n = 16) without prescriptions.
 - Commercial farmers were more likely to be aware of AMR compared to medium-scale farmers, as were farmers who used prescriptions to access antibiotics compared to those who did not, and farmers who did not treat market-ready birds with antibiotics compared to those who did.
 - The awareness of AMR among some layer farmers was low.
 - Therefore, policies that promote the rational use of antibiotics need to be implemented together with heightened surveillance activities aimed at curbing AMR.
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- Mpundu *et al.*, 2022 [211]
- This cross-sectional study investigated the presence of *Listeria* species in chickens from abattoirs and assessed their AMR profiles.
 - A total of 150 broiler carcass swabs were collected, including cloacal (n = 60), exterior surface (n = 60), and environmental (n = 30) samples.
 - *Listeria* species were identified using biochemical tests and PCR, while antibiotic resistance was tested via disc diffusion and Etest methods.
 - *Listeria* species were isolated in 15% (23/150) of the samples, with 2% from environmental swabs and 13% from carcass swabs.
 - The species distribution included *L. monocytogenes* (74%), *L. welshimeri* (22%), and *L. innocua* (4%).
 - Most isolates came from exterior carcass swabs (61%), followed by cloacal swabs (26%), and environmental swabs (3%).
 - *L. monocytogenes* showed the highest resistance to clindamycin (61%), tetracycline (30%), and erythromycin (13%).
 - The relatively high isolation of *L. monocytogenes* and its AMR profile indicates a potential public health risk, highlighting concerns about food safety for consumers.
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- Kabali *et al.*, 2021 [212]
- A cross-sectional study was conducted on a 10,000-acre game ranch near Lusaka, Zambia, to assess the prevalence and AMR profiles of *E. coli* and other enterobacteria in wildlife and livestock cohabiting in the area.
 - The study involved purposive sampling of 84 fecal samples from animals with similar behaviors and grazing habits, resulting in 66 bacterial isolates.
 - These included *E. coli* (72.7%), *E. fergusonii* (1.5%), *Shigella sonnei* (22.7%), *Sh. flexneri* (1.5%), and an unidentified Enterobacteriaceae bacterium (1.5%).
 - The study found that 89.6% of *E. coli* and 73.3% of *Shigella* isolates exhibited resistance or intermediate sensitivity to at least one antimicrobial agent.
 - Among *E. coli* isolates, the highest resistance rates were to ampicillin (27%), ceftazidime (14.3%), cefotaxime (9.5%), and kanamycin (9.5%).
 - MDR was observed in 18.8% of *E. coli* and 13.3% of *Shigella* isolates, including those from both wild and domesticated animals.
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- Kaonga *et al.*, 2021 [213]
- This study analysed 384 poultry fecal samples using microbiological and molecular methods. *S. Typhimurium* was detected at 17.7% in commercial poultry farms in Copperbelt province, of which 12.8% were found harboring the CTX-M-type ESBL genes.
 - *S. Typhimurium* isolates showed 88.2% resistance to at least one antimicrobial compound. All the isolates showed 100% resistance to tetracycline, followed by ampicillin and amoxicillin at 91.2%.
 - These isolates also showed 58.8% resistance to cefotaxime and 54.4% to ceftazidime.
 - Detection of CTX-M ESBL-producing *S. Typhimurium* suggests the contamination of the chicken food chain at the farm level and calls for public health protection measures.
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- Shawa *et al.*, 2021 [214]
- This study was conducted on 20 cefotaxime-resistant *E. coli* isolates collected from poultry in Lusaka, Zambia.
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- These isolates were analyzed for MDR and underwent genome sequencing using both MiSeq and MinION platforms.
 - The genomes were assembled de novo and compared with 36 previously reported cefotaxime-resistant *E. coli* isolates obtained from inpatients at the University Teaching Hospital in Lusaka.
 - The study found that all 20 poultry-derived *E. coli* isolates (100%) were resistant to ampicillin, chloramphenicol, and doxycycline.
 - Phylogenetic analysis and hierarchical clustering revealed a high degree of genetic similarity between *E. coli* O17 isolates from both poultry and human sources.
 - Specifically, the *E. coli* O17 clone was found in 4 out of the 20 (20%) poultry isolates and 9 out of the 36 (25%) human-associated isolates.
 - These isolates shared two plasmids that contained 14 AMR genes.
 - The comparison analysis also showed that while these isolates shared some AMR plasmids, they each possessed other plasmids that were unique to their respective environments—poultry or humans.
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- Phiri *et al.*, 2020 [84]
- A cross-sectional study was conducted across seven districts in Zambia to assess the resistance profiles of *Salmonella* spp. and *E. coli* isolated from broiler chickens at farms, abattoirs, and open markets.
 - A total of 470 samples, including litter, cloacal swabs, and carcass swabs, were collected. In total, 4 *Salmonella* spp. and 280 *E. coli* isolates were identified.
 - Among the *Salmonella* spp., one showed resistance to ampicillin (25%), amoxicillin/clavulanic acid (25%), and cefotaxime (25%).
 - *E. coli* demonstrated the highest resistance to tetracycline (81.4%) and was 100% susceptible to imipenem.
 - The antibiotic susceptibility profile indicated that 75.7% (237/280) of the *E. coli* isolates were MDR.
 - The highest MDR profile was found in 8.2% (23/280) of the isolates, with resistance observed in 6 out of the 9 antibiotic classes tested. Additionally, 11.4% (32/280) of the isolates exhibited XDR.
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- Muligisa *et al.*, 2020 [85]
- This study aimed to determine the AMR profiles of *E. coli* and *Salmonella* species isolated from retail broiler chicken carcasses purchased from open markets and supermarkets in Zambia.
 - A total of 189 *E. coli* and five *Salmonella* isolates were identified.
 - The *E. coli* isolates showed high resistance to tetracycline (79.4%), ampicillin (51.9%), and trimethoprim/sulfamethoxazole (49.7%).
 - Additionally, two of the five *Salmonella* isolates were resistant to at least one antibiotic.
 - This study highlights the presence of AMR in *E. coli* and *Salmonella* on retail broiler chicken carcasses from both open markets and supermarkets, posing a public health risk.
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- Mainda *et al.*, 2019 [215]
- This study compared whole genome sequences of *E. coli* isolates from dairy cattle (n = 224) and patients at a local hospital (n = 73) to identify acquired AMR genes.
 - Additionally, the researchers analyzed publicly available genomes of 317 human *E. coli* isolates from across Africa.
 - The study identified antibiotic resistance genes and phylogroups from de novo assemblies and used SNP-based phylogenetic analyses to visualize the distribution of resistance genes between the two hosts.
 - The findings revealed greater diversity of acquired AMR genes in human *E. coli* isolates compared to those from bovines, particularly for genes conferring resistance to ESBL, quinolones, macrolides, and fosfomycin, which were only found in human isolates.
 - Notably, *E. coli* isolates from Zambian and other African human sources were significantly more likely to carry multiple AMR genes compared to those from Zambian dairy cattle.
 - The median number of resistance genes in the Zambian cattle cohort was 0 (interquartile range: 0 - 1), while in the Zambian human and wider African cohorts, the medians were 6 (interquartile ranges: 4 - 9 and 0 - 8, respectively).
 - The lower frequency and diversity of AMR genes in dairy cattle isolates align with the relatively limited antibiotic use documented in the region, especially among smallholder farmers.
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- Chishimba *et al.*, 2017 [75]
- Of the 384 poultry samples collected and analyzed, 20.1% were ESBL-producing *E. coli*.
 - Additionally, 85.7% of ESBL-producing *E. coli* isolates conferred resistance to beta-lactam and other antibiotics.
 - These findings demonstrate that ESBL-producing *E. coli* isolates are also found in poultry and may be transmitted to human consumers.
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Mainda <i>et al.</i> , 2015 [216]	<ul style="list-style-type: none"> • An <i>E. coli</i> isolate was obtained from 98.67% (371/376) of the sampled animals and tested for resistance against six classes of antibiotics. • The estimated prevalence of resistance across different farming systems was: tetracycline (10.61%), ampicillin (6.02%), sulfamethoxazole/trimethoprim (4.49%), cefpodoxime (1.91%), gentamicin (0.89%), and ciprofloxacin (0%). • Univariate analyses identified certain diseases, exotic breeds, location, farm size, and specific management practices as risk factors for antibiotic resistance. • Multivariate analyses further revealed an association with lumpy skin disease and suggested a protective effect for older animals (>25 months).
Phiri <i>et al.</i> , 2022 [217]	<ul style="list-style-type: none"> • The study investigated the prevalence and diversity of <i>Staphylococcus aureus</i> in Zambia's dairy value chain, focusing on raw milk from traditional and smallholder farms. • <i>S. aureus</i> contamination was found in 33% to 46% of raw milk samples, varying by province. It was also detected in milk collection centers, informal traders, traditional market sellers, processors, and on swabs from milk buckets, as well as nasal and hand swabs of milkers. • No <i>S. aureus</i> was found in industrially processed (heat-treated) milk or dairy products. Although MRSA was not detected, 10% of isolates carried the <i>lukS-PV</i> gene, which is associated with the virulence factor Pantone-Valentine leucocidin (PVL) and severe human diseases. • Molecular typing revealed 44 spa types, including 13 novel types, and 12 new multi-locus sequence types (MLSTs), some of which were linked to the bovine-associated clonal lineage CC97. • The dominant spa types varied by province, though some were common across all regions. Whole-genome sequencing (WGS) and core genome multi-locus sequence typing (cgMLST) indicated transmission of <i>S. aureus</i> strains along the dairy value chain, with potential persistence over time. • Genetic similarities were observed between isolates from milkers and those from raw milk or milk buckets. • The study underscores the widespread contamination of raw milk with <i>S. aureus</i> in Zambia's dairy sector and calls for continued monitoring to mitigate public health risks.
Youn <i>et al.</i> , 2014 [218]	<ul style="list-style-type: none"> • The study focused on the prevalence and characterization of <i>S. aureus</i> and <i>Staphylococcus pseudintermedius</i> (SP) isolated from companion animals and their environment at a veterinary teaching hospital in Zambia. • The highest resistance rates observed for SA were to penicillin (63.6%) and trimethoprim-sulfamethoxazole (36.4%), while SP showed the highest resistance to penicillin (52.1%) and tetracycline (25.0%). • A diverse array of sequence types (STs) was identified, with no predominant type, and several novel STs were found, particularly in SP (39.6%). • The spa typing successfully assigned clonal types to all SA isolates (100%) and to 24 SP isolates (50%), revealing three and two novel types, respectively.

3.2. Risk Factors Contributing to Antimicrobial Resistance in Zambia

The main risk factors for AMR in Zambia were the high burden of diseases, over-use and misuse of antimicrobials, lack of awareness and knowledge regarding AMU, AMR, and AMS, self-medication, and lack of diagnostic capacity in healthcare facilities in Zambia (Table 2).

Table 2. Risk factors and challenges contributing to the emergence and spread of AMR in Zambia.

Authors, Year	Findings
Bumbangi <i>et al.</i> , 2022 [73]; Chiyangi <i>et al.</i> , 2027 [74]; Mukomena <i>et al.</i> , 2023 [219]	<ul style="list-style-type: none"> • High burden of diseases in Zambia prompting the use of antimicrobials
Ngoma <i>et al.</i> , 2024 [167]; Chilawa <i>et al.</i> , 2023 [210]; Kalungia <i>et al.</i> , 2022 [62]; Masich <i>et al.</i> , 2020 [61]; Mudenda <i>et al.</i> , 2023 [63]	<ul style="list-style-type: none"> • Overuse and misuse of antimicrobial agents in humans and animals

Continued

Mudenda <i>et al.</i> , 2023 [59]	<ul style="list-style-type: none"> • Lack of awareness of AMU and AMR among farmers
Mukwato <i>et al.</i> , 2008 [220]	<ul style="list-style-type: none"> • Poor infection prevention and control practices in healthcare facilities in Zambia
Shivangi <i>et al.</i> , 2023 [173]	<ul style="list-style-type: none"> • The presence of bacteria with significant AMR on supermarket trolley and basket handles in Zambia
Matee <i>et al.</i> , 2023 [57]	<ul style="list-style-type: none"> • Lack of effective surveillance and monitoring systems, and limited access to quality healthcare and diagnostic services
Mudenda <i>et al.</i> , 2023 [221]; Banda <i>et al.</i> , 2021 [222]	<ul style="list-style-type: none"> • High practice of self-medication in Zambia
Mudenda <i>et al.</i> , 2021 [186]; Kalungia <i>et al.</i> , 2016 [34]; Mudenda <i>et al.</i> , 2024 [33]	<ul style="list-style-type: none"> • Access to antibiotics without prescriptions. The reasons behind the dispensing of antibiotics without a prescription in community pharmacies needs to be explored in future studies.
Yamba <i>et al.</i> , 2024 [35]	<ul style="list-style-type: none"> • Lack of laboratory capacity to conduct bacteriology and AMR testing
Mudenda <i>et al.</i> , 2022 [67]	<ul style="list-style-type: none"> • Lack of awareness and knowledge of AMR among university students
Mudenda <i>et al.</i> , 2024 [66]	<ul style="list-style-type: none"> • Poor knowledge, attitudes, and practices concerning AMU and AMR among community members
Mudenda <i>et al.</i> , 2024 [33]	<ul style="list-style-type: none"> • Inadequate regulatory systems regarding access to antimicrobials and antimicrobial use
Mudenda <i>et al.</i> , 2024 [168]; Ngoma <i>et al.</i> , 2024 [167]; Mudenda <i>et al.</i> , 2023 [63]; Mudenda <i>et al.</i> , 2022 [64]; Kalungia <i>et al.</i> , 2022 [62]	<ul style="list-style-type: none"> • Non-adherence to recommended treatment guidelines in healthcare facilities
Kalungia <i>et al.</i> , 2019 [129]	<ul style="list-style-type: none"> • Lack of knowledge on AMS among physicians and pharmacists
Yamba <i>et al.</i> , 2024 [35]	<ul style="list-style-type: none"> • Limited diagnostic capacity of laboratories to conduct microbiological tests and AMR surveillance contributing to poor diagnostic stewardship
Yamba <i>et al.</i> , 2024 [35]	<ul style="list-style-type: none"> • Limited finances and laboratory consumables required for effective surveillance of AMR
Munyeme <i>et al.</i> , 2024 [101]	<ul style="list-style-type: none"> • One of the major challenges in Zambia is the acceptance, integration, and institutionalization of the One Health approach across all relevant sectors. • A significant issue is the absence of a unifying policy, framework, and governance structure that is independent of any single ministry. • Currently, the Zambia National Public Health Institute (ZNPPI) is still perceived as being under the Ministry of Health, creating operational difficulties. • To address this, there is a need for a fully independent One Health platform under the Vice President's office. • Another challenge is the practical implementation of the One Health approach, as observed during recent anthrax outbreaks. In districts with a good understanding of One Health, teams were quickly formed to implement cross-sectoral interventions. • However, operationalization faced practical challenges, particularly in the early stages of coordination. • The anthrax and COVID-19 outbreaks highlighted the necessity of having a well-established One Health workforce, making capacity building across all sectors crucial to ensure the necessary skills and knowledge are in place. • Financing for One Health initiatives in Zambia is a consistent challenge. • Resource mobilization to support One Health interventions needs better organization, and there is a lack of sustainable financing mechanisms to ensure the long-term success of these interventions.
Shempela <i>et al.</i> , 2024 [36]	<ul style="list-style-type: none"> • Lack of AMS committees and programs in some healthcare facilities in Zambia

3.3. Proposed Solutions and Recommendations

Some of the solutions and recommendations to address AMR in Zambia include the instigation of AMS programs to target healthcare workers, universities, colleges, and schools, animal health personnel, farmers, and community members. Additionally, addressing AMR will require improvement of diagnostic stewardship, AMR and AMS awareness campaigns, and strengthened IPC measures in healthcare facilities and communities. Furthermore, there is an urgent need to promote acceptance, integration, and operationalization of the One Health approach in disease surveillance and addressing AMR (Table 3).

Table 3. Solutions and recommendations to address AMR in Zambia.

Authors, Year	Findings and recommendations
Munyeme <i>et al.</i> , 2024 [101]	<ul style="list-style-type: none"> • There is a need to develop educational programs to raise awareness and understanding of the One Health concept among implementers and policymakers. • This includes creating short, targeted courses and training programs to build the capacity of all One Health actors. • This will enhance disease surveillance and combating of AMR across the One Health sectors
Munyeme <i>et al.</i> , 2024 [101]	<ul style="list-style-type: none"> • There is an urgent coordinated need for acceptance, integration, institutionalization, and operationalization of the One Health approach across all relevant sectors to promote diseases surveillance and combating AMR
Yamba <i>et al.</i> , 2024 [35]; Shempela <i>et al.</i> , 2024 [36]	<ul style="list-style-type: none"> • Strengthening surveillance and monitoring systems for early detection and identification of disease-causing pathogens and AMR trends
Mudenda <i>et al.</i> , 2024 [130]; Mudenda <i>et al.</i> , 2023 [44]; Mudenda <i>et al.</i> , 2023 [223]; Chizimu <i>et al.</i> , 2024 [111]	<ul style="list-style-type: none"> • Instigating AMS programs to optimize antimicrobial use in healthcare facilities, universities, colleges, schools, communities, veterinary practice, aquaculture, and agriculture
Mudenda <i>et al.</i> , 2023 [224]; Shivangi <i>et al.</i> , 2023 [173]; Mukwato <i>et al.</i> , 2008 [220]	<ul style="list-style-type: none"> • Enhancing infection prevention and control practices in healthcare facilities and communities
Yamba <i>et al.</i> , 2024 [35]; Shempela <i>et al.</i> , 2024 [36]	<ul style="list-style-type: none"> • Increasing access to diagnostic services and improved laboratory capacity to conduct microbiological tests and AMR surveillance
Mudenda <i>et al.</i> , 2023 [44]; Godman <i>et al.</i> , 2022 [24]	<ul style="list-style-type: none"> • Promoting public awareness and education on AMU, AMR, and AMS
Zambian NAP on AMR, 2017 [103]; GAP on AMR, 2015 [102]	<ul style="list-style-type: none"> • Promote research and surveillance to support evidence-based decision-making to address AMR
Munyeme <i>et al.</i> 2024 [101]	<ul style="list-style-type: none"> • Improving funding required to combat AMR in the One Health approach to address AMR
Mudenda <i>et al.</i> , 2023 [44]; Mudenda, 2024 [225]	<ul style="list-style-type: none"> • Strengthening local and international collaborations in instigating strategies to combat AMR
Zambian NAP on AMR, 2017 [103]	<ul style="list-style-type: none"> • Community engagement in AMS programs
Mudenda <i>et al.</i> , 2022 [178]	<ul style="list-style-type: none"> • Strengthening University and College curricular on AMR and AMS
Mutati <i>et al.</i> , 2022 [226]	<ul style="list-style-type: none"> • Providing CPD education for healthcare workers concerning AMU, AMR, IPC, and AMS
Mudenda <i>et al.</i> , 2023 [63]; Mudenda <i>et al.</i> , 2024 [168]; Kalungia <i>et al.</i> , 2022 [62]	<ul style="list-style-type: none"> • Frequent monitoring of antimicrobial prescribing and use in healthcare facilities
GAP on AMR, 2015 [102]	<ul style="list-style-type: none"> • Embracing a One Health approach is essential to combat AMR

Continued

Mudenda *et al.*, 2023 [227];

Mudenda *et al.*, 2023 [228];

Hikaambo *et al.*, 2023 [229];

Hikaambo *et al.*, 2022 [230];

Kabuka *et al.*, 2021 [231];

Mudenda *et al.*, 2024 [232]

- Promote research in traditional medicines as a source of antimicrobial agents

- Based on the GAP and NAPs on AMR, countries need to improve awareness and understanding of AMR through good governance, effective communication, education and training.

- Further, there is a need to strengthen knowledge and evidence-base through surveillance and research.

Zambian NAP on AMR, 2017 [103];
GAP on AMR, 2015 [102]

- Furthermore, there is a need to reduce the incidence of infection through effective sanitation, hygiene and infection prevention measures, and biosecurity.

- Alongside this, there is a need to optimize the use of antimicrobial medicines in human, animal, and plant health.

- Finally, countries must develop the economic case for sustainable investment that takes account of the national needs and to increase investment in new medicines, diagnostic tools, vaccines, and other interventions.
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4. Discussion

Antimicrobial resistance (AMR) is a growing public health concern worldwide, and Zambia is no exception. The findings of this review highlight the high prevalence of AMR in Zambia, which has significant implications for public health. Further, the review highlights the gaps in awareness, knowledge, attitudes, and practices regarding AMU, AMR, and AMS among healthcare workers, students, and the general population. Furthermore, the high use of antimicrobials across the One Health sector has been reported in Zambia. Therefore, interventions to combat AMR in Zambia must be established and strengthened.

The high prevalence of AMR in Zambia can be attributed to several factors, including the overuse and misuse of antimicrobial agents [61] [63] [64], limited access to quality healthcare and diagnostic services [57], poor infection prevention and control practices [220], and lack of effective surveillance and monitoring systems [35] [36]. These factors are interconnected and often exacerbate each other, making it challenging to address AMR effectively. However, there is a paucity of information on the burden of AMR in Zambia which calls for urgent action among researchers and scholars to address this gap.

The findings of this review also highlight the need for a multi-sectoral approach to address AMR in Zambia. Since AMR affects humans, animals, plants, and the environment, there is a need to address this problem using a One Health approach [44] [54] [101]. Strengthening surveillance and monitoring systems of antimicrobial consumption, use, and resistance [35] [36] [57] [233], improving antibiotic stewardship and prescribing practices [1] [107] [234], enhancing infection prevention and control practices [220] [224], increasing access to quality healthcare and diagnostic services [35], and promoting public awareness and education [130] are all critical components of an effective response to AMR.

In Zambia, the prevalence of infectious diseases is high including diarrhoea, UTIs, STIs, malaria, and respiratory tract infections [184] [235]. Evidence has shown that most of the pathogens that cause these infections in Zambia have developed resistance against most antimicrobials [73] [74] [177]. These findings highlight the need to develop integrated surveillance systems focused on early and regular screening of infections, along with concurrent testing for antibiotic susceptibility. Such measures are crucial to prevent complications that could compromise maternal and fetal health outcomes. Additionally, further research is warranted to investigate the underlying causes of the high prevalence of AMR, including potential links to the misuse of antibiotics. Insights from such research could inform and strengthen prescription-only policies and AMS programs.

The emergence and spread of TB resistance is a threat to public health in Zambia based on the evidence from previous studies [87]-[92] [94] [204] [236]. The emergence of pre-extensively drug-resistant tuberculosis (pre-XDR-TB) poses a significant threat to TB control programs in developing countries like Zambia [93]. The emergence of resistance to second-line drugs among MDR-TB strains is a serious concern for TB control efforts [93]. This evidence highlights the urgent need to strengthen routine drug susceptibility testing for second-line TB drugs to prevent the progression from pre-XDR to XDR-TB and to improve treatment outcomes for patients. Further, to reduce further morbidity and mortality associated with TB, there is a need for increased and sustained investment in case detection and diagnostics [237]. Furthermore, there is an urgent need for the implementation of measures to improve surveillance, facilitate early detection, ensure timely initiation of treatment, and enhance patient follow-up [92].

The present review found that viral resistance is also prevalent in Zambia [98] [238] [239]. The country has faced a lot of viral infections including HIV/AIDs, COVID-19, influenza, and many other diseases like those affecting the respiratory tract [240]-[245]. Viral infections tend to increase the use of antimicrobials which is unnecessary most times. Therefore, more strategies need to be developed to address antiviral resistance in Zambia, similar to what is being done in other countries [246]-[248].

Malaria is among the major causes of morbidity and mortality in Zambia [249] [250]. Additionally, malaria resistance has been reported in Zambia and affects the elimination of the disease [190] [209] [251]-[253]. Therefore, there is an urgent need to strengthen malaria prevention and control strategies in Zambia [254] [255]. For instance, strengthening the surveillance of malaria markers is a very significant strategy to prevent drug-resistant malarial infections [256] [257]. We also need to strengthen malaria prevention, diagnosis, and treatment based on the WHO recommendations.

In Zambia, studies regarding antifungal resistance (AFR) are very inadequate [258]. This is evidenced by a few studies that have been published under this subject matter [96] [174]. Therefore, there is a need to promote research and surveillance of AFR [225] [258]. The country must develop surveillance and antifungal

stewardship programs similar to what other countries have done [225] [259]-[266].

Substandard and falsified (SF) medicines have been associated with the development and spread of AMR [267]. A Zambian review study demonstrated the presence of SF medical products in the Zambian healthcare system evidenced by recalls done by Zambia's regulatory authority, ZAMRA [180]. On the other hand, another Zambian study found that all antiretrovirals, antimalarials, and antituberculosis medicines met the WHO-recommended quality standards [166]. Hence, there is a need for continuous large-scale monitoring of medicine quality is recommended to maintain standards and eliminate substandard products from the pharmaceutical supply chain [166] [180].

In Zambia, there is little evidence regarding the implementation of IPC practices in healthcare facilities. A previous study found low adherence to IPC guidelines among healthcare workers [220]. Additionally, a recent study found good knowledge, attitudes, and practices regarding IPC among students during the COVID-19 pandemic [224]. IPC practices are critical in preventing infections and thus reducing the use of antibiotics [268]-[271]. In this regard, there is a need to promote education and training programs on IPC measures among healthcare workers [272]. Therefore, as enshrined in objective three of the Zambian NAP on AMR, there is a need to promote IPC measures in healthcare facilities and adherence to the guidelines.

In Zambia, poultry is a rapidly increasing sector, contributing 4.8% of the Agricultural Gross Domestic Product (GDP), thus providing a significant income-generating activity [213]. The poultry sector in Zambia is among the major users of antibiotics based on previous studies [33] [59] [67] [210]. Most of the antibiotics are obtained without a prescription, especially from drug stores and agro-veterinary shops [33] [67]. There is evidence of high antibiotic-resistant *E. coli* isolated from poultry in Zambia [69] [76] [77] [84] [85] [99]. This evidence underscores the importance of a One Health approach, which integrates efforts from both human and animal health sectors, to effectively control the spread of MDR *E. coli*. Given the evidence of clonal transmission and the potential for cross-species transmission of resistance genes, coordinated strategies that address both human and animal health are crucial to managing and mitigating the risks posed by MDR pathogens [273]. This finding suggests that while there is clonal transmission of MDR *E. coli* between poultry and humans, these bacteria may also acquire additional, niche-specific AMR plasmids depending on the environment they inhabit [214]. Other evidence has shown the potential for transmission of drug-resistant microorganisms between animals at the wildlife-livestock interface, highlighting the need for further research on the role of wildlife in the development and spread of AMR, a critical global issue [212].

The high prevalence of enterococci in poultry was reported in some studies conducted in Zambia [79] [80]. Resistance genes in the *Enterococcus* species can also be transmitted to pathogenic bacteria if they colonize the same poultry, thus

threatening the safety of poultry production, and leading to significant public health concerns [274]. The presence of antimicrobial-resistant enterococci in poultry is a growing public health concern worldwide due to its potential for transmission to humans [80] [275]. Worldwide, poultry is a major reservoir of Salmonella with an increasing incidence of ESBL-producing strains, similar to findings from Zambia [213]. Therefore, this entails the need to combat AMR using a One Health approach [44] [276].

The presence of antibiotic-resistant bacteria has also been reported in Zambian dairy animals and products [72] [216]. Similar findings have been reported in other studies indicating that AMR is a huge problem in dairy and should be closely monitored to reduce the transmission of resistance genes to humans through the food chain [277]-[280]. This evidence demonstrates the need to strengthen AMR surveillance in other animal species and the environment in line with the GAP recommendations of combating AMR using a One Health approach.

The findings of this review have several implications for policy and practice. Firstly, there is a need for increased investment in healthcare infrastructure, including diagnostic services and infection prevention and control practices [35] [36]. Secondly, there is a need for improved AMS and prescribing practices, including the development of guidelines and training for healthcare professionals [130] [281]. Thirdly, there is a need for increased public awareness, education, and community engagement on AMR and its implications for public health [66] [167]. Addressing the problem of AMR requires strengthened collaborations among different healthcare professionals and sectors [282]-[287]. Evidence from this review paper demonstrates the need to establish and strengthen AMR surveillance systems across the One Health sector, monitor antimicrobial consumption and use, improve adherence to treatment guidelines, improve infection prevention and control measures, promote rational use of antimicrobials, strengthen IPC, reduce overuse and misuse of antimicrobials across the One Health sector, behavioural change concerning the prescribing, dispensing, administration, and use of antimicrobials, and develop effective sustainable strategies to combat AMR in Zambia.

This review provided insight into the publications conducted in Zambia across the One Health sector. The findings demonstrate the presence of drug-resistant pathogens across the One Health sector thereby requiring a collaborative multi-disciplinary and multi-sectoral approach to address AMR.

Future Directions and Policy Implications

The Zambian government has taken various steps to address AMR, including the development of NAP on AMR [103] and the establishment of a national surveillance system on AMR [56]. Most future strategies and research to combat AMR in Zambia must focus and build on the following key areas:

1) Leadership Commitment to Support Strategies to Combat AMR

- To effectively address AMR, there is a need for leadership willing and support intervention strategies for combating AMR. Studies have shown that leadership

support in activities that target to combat AMR has led to successful outcomes in the fight against AMR [288]-[291]. Effective implementation of strategies to address AMR also requires the support and involvement of political leadership [292]-[297]. Therefore, the authors recommend total leadership support and commitment to combat AMR, including leadership at the country level, provincial level, district level, facility level, community level, political, health, economic, business, financial, educational, agricultural, and environmental sectors. The progress made in the implementation of strategies to address AMR in Zambia has been made possible through leadership willingness and commitment. This has been done in line with the recommendation from the GAP and Zambian NAP on AMR [102] [103].

2) Improving Awareness and Understanding of AMR through Effective Communication, Education and Training

- In line with the NAP on AMR, there is a need to continuously strengthen awareness and education across the One Health sector [103]. This would help to promote dissemination of information across all sectors where antimicrobials are used. Currently, the AMRCC has instigated several ways of promoting awareness and has conducted university debates on IPC, AMR, and AMS using a One Health approach. Other activities have included awareness training and meetings involving healthcare workers, farmers, community members, and hospital leadership.

- Further, aligning with the NAP on AMR, there is a need for the inclusion of AMU, AMR, AMS, IPC, and related topics into the education curricula at all levels, and develop accredited continuing professional development (CPD) and in-service training programmes on AMR, including alternative learning methods. Furthermore, there is a need to conduct studies to estimate baseline and endline awareness and knowledge of participants across the One Health sector [103]. The findings of these studies may be used to strengthen interventions to combat AMR in Zambia. The WHO has provided recommendations on how to improve the awareness and knowledge of healthcare workers regarding AMR and AMS [298].

3) Strengthening Knowledge and Evidence Base through Surveillance and Research

- In Zambia, there is a need to promote research and development in traditional medicines as sources of antimicrobial agents as outlined in the NAP on AMR [103]. Further, strengthening integrated AMR surveillance across the One Health sector is crucial to combat AMR in Zambia [50]. Surveillance of AMR patterns in Zambia is significant as it can guide decision-making and empiric treatment of infections [299].

- The AMRCC coordinates surveillance and research regarding AMR and IPC across the One Health sector which is used to inform policy.

- In Zambia, a national coordination structure for AMR surveillance was established, integrating sector-specific surveillance systems into the National Surveillance System. A traceability strategy for food safety surveillance, which included AMR, was implemented.

- Laboratory capacity covering human resources, materials, and infrastructure are being strengthened, and an AMR laboratory network was created and linked to the Global Antimicrobial Surveillance System for data sharing. This ensures reliable drug susceptibility data and provides insights to interpret AMR trends for policy decisions.

- Surveillance in agriculture facilitated early detection of pathogens entering the food chain and their resistance patterns, supporting the development of intervention strategies. An AMR research plan was also developed and implemented through the engagement of research institutions and researchers, who mobilized resources to conduct studies aligned with the national AMR research plan.

- Instigating AMS programs is critical as these activities improve awareness and knowledge of AMU and AMR among target populations [114] [119] [300].

- Hence, the Zambian AMRCC has established and implemented AMS programs in various hospitals to improve knowledge among healthcare workers and hospital management [111].

4) Reducing Infections through Effective Sanitation, Hygiene and Infection Prevention Measures

- Under IPC, Zambia has made progress through the strengthening of national coordination structures for sanitation, infection prevention and control, hygiene, biosecurity, and phytosanitary measures. Other activities have already been implemented and some are ongoing including conducting situation analyses on IPC practices in hospitals, revision of national guidelines and protocols, collaborating with stakeholders across all levels to ensure implementation of national guidelines, strengthening of vaccination programs and preventing and managing AMR in the One Health sector. According to recent evidence, it is important that interventions to address AMR combine AMS, infection prevention, control, sanitation, hygiene, and vaccination [267] [271] [301]-[303].

- Promoting disease prevention through effective IPC strategies is important in reducing the use of antimicrobials and hence preventing the emergence and spread of AMR [268]-[270] [304]. Therefore, there is a need to strengthen IPC measures in line with the GAP and Zambian NAP on AMR [102] [103].

5) Optimizing the Use of Antimicrobials in the One Health Sector

- With evidence of overuse and misuse of antimicrobials across the One Health sector in Zambia, there is a need to promote rational use of antimicrobials as guided in objective four of the NAP on AMR [103].

- The AMRCC strengthens AMS programmes in human, animal, and plant health practices through the engagement of healthcare facility management and professional bodies to mainstream stewardship committees.

- There is also a need to strengthen the pharmaceutical manufacturing and supply chain by reviewing and strengthening the existing quality management system for the supply of medicines, covering manufacturing, production, storage, transport etc. and strengthening the regulatory mechanisms (ZAMRA and Professional bodies) for access to antimicrobial medicines in human, animal, and plant health.

- Quality management systems should be introduced and strengthened at all levels of the supply chain.
- Guidelines for proper disposal of antimicrobials, and animal, and plant waste should be developed, implemented, and/or re-enforced.
- Promoting appropriate use of antimicrobials must be done across the One Health sector [301].
- AMS programs have been reported to be effective in optimizing antimicrobial use [113] [305] [306].
- For healthcare workers, these programs improve prescribing practices for antibiotics and Zambia is currently rolling out AMS programs in hospitals across the country. Going forward, there is a need to reach out and engage communities and all facilities including hospices and clinics that offer health services to the Zambian population.
- Legal provisions in the existing regulations shall be strengthened to address AMR and related factors. Regulations for antimicrobials in food and feed need to be enforced, as well as strengthening antimicrobial policies and standard treatment guidelines for human, terrestrial and aquatic animals, plants, and the environment.

6) Investment in Research and Development of New Medicines, Vaccines, Diagnostic Tools, and Other Interventions

- A plan to secure and use financing for implementation of the AMR NAP and measure the burden of AMR in various sectors. This shall include the assessment and mobilisation of investment requirements for the implementation and development of policies, guidelines, and procedures for the implementation of NAP. Measurements of QALYs, DALYs, mortality rates, and costs associated with infectious diseases/bed spaces/drugs/treatment shall be done to establish the impact of AMR with periodic efficacy studies on antimicrobial medicines.
- The plan promotes access to incentives for industry to invest in the research and development of new antimicrobials and vaccines and promotes linkages among various relevant stakeholders to search for new drugs, vaccines and diagnostic tools.
- The implementation of this plan will require close collaboration among all stakeholders, and it is hoped that there shall be timely dissemination of data to relevant parties in order to take quick actions to contain the spread of antimicrobial-resistant pathogens.
- Research into new antimicrobials can help mitigate morbidity and mortality associated with AMR [301]. There is also a recommendation to conduct research in the 40 priority areas identified and set by the WHO [307].
- Due to the evidence of AMR in humans, animals, and the environment, this calls for addressing this problem using a One Health approach [101]. With many efforts being put in place, there is a need to strengthen all efforts to combat AMR in Zambia. Further, strengthening the regulation of appropriate use of antimicrobials in humans, animals, agriculture, and the environment is very critical in

addressing AMR.

7) Strengthened International and Local Collaborations

- Addressing AMR requires effective collaborations among stakeholders and key players [282] [285] [287] [308] [309]. Partners and organizations play vital roles in providing resources, materials, and training to combat AMR [310] [311]. Hence, it is critical to leverage international and local collaborations to address AMR as it is a global public health problem [312]. Further, countries need to collaborate by contributing various resources towards the fight against AMR. Further, maintaining partners and stakeholders is essential to the success of the fight against AMR.

5. Conclusion

Antimicrobial resistance is a significant public health concern in Zambia, with high rates of resistance reported among various microorganisms including *E. coli*, *K. pneumoniae*, *S. aureus*, *P. aeruginosa*, *E. faecalis*, *E. faecium*, *Salmonella* species, *M. Tuberculosis*, *Candida albicans*, *Plasmodium falciparum*, and HIV. The drug resistance index was reported to be high in Zambia indicating a low effectiveness of antibiotics. Consequently, the burden of AMR is not well documented in Zambia despite indicating a high drug resistance index. This review found that the main drivers of AMR include the overuse and misuse of antimicrobials, a lack of awareness and knowledge of antimicrobial use and AMR, limited access to quality healthcare and diagnostic services, poor infection prevention and control practices, non-adherence to treatment guidelines, and lack of effective surveillance and monitoring systems. Addressing AMR in Zambia requires a multi-sectoral approach that includes strengthening surveillance and monitoring systems, improving AMS and prescribing practices, enhancing infection prevention and control practices, increasing access to quality healthcare and diagnostic services, and promoting public awareness and education. The Zambian government must strengthen collaborations with other stakeholders and ensure the effective implementation of interventions to combat AMR and protect public health and food security.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

- [1] Sartelli, M., Barie, P.S., Coccolini, F., Abbas, M., Abbo, L.M., Abdukhalilova, G.K., *et al.* (2023) Ten Golden Rules for Optimal Antibiotic Use in Hospital Settings: The WARNING Call to Action. *World Journal of Emergency Surgery*, **18**, Article No. 50. <https://wjeb.biomedcentral.com/articles/10.1186/s13017-023-00518-3>
- [2] Murray, C.J., Ikuta, K.S., Sharara, F., Swetschinski, L., Robles Aguilar, G., Gray, A., *et al.* (2022) Global Burden of Bacterial Antimicrobial Resistance in 2019: A Systematic Analysis. *The Lancet*, **399**, 629-655. <http://www.thelancet.com/article/S0140673621027240/fulltext>

- [3] Prestinaci, F., Pezzotti, P. and Pantosti, A. (2015) Antimicrobial Resistance: A Global Multifaceted Phenomenon. *Pathogens and Global Health*, **109**, 309-318. <https://doi.org/10.1179/2047773215y.0000000030>
- [4] Salam, M.A., Al-Amin, M.Y., Salam, M.T., Pawar, J.S., Akhter, N., Rabaan, A.A., *et al.* (2023) Antimicrobial Resistance: A Growing Serious Threat for Global Public Health. *Healthcare*, **11**, Article 1946. <https://doi.org/10.3390/healthcare11131946>
- [5] Huttner, A., Harbarth, S., Carlet, J., Cosgrove, S., Goossens, H., Holmes, A., *et al.* (2013) Antimicrobial Resistance: A Global View from the 2013 World Healthcare-Associated Infections Forum. *Antimicrobial Resistance and Infection Control*, **2**, Article No. 31. <https://doi.org/10.1186/2047-2994-2-31>
- [6] Ikuta, K.S., Swetschinski, L.R., Robles Aguilar, G., Sharara, F., Mestrovic, T., Gray, A.P., *et al.* (2022) Global Mortality Associated with 33 Bacterial Pathogens in 2019: A Systematic Analysis for the Global Burden of Disease Study 2019. *The Lancet*, **400**, 2221-2248. <http://www.thelancet.com/article/S0140673622021857/fulltext>
- [7] Ahmed, S.K., Hussein, S., Qurbani, K., Ibrahim, R.H., Fareeq, A., Mahmood, K.A., *et al.* (2024) Antimicrobial Resistance: Impacts, Challenges, and Future Prospects. *Journal of Medicine, Surgery, and Public Health*, **2**, Article ID: 100081. <https://doi.org/10.1016/j.gmedi.2024.100081>
- [8] Dadgostar, P. (2019) Antimicrobial Resistance: Implications and Costs. *Infection and Drug Resistance*, **12**, 3903-3910. <https://doi.org/10.2147/idr.s234610>
- [9] Ait Ouakrim, D., Cassini, A., Cecchini, M. and Plauchoras, D. (2020) The Health and Economic Burden of Antimicrobial Resistance. *European Journal of Public Health*, **30**, 23-44. <https://doi.org/10.1093/eurpub/ckaa165.1201>
- [10] Jain, A., Mahajan, M., Upananlawar, A. and Upasani, C. (2024) Impact of Antimicrobial Resistance in Health and Economic Outcomes: A Review. *Advances in Pharmacology and Clinical Trials*, **9**, Article ID: 000234. <https://doi.org/10.23880/apct-16000234>
- [11] Innes, G.K., Randad, P.R., Korinek, A., Davis, M.F., Price, L.B., So, A.D., *et al.* (2020) External Societal Costs of Antimicrobial Resistance in Humans Attributable to Antimicrobial Use in Livestock. *Annual Review of Public Health*, **41**, 141-157. <https://doi.org/10.1146/annurev-publhealth-040218-043954>
- [12] ZNPHI (2022) Approximately 1.2 Million People Died from Antimicrobial Resistance in 2019. Zambia National Public Health Institute. <https://w2.znphi.co.zm/2022/10/08/approximately-1-2-million-people-died-from-antimicrobial-resistance-in-2019/>
- [13] Paneri, M. and Sevta, P. (2023) Overview of Antimicrobial Resistance: An Emerging Silent Pandemic. *Global Journal of Medical, Pharmaceutical, and Biomedical Update*, **18**, Article 11. https://doi.org/10.25259/gjmbu_153_2022
- [14] Porter, G., Joshi, J., Bhullar, L. and Kotwani, A. (2020) Using 'Smart Regulation' to Tackle Antimicrobial Resistance in Low-Income and Middle-Income Countries. *BMJ Global Health*, **5**, e001864. <https://doi.org/10.1136/bmjgh-2019-001864>
- [15] de Kraker, M.E.A., Stewardson, A.J. and Harbarth, S. (2016) Will 10 Million People Die a Year Due to Antimicrobial Resistance by 2050? *PLOS Medicine*, **13**, e1002184. <https://doi.org/10.1371/journal.pmed.1002184>
- [16] EClinicalMedicine, (2021) Antimicrobial Resistance: A Top Ten Global Public Health Threat. *eClinicalMedicine*, **41**, Article ID: 101221. <https://doi.org/10.1016/j.eclinm.2021.101221>
- [17] World Health Organization (2019) Ten Threats to Global Health in 2019. <https://www.who.int/news-room/spotlight/ten-threats-to-global-health-in-2019>

- [18] Bertagnolio, S., Suthar, A.B., Tosas, O. and Van Weezenbeek, K. (2023) Antimicrobial Resistance: Strengthening Surveillance for Public Health Action. *PLOS Medicine*, **20**, e1004265. <https://doi.org/10.1371/journal.pmed.1004265>
- [19] Sharma, C., Rokana, N., Chandra, M., Singh, B.P., Gulhane, R.D., Gill, J.P.S., *et al.* (2018) Antimicrobial Resistance: Its Surveillance, Impact, and Alternative Management Strategies in Dairy Animals. *Frontiers in Veterinary Science*, **4**, Article 237. <https://doi.org/10.3389/fvets.2017.00237>
- [20] Leonard, C., Crabb, N., Glover, D., Cooper, S., Bouvy, J., Wobbe, M., *et al.* (2023) Can the UK 'Netflix' Payment Model Boost the Antibacterial Pipeline? *Applied Health Economics and Health Policy*, **21**, 365-372. <https://doi.org/10.1007/s40258-022-00786-1>
- [21] Wasan, H., Singh, D., Reeta, K.H. and Gupta, Y.K. (2023) Landscape of Push Funding in Antibiotic Research: Current Status and Way Forward. *Biology*, **12**, Article 101. <https://doi.org/10.3390/biology12010101>
- [22] Sartorius, B., Gray, A.P., Davis Weaver, N., Robles Aguilar, G., Swetschinski, L.R., Ikuta, K.S., *et al.* (2024) The Burden of Bacterial Antimicrobial Resistance in the WHO African Region in 2019: A Cross-Country Systematic Analysis. *The Lancet Global Health*, **12**, E201-E216. <http://www.thelancet.com/article/S2214109X23005399/fulltext>
- [23] Lubanga, A.F., Bwanali, A.N., Kambiri, F., Harawa, G., Mudenda, S., Mpinganjira, S.L., *et al.* (2024) Tackling Antimicrobial Resistance in Sub-Saharan Africa: Challenges and Opportunities for Implementing the New People-Centered WHO Guidelines. *Expert Review of Anti-infective Therapy*, **22**, 379-386. <https://doi.org/10.1080/14787210.2024.2362270>
- [24] Godman, B., Ekwuenu, A., Wesangula, E., Schellack, N., Kalungia, A.C., Tiroyakgosi, C., *et al.* (2022) Tackling Antimicrobial Resistance across Sub-Saharan Africa: Current Challenges and Implications for the Future. *Expert Opinion on Drug Safety*, **21**, 1089-1111. <https://doi.org/10.1080/14740338.2022.2106368>
- [25] Kariuki, S., Kering, K., Wairimu, C., Onsare, R. and Mbae, C. (2022) Antimicrobial Resistance Rates and Surveillance in Sub-Saharan Africa: Where Are We Now? *Infection and Drug Resistance*, **15**, 3589-3609. <https://doi.org/10.2147/idr.s342753>
- [26] Woldu, M.A. (2024) Antimicrobial Resistance in Ethiopia: Current Landscape, Challenges, and Strategic Interventions. *Discover Medicine*, **1**, Article No. 68. <https://doi.org/10.1007/s44337-024-00090-y>
- [27] Kakkar, A.K., Shafiq, N., Singh, G., Ray, P., Gautam, V., Agarwal, R., *et al.* (2020) Antimicrobial Stewardship Programs in Resource Constrained Environments: Understanding and Addressing the Need of the Systems. *Frontiers in Public Health*, **8**, Article 140. <https://doi.org/10.3389/fpubh.2020.00140>
- [28] Sharma, A., Singh, A., Dar, M.A., Kaur, R.J., Charan, J., Iskandar, K., *et al.* (2022) Menace of Antimicrobial Resistance in LMICs: Current Surveillance Practices and Control Measures to Tackle Hostility. *Journal of Infection and Public Health*, **15**, 172-181. <https://doi.org/10.1016/j.jiph.2021.12.008>
- [29] Gandra, S., Alvarez-Uria, G., Turner, P., Joshi, J., Limmathurotsakul, D. and van Doorn, H.R. (2020) Antimicrobial Resistance Surveillance in Low- and Middle-Income Countries: Progress and Challenges in Eight South Asian and Southeast Asian Countries. *Clinical Microbiology Reviews*, **33**, e00048-19. <https://doi.org/10.1128/cmr.00048-19>
- [30] Sartelli, M., C. Hardcastle, T., Catena, F., Chichom-Mefire, A., Coccolini, F., Dhingra, S., *et al.* (2020) Antibiotic Use in Low and Middle-Income Countries and the Challenges

- of Antimicrobial Resistance in Surgery. *Antibiotics*, **9**, Article 497.
<https://doi.org/10.3390/antibiotics9080497>
- [31] O'Neill, J. (2016) Tackling Drug-Resistant Infections Globally: Final Report and Recommendations. The Review on Antimicrobial Resistance.
https://amr-review.org/sites/default/files/160518_Final%20paper_with%20cover.pdf
- [32] Sono, T.M., Yeika, E., Cook, A., Kalungia, A., Opanga, S.A., Acolatse, J.E.E., *et al.* (2023) Current Rates of Purchasing of Antibiotics without a Prescription across Sub-Saharan Africa; Rationale and Potential Programmes to Reduce Inappropriate Dispensing and Resistance. *Expert Review of Anti-Infective Therapy*, **21**, 1025-1055.
<https://doi.org/10.1080/14787210.2023.2259106>
- [33] Mudenda, S., Mulenga, K.M., Nyirongo, R., Chabalenge, B., Chileshe, C., Daka, V., *et al.* (2024) Non-prescription Sale and Dispensing of Antibiotics for Prophylaxis in Broiler Chickens in Lusaka District, Zambia: Findings and Implications on One Health. *JAC-Antimicrobial Resistance*, **6**, dlac094.
<https://doi.org/10.1093/jacamr/dlae094>
- [34] Kalungia, A.C., Burger, J., Godman, B., Costa, J.d.O. and Simuwelu, C. (2016) Non-prescription Sale and Dispensing of Antibiotics in Community Pharmacies in Zambia. *Expert Review of Anti-Infective Therapy*, **14**, 1215-1223.
<https://doi.org/10.1080/14787210.2016.1227702>
- [35] Yamba, K., Chizimu, J.Y., Mudenda, S., Lukwesa, C., Chanda, R., Nakazwe, R., *et al.* (2024) Assessment of Antimicrobial Resistance Laboratory-Based Surveillance Capacity of Hospitals in Zambia: Findings and Implications for System Strengthening. *Journal of Hospital Infection*, **148**, 129-137.
<https://doi.org/10.1016/j.jhin.2024.03.014>
- [36] Shempela, D.M., Mudenda, S., Kasanga, M., Daka, V., Kangongwe, M.H., Kamayani, M., *et al.* (2024) A Situation Analysis of the Capacity of Laboratories in Faith-Based Hospitals in Zambia to Conduct Surveillance of Antimicrobial Resistance: Opportunities to Improve Diagnostic Stewardship. *Microorganisms*, **12**, Article 1697.
<https://doi.org/10.3390/microorganisms12081697>
- [37] Moirongo, R.M., Aglanu, L.M., Lamshöft, M., Adero, B.O., Yator, S., Anyona, S., *et al.* (2022) Laboratory-based Surveillance of Antimicrobial Resistance in Regions of Kenya: An Assessment of Capacities, Practices, and Barriers by Means of Multi-Facility Survey. *Frontiers in Public Health*, **10**, Article 1003178.
<https://doi.org/10.3389/fpubh.2022.1003178>
- [38] Zongo, E., Dama, E., Yenyetou, D., Muhigwa, M., Nikiema, A., Dahourou, G.A., *et al.* (2024) On-Site Evaluation as External Quality Assessment of Microbiology Laboratories Involved in Sentinel Laboratory-Based Antimicrobial Resistance Surveillance Network in Burkina Faso. *Antimicrobial Resistance & Infection Control*, **13**, Article No. 3. <https://doi.org/10.1186/s13756-023-01362-5>
- [39] Iskandar, K., Molinier, L., Hallit, S., Sartelli, M., Catena, F., Coccolini, F., *et al.* (2020) Drivers of Antibiotic Resistance Transmission in Low- and Middle-Income Countries from a “One Health” Perspective—A Review. *Antibiotics*, **9**, Article 372.
<https://doi.org/10.3390/antibiotics9070372>
- [40] Essack, S.Y. and Lenglet, A. (2024) Bacterial Antimicrobial Resistance Burden in Africa: Accuracy, Action, and Alternatives. *The Lancet Global Health*, **12**, e171-e172.
[https://doi.org/10.1016/s2214-109x\(23\)00587-9](https://doi.org/10.1016/s2214-109x(23)00587-9)
- [41] Sengupta, S., Barman, P. and Lo, J. (2019) Opportunities to Overcome Implementation Challenges of Infection Prevention and Control in Low-Middle Income Countries. *Current Treatment Options in Infectious Diseases*, **11**, 267-280.
<https://doi.org/10.1007/s40506-019-00200-w>

- [42] Gandra, S., Tseng, K.K., Arora, A., Bhowmik, B., Robinson, M.L., Panigrahi, B., *et al.* (2018) The Mortality Burden of Multidrug-Resistant Pathogens in India: A Retrospective, Observational Study. *Clinical Infectious Diseases*, **69**, 563-570. <https://doi.org/10.1093/cid/ciy955>
- [43] Solomon, E.T., Gari, S.R., Kloos, H. and Mengistie, B. (2020) Diarrheal Morbidity and Predisposing Factors among Children under 5 Years of Age in Rural East Ethiopia. *Tropical Medicine and Health*, **48**, Article No. 66. <https://doi.org/10.1186/s41182-020-00253-4>
- [44] Mudenda, S., Chabalenge, B., Daka, V., Mfuno, R.L., Salachi, K.I., Mohamed, S., *et al.* (2023) Global Strategies to Combat Antimicrobial Resistance: A One Health Perspective. *Pharmacology & Pharmacy*, **14**, 271-328. <https://doi.org/10.4236/pp.2023.148020>
- [45] Khadse, S.N., Ugemuge, S. and Singh, C. (2023) Impact of Antimicrobial Stewardship on Reducing Antimicrobial Resistance. *Cureus*, **15**, e49935. <https://doi.org/10.7759/cureus.49935>
- [46] Godman, B., Haque, M., McKimm, J., Abu Bakar, M., Sneddon, J., Wale, J., *et al.* (2019) Ongoing Strategies to Improve the Management of Upper Respiratory Tract Infections and Reduce Inappropriate Antibiotic Use Particularly among Lower and Middle-Income Countries: Findings and Implications for the Future. *Current Medical Research and Opinion*, **36**, 301-327. <https://doi.org/10.1080/03007995.2019.1700947>
- [47] Agyare, E., Acolatse, J.E.E., Dakorah, M.P., Akafity, G., Chalker, V.J., Spiller, O.B., *et al.* (2024) Antimicrobial Stewardship Capacity and Antibiotic Utilisation Practices in the Cape Coast Teaching Hospital, Ghana: A Point Prevalence Survey Study. *PLOS ONE*, **19**, e0297626. <https://doi.org/10.1371/journal.pone.0297626>
- [48] Rogers Van Katwyk, S., Hoffman, S.J., Mendelson, M., Taljaard, M. and Grimshaw, J.M. (2020) Strengthening the Science of Addressing Antimicrobial Resistance: A Framework for Planning, Conducting and Disseminating Antimicrobial Resistance Intervention Research. *Health Research Policy and Systems*, **18**, e0297626. <https://doi.org/10.1186/s12961-020-00549-1>
- [49] Shawa, M., Paudel, A., Chambaro, H., Kamboyi, H., Nakazwe, R., Alutuli, L., *et al.* (2024) Trends, Patterns and Relationship of Antimicrobial Use and Resistance in Bacterial Isolates Tested between 2015-2020 in a National Referral Hospital of Zambia. *PLOS ONE*, **19**, e0302053. <https://doi.org/10.1371/journal.pone.0302053>
- [50] Zambia National Public Health Institute (2020) Baseline Information for Integrated Anti-Microbial Resistance Surveillance in Zambia. <https://www.afro.who.int/publications/baseline-information-integrated-antimicrobial-resistance-surveillance-zambia>
- [51] Mwansa, T.N., Kamvuma, K., Mulemena, J.A., Phiri, C.N. and Chanda, W. (2022) Antibiotic Susceptibility Patterns of Pathogens Isolated from Laboratory Specimens at Livingstone Central Hospital in Zambia. *PLOS Global Public Health*, **2**, e0000623. <https://doi.org/10.1371/journal.pgph.0000623>
- [52] Kasanga, M., Mukosha, R., Kasanga, M., Siyanga, M., Mudenda, S., Solochi, B.B., *et al.* (2021) Antimicrobial Resistance Patterns of Bacterial Pathogens: Their Distribution in University Teaching Hospitals in Zambia. *Future Microbiology*, **16**, 811-824. <https://doi.org/10.2217/fmb-2021-0104>
- [53] Nowbuth, A., Asombang, A., Tazikeng, N., Makinde, O. and Sheets, L. (2022) Antimicrobial Resistance in Zambia: A Systematic Review. *International Journal of Infectious Diseases*, **116**, S17-S18. <https://doi.org/10.1016/j.ijid.2021.12.042>

- [54] Nowbuth, A.A., Asombang, A.W., Tazinkeng, N.N., Makinde, O.Y. and Sheets, L.R. (2023) Antimicrobial Resistance from a One Health Perspective in Zambia: A Systematic Review. *Antimicrobial Resistance & Infection Control*, **12**, Article No. 15. <https://doi.org/10.1186/s13756-023-01224-0>
- [55] Centre for Infectious Disease Research in Zambia (2020) One Health Surveillance Platform for Antimicrobial Resistance Launched in Zambia. <https://www.cidrz.org/2020/03/26/one-health-surveillance-platform-for-antimicrobial-resistance-launched-in-zambia/>
- [56] Republic of Zambia AMRCC (2020) Zambia's Integrated Antimicrobial Resistance Surveillance Framework. <https://www.afro.who.int/publications/zambias-integrated-antimicrobial-resistance-surveillance-framework>
- [57] Matee, M., Mshana, S.E., Mtebe, M., Komba, E.V., Moremi, N., Lutamwa, J., *et al.* (2023) Mapping and Gap Analysis on Antimicrobial Resistance Surveillance Systems in Kenya, Tanzania, Uganda and Zambia. *Bulletin of the National Research Centre*, **47**, Article No. 12. <https://doi.org/10.1186/s42269-023-00986-2>
- [58] ASLM (2022) MAAP Report Zambia 2016-2018. <https://aslm.org/flip-books/ZAMBIA/REPORT-ZAMBIA-PRINT.html>
- [59] Mudenda, S., Bumbangi, F.N., Yamba, K., Munyeme, M., Malama, S., Mukosha, M., *et al.* (2023) Drivers of Antimicrobial Resistance in Layer Poultry Farming: Evidence from High Prevalence of Multidrug-Resistant *Escherichia coli* and Enterococci in Zambia. *Veterinary World*, **16**, 1803-1814. <https://doi.org/10.14202/vetworld.2023.1803-1814>
- [60] Otaigbe, I.I. and Elikwu, C.J. (2023) Drivers of Inappropriate Antibiotic Use in Low- and Middle-Income Countries. *JAC-Antimicrobial Resistance*, **5**, dlad062. <https://doi.org/10.1093/jacamr/dlad062>
- [61] Masich, A.M., Vega, A.D., Callahan, P., Herbert, A., Fwoloshi, S., Zulu, P.M., *et al.* (2020) Antimicrobial Usage at a Large Teaching Hospital in Lusaka, Zambia. *PLOS ONE*, **15**, e0228555. <https://doi.org/10.1371/journal.pone.0228555>
- [62] Kalungia, A.C., Mukosha, M., Mwila, C., Banda, D., Mwale, M., Kagulura, S., *et al.* (2022) Antibiotic Use and Stewardship Indicators in the First- And Second-Level Hospitals in Zambia: Findings and Implications for the Future. *Antibiotics*, **11**, Article 1626. <https://doi.org/10.3390/antibiotics11111626>
- [63] Mudenda, S., Nsofu, E., Chisha, P., Daka, V., Chabalenge, B., Mufwambi, W., *et al.* (2023) Prescribing Patterns of Antibiotics According to the WHO Aware Classification during the COVID-19 Pandemic at a Teaching Hospital in Lusaka, Zambia: Implications for Strengthening of Antimicrobial Stewardship Programmes. *Pharmacoepidemiology*, **2**, 42-53. <https://doi.org/10.3390/pharma2010005>
- [64] Mudenda, S., Chomba, M., Chabalenge, B., Hikaambo, C.N., Banda, M., Daka, V., *et al.* (2022) Antibiotic Prescribing Patterns in Adult Patients According to the WHO AWaRe Classification: A Multi-Facility Cross-Sectional Study in Primary Healthcare Hospitals in Lusaka, Zambia. *Pharmacology & Pharmacy*, **13**, 379-392. <http://www.scirp.org/journal/PaperInformation.aspx?PaperID=120529>
- [65] Mudenda, W., Chikatula, E., Chambula, E., Mwanashimbala, B., Chikuta, M., Masaninga, F., *et al.* (2016) Prescribing Patterns and Medicine Use at the University Teaching Hospital, Lusaka, Zambia. *Medical Journal of Zambia*, **43**, 94-102. <https://doi.org/10.55320/mjz.43.2.344>
- [66] Mudenda, S., Simukoko, N. and Mohamed, S. (2024) Knowledge, Attitude and Practices Regarding Antimicrobial Use and Resistance among Community Members of

- Mtendere Township in Lusaka, Zambia: Findings and Implications on Antimicrobial Stewardship. *International Journal of Basic & Clinical Pharmacology*, **13**, 315-321. <https://doi.org/10.18203/2319-2003.ijbcp20240985>
- [67] Mudenda, S., Malama, S., Munyeme, M., Hang'ombe, B.M., Mainda, G., Kapona, O., *et al.* (2022) Awareness of Antimicrobial Resistance and Associated Factors among Layer Poultry Farmers in Zambia: Implications for Surveillance and Antimicrobial Stewardship Programs. *Antibiotics*, **11**, Article 383. <https://doi.org/10.3390/antibiotics11030383>
- [68] Mudenda, S., Chisha, P., Chabalenge, B., Daka, V., Mfuno, R.L., Kasanga, M., *et al.* (2023) Antimicrobial Stewardship: Knowledge, Attitudes and Practices Regarding Antimicrobial Use and Resistance among Non-Healthcare Students at the University of Zambia. *JAC-Antimicrobial Resistance*, **5**, dlad116. <https://doi.org/10.1093/jacamr/dlad116>
- [69] Mudenda, S., Malama, S., Munyeme, M., Matafwali, S.K., Kapila, P., Katemangwe, P., *et al.* (2023) Antimicrobial Resistance Profiles of *Escherichia coli* Isolated from Laying Hens in Zambia: Implications and Significance on One Health. *JAC-Antimicrobial Resistance*, **5**, dlad060. <https://doi.org/10.1093/jacamr/dlad060>
- [70] Kasanga, M., Shempela, D.M., Daka, V., Mwikisa, M.J., Sikalima, J., Chanda, D., *et al.* (2024) Antimicrobial Resistance Profiles of *Escherichia coli* Isolated from Clinical and Environmental Samples: Findings and Implications. *JAC-Antimicrobial Resistance*, **6**, dlac061. <https://doi.org/10.1093/jacamr/dlac061>
- [71] Kasanga, M., Kwenda, G., Wu, J., Kasanga, M., Mwikisa, M.J., Chanda, R., *et al.* (2023) Antimicrobial Resistance Patterns and Risk Factors Associated with ESBL-Producing and MDR *Escherichia coli* in Hospital and Environmental Settings in Lusaka, Zambia: Implications for One Health, Antimicrobial Stewardship and Surveillance Systems. *Microorganisms*, **11**, Article 1951. <https://doi.org/10.3390/microorganisms11081951>
- [72] Mwasinga, W., Shawa, M., Katemangwe, P., Chambaro, H., Mpundu, P., M'kandawire, E., *et al.* (2023) Multidrug-Resistant *Escherichia coli* from Raw Cow Milk in Namwala District, Zambia: Public Health Implications. *Antibiotics*, **12**, Article 1421. <https://doi.org/10.3390/antibiotics12091421>
- [73] Bumbangi, F.N., Llarena, A., Skjerve, E., Hang'ombe, B.M., Mpundu, P., Mudenda, S., *et al.* (2022) Evidence of Community-Wide Spread of Multi-Drug Resistant *Escherichia coli* in Young Children in Lusaka and Ndola Districts, Zambia. *Microorganisms*, **10**, Article 1684. <https://doi.org/10.3390/microorganisms10081684>
- [74] Chiyangi, H., Muma, J.B., Malama, S., Manyahi, J., Abade, A., Kwenda, G., *et al.* (2017) Identification and Antimicrobial Resistance Patterns of Bacterial Enteropathogens from Children Aged 0-59 Months at the University Teaching Hospital, Lusaka, Zambia: A Prospective Cross Sectional Study. *BMC Infectious Diseases*, **17**, Article No. 117. <https://doi.org/10.1186/s12879-017-2232-0>
- [75] Chishimba, K., Hang'ombe, B.M., Muzandu, K., Mshana, S.E., Matee, M.I., Nakajima, C., *et al.* (2016) Detection of Extended-Spectrum β -Lactamase-Producing *Escherichia coli* in Market-Ready Chickens in Zambia. *International Journal of Microbiology*, **2016**, Article ID: 5275724. <https://doi.org/10.1155/2016/5275724>
- [76] Mwansa, M., Mukuma, M., Mulilo, E., Kwenda, G., Mainda, G., Yamba, K., *et al.* (2023) Determination of Antimicrobial Resistance Patterns of *Escherichia coli* Isolates from Farm Workers in Broiler Poultry Production and Assessment of Antibiotic Resistance Awareness Levels among Poultry Farmers in Lusaka, Zambia. *Frontiers in Public Health*, **10**, Article 998860. <https://doi.org/10.3389/fpubh.2022.998860>

- [77] Sinyawa, T., Shawa, M., Muuka, G.M., Goma, F., Fandamu, P., Chizimu, J.Y., *et al.* (2024) Antimicrobial Use Survey and Detection of ESBL-*Escherichia coli* in Commercial and Medium-/Small-Scale Poultry Farms in Selected Districts of Zambia. *Antibiotics*, **13**, Article 467. <https://doi.org/10.3390/antibiotics13050467>
- [78] Kasanga, M., Gajdacs, M., Muleya, W., Ikhimiukor, O.O., Mudenda, S., Kasanga, M., *et al.* (2024) Genotypic Characterisation and Antimicrobial Resistance of Extended-Spectrum B-Lactamase-Producing *Escherichia coli* in Humans, Animals, and the Environment from Lusaka, Zambia: Public Health Implications and One Health Surveillance. *Antibiotics*, **13**, Article 951. <https://doi.org/10.3390/antibiotics13100951>
- [79] Mudenda, S., Matafwali, S.K., Malama, S., Munyeme, M., Yamba, K., Katemangwe, P., *et al.* (2022) Prevalence and Antimicrobial Resistance Patterns of *Enterococcus* Species Isolated from Laying Hens in Lusaka and Copperbelt Provinces of Zambia: A Call for AMR Surveillance in the Poultry Sector. *JAC-Antimicrobial Resistance*, **4**, dlac126. <https://doi.org/10.1093/jacamr/dlac126>
- [80] Mwikuma, G., Kainga, H., Kallu, S.A., Nakajima, C., Suzuki, Y. and Hang'ombe, B.M. (2023) Determination of the Prevalence and Antimicrobial Resistance of *Enterococcus Faecalis* and *Enterococcus Faecium* Associated with Poultry in Four Districts in Zambia. *Antibiotics*, **12**, Article 657. <https://doi.org/10.3390/antibiotics12040657>
- [81] Chakolwa, G., Samutela, M.T., Kwenda, G., Mulundu, G., Mwansa, J., Hang'ombe, B.M., *et al.* (2019) Carriage Rate and Antimicrobial Resistance Profiles of *Staphylococcus aureus* among Healthcare Workers at a Large Tertiary Referral Hospital in Lusaka, Zambia. *Scientific African*, **5**, e00105. <https://doi.org/10.1016/j.sciaf.2019.e00105>
- [82] Samutela, M.T., Phiri, B.S.J., Simulundu, E., Kwenda, G., Moonga, L., Bwalya, E.C., *et al.* (2022) Antimicrobial Susceptibility Profiles and Molecular Characterisation of *Staphylococcus aureus* from Pigs and Workers at Farms and Abattoirs in Zambia. *Antibiotics*, **11**, Article 844. <https://doi.org/10.3390/antibiotics11070844>
- [83] Samutela, M.T., Kalonda, A., Mwansa, J., Lukwesa-Musyani, C., Mwaba, J., Mumbula, E.M., *et al.* (2017) Molecular Characterisation of Methicillin-Resistant *Staphylococcus aureus* (MRSA) Isolated at a Large Referral Hospital in Zambia. *Pan African Medical Journal*, **26**, Article 108. <https://www.panafrican-med-journal.com/content/article/26/108/full/>
- [84] Phiri, N., Mainda, G., Mukuma, M., Sinyangwe, N.N., Banda, L.J., Kwenda, G., *et al.* (2020) Antibiotic-Resistant *Salmonella* Species and *Escherichia coli* in Broiler Chickens from Farms, Abattoirs, and Open Markets in Selected Districts of Zambia. *Journal of Epidemiological Research*, **6**, 13-21. <https://doi.org/10.5430/jer.v6n1p13>
- [85] Muligisa-Muonga, E., Mainda, G., Mukuma, M., Kwenda, G., Hang'ombe, B., Flavien, B.N., *et al.* (2021) Antimicrobial Resistance of *Escherichia coli* and *Salmonella* Isolated from Retail Broiler Chicken Carcasses in Zambia. *Journal of Epidemiological Research*, **6**, 35-43. <https://doi.org/10.5430/jer.v6n1p35>
- [86] Chizimu, J.Y., Solo, E.S., Bwalya, P., Kapalamula, T.F., Akapelwa, M.L., Lungu, P., *et al.* (2022) Genetic Diversity and Transmission of Multidrug-Resistant *Mycobacterium Tuberculosis* Strains in Lusaka, Zambia. *International Journal of Infectious Diseases*, **114**, 142-150. <https://doi.org/10.1016/j.ijid.2021.10.044>
- [87] Habeenzu, C., Mitarai, S., Lubasi, D., Mudenda, V., Kantenga, T., Mwansa, J., *et al.* (2007) Tuberculosis and Multidrug Resistance in Zambian Prisons, 2000-2001. *The International Journal of Tuberculosis and Lung Disease*, **11**, 1216-1220.
- [88] Masenga, S.K., Mubila, H. and Hamooya, B.M. (2017) Rifampicin Resistance in *Mycobacterium Tuberculosis* Patients Using Genexpert at Livingstone Central Hospital for the Year 2015: A Cross Sectional Explorative Study. *BMC Infectious Diseases*, **17**,

- Article No. 640. <https://doi.org/10.1186/s12879-017-2750-9>
- [89] Kapata, N., Chanda-Kapata, P., Bates, M., Mwaba, P., Cobelens, F., Grobusch, M.P., *et al.* (2013) Multidrug-Resistant tb in Zambia: Review of National Data from 2000 to 2011. *Tropical Medicine & International Health*, **18**, 1386-1391. <https://doi.org/10.1111/tmi.12183>
- [90] Monde, N., Munyeme, M., Chongwe, G., Wensman, J.J., Zulu, M., Siziya, S., *et al.* (2023) First and Second-Line Anti-Tuberculosis Drug-Resistance Patterns in Pulmonary Tuberculosis Patients in Zambia. *Antibiotics*, **12**, Article 166. <https://doi.org/10.3390/antibiotics12010166>
- [91] Monde, N., Zulu, M., Tembo, M., Handema, R., Munyeme, M. and Malama, S. (2021) Drug Resistant Tuberculosis in the Northern Region of Zambia: A Retrospective Study. *Frontiers in Tropical Diseases*, **2**, Article 735028. <https://doi.org/10.3389/fitd.2021.735028>
- [92] Chanda, E. (2024) The Clinical Profile and Outcomes of Drug Resistant Tuberculosis in Central Province of Zambia. *BMC Infectious Diseases*, **24**, Article No. 364. <https://doi.org/10.1186/s12879-024-09238-8>
- [93] Chizimu, J.Y., Solo, E.S., Bwalya, P., Kapalamula, T.F., Mwale, K.K., Squarre, D., *et al.* (2023) Genomic Analysis of Mycobacterium Tuberculosis Strains Resistant to Second-Line Anti-Tuberculosis Drugs in Lusaka, Zambia. *Antibiotics*, **12**, Article 1126. <https://doi.org/10.3390/antibiotics12071126>
- [94] Kangongwe, M.H., Mwanza, W., Mwamba, M., Mwenya, J., Muzyamba, J., Mzyece, J., *et al.* (2024) Drug Resistance Profiles of *Mycobacterium tuberculosis* Clinical Isolates by Genotype MTBDRplus Line Probe Assay in Zambia: Findings and Implications. *JAC-Antimicrobial Resistance*, **6**, dlae122. <https://doi.org/10.1093/jacamr/dlae122>
- [95] Sikwewa, K., Simusika, P., Mumbula, M., M Mwenya, D., Mandona, C. and Mulundu, G. (2023) The Occurrence of Fungi from Burn Wound Patients and Antifungal Susceptibility Patterns: A Cross-Sectional Study in Lusaka, Zambia. *African Health Sciences*, **23**, 506-513. <https://doi.org/10.4314/ahs.v23i3.58>
- [96] Sarenje, K.L., Lukwesa-Musyani, C., Mwansa, J.C.L., Samutela, M.T., Kalonda, A., Kaile, T., *et al.* (2017) Distribution and Antifungal Susceptibility Ofcandida Species Isolated from Clinical Specimens at the University Teaching Hospital, Lusaka, Zambia. *IOSR Journal of Pharmacy (IOSRPHR)*, **7**, 1-9. <https://doi.org/10.9790/3013-0702010109>
- [97] Bennett, S.J., Chunda-Liyoka, C., Poppe, L.K., Meinders, K., Chileshe, C., West, J.T., *et al.* (2020) High Nonnucleoside Reverse Transcriptase Inhibitor Resistance Levels in HIV-1-Infected Zambian Mother-Infant Pairs. *AIDS*, **34**, 1833-1842. <https://doi.org/10.1097/qad.0000000000002614>
- [98] Miti, S., Handema, R., Mulenga, L., Mwansa, J.K., Abrams, E., Frimpong, C., *et al.* (2020) Prevalence and Characteristics of HIV Drug Resistance among Antiretroviral Treatment (ART) Experienced Adolescents and Young Adults Living with HIV in Ndola, Zambia. *PLoS ONE*, **15**, e0236156. <https://doi.org/10.1371/journal.pone.0236156>
- [99] Chileshe, C., Shawa, M., Phiri, N., Ndebe, J., Khumalo, C.S., Nakajima, C., *et al.* (2024) Detection of Extended-Spectrum β -Lactamase (ESBL)-Producing *Enterobacteriaceae* from Diseased Broiler Chickens in Lusaka District, Zambia. *Antibiotics*, **13**, Article 259. <https://doi.org/10.3390/antibiotics13030259>
- [100] Siame, A., Yamba, K., Samutela, M., Mukubesa, A. and Mulundu, G. (2024) Carriage and Antimicrobial Susceptibility Patterns of Rectal ESBL *E. coli* in Surgical Patients at the University Teaching Hospitals in Lusaka, Zambia. *JAC-Antimicrobial*

- Resistance*, **6**, dlac159. <https://doi.org/10.1093/jacamr/dlae159>
- [101] Munyeme, M., Hamoonga, R., Chitambo, B., Ngoma, V., Maambo, B., Nalubamba, K.S., et al. (2024) Assessing One Health in Zambia: Necessity, Application and Operationalisation. *One Health Cases*. <https://doi.org/10.1079/onehealthcases.2024.0021>
- [102] World Health Organization (2015) Global Action Plan on Antimicrobial Resistance. <https://apps.who.int/iris/handle/10665/193736>
- [103] Government of the Republic of Zambia (2017) Multi-Sectoral National Action Plan on Antimicrobial Resistance. Zambia National Public Health Institute. <https://www.afro.who.int/publications/multi-sectoral-national-action-plan-antimicrobial-resistance-2017-2027>
- [104] Kapona, O. (2017) Zambia Successfully Launches the First Multi-Sectoral National Action Plan on Antimicrobial Resistance (AMR). *Health Press Zambia Bulletin*, **1**, 5-7. <https://www.flemingfund.org/app/uploads/ec74b8a828168c148bcba3700ace7989.pdf>
- [105] Zambia National Public Health Institute (2019) Prioritised Activities of Zambia's Multi-Sectoral National Action Plan on Antimicrobial Resistance. World Health Organization. <https://www.afro.who.int/publications/prioritised-activities-zambias-multi-sectoral-national-action-plan-antimicrobial>
- [106] Helmi, R.T., Al-Maqbali, J.S., Gamal, S., Ba Wazir, H., Al Sulemani, Y. and Al Za'abi, M. (2024) Short-term Effects of Antimicrobial Stewardship Programs on Antibiotics Usage, Clinical Outcomes, and Multidrug Resistant Organisms in the Post COVID-19 Era. *Journal of Infection and Public Health*, **17**, 819-824. <https://doi.org/10.1016/j.jiph.2024.03.013>
- [107] Mendelson, M., Morris, A.M., Thursky, K. and Pulcini, C. (2020) How to Start an Antimicrobial Stewardship Programme in a Hospital. *Clinical Microbiology and Infection*, **26**, 447-453. <https://doi.org/10.1016/j.cmi.2019.08.007>
- [108] Dyar, O.J., Huttner, B., Schouten, J. and Pulcini, C. (2017) What Is Antimicrobial Stewardship? *Clinical Microbiology and Infection*, **23**, 793-798. <https://doi.org/10.1016/j.cmi.2017.08.026>
- [109] Majumder, M.A.A., Rahman, S., Cohall, D., Bharatha, A., Singh, K., Haque, M., et al. (2020) Antimicrobial Stewardship: Fighting Antimicrobial Resistance and Protecting Global Public Health. *Infection and Drug Resistance*, **13**, 4713-4738. <https://doi.org/10.2147/idr.s290835>
- [110] Obasanya, J.O., Ogunbode, O. and Landu-Adams, V. (2022) An Appraisal of the Contextual Drivers of Successful Antimicrobial Stewardship Implementation in Nigerian Health Care Facilities. *Journal of Global Antimicrobial Resistance*, **31**, 141-148. <https://doi.org/10.1016/j.jgar.2022.08.007>
- [111] Chizimu, J.Y., Mudenda, S., Yamba, K., Lukwesa, C., Chanda, R., Nakazwe, R., et al. (2024) Antimicrobial Stewardship Situation Analysis in Selected Hospitals in Zambia: Findings and Implications from a National Survey. *Frontiers in Public Health*, **12**, Article 1367703. <https://doi.org/10.3389/fpubh.2024.1367703>
- [112] Kalungia, A.C., Kampamba, M., Banda, D., Bambala, A.M., Marshall, S., Newport, M., et al. (2024) Impact of a Hub-and-Spoke Approach to Hospital Antimicrobial Stewardship Programmes on Antibiotic Use in Zambia. *JAC-Antimicrobial Resistance*, **6**, dlac178. <https://doi.org/10.1093/jacamr/dlae178>
- [113] Amponsah, O.K.O., Courtenay, A., Ayisi-Boateng, N.K., Abuelhana, A., Opoku, D.A., Blay, L.K., et al. (2023) Assessing the Impact of Antimicrobial Stewardship Implementation at a District Hospital in Ghana Using a Health Partnership Model. *JAC-Antimicrobial Resistance*, **5**, dlad084. <https://doi.org/10.1093/jacamr/dlad084>

- [114] Tagoon, M.A., Khalil, M.M., Hammad, E., Morad, W.S., awad, S.M. and Ezzat, S. (2020) The Effect of Educational Intervention on Healthcare Providers' Knowledge, Attitude, & Practice Towards Antimicrobial Stewardship Program At, National Liver Institute, Egypt. *Egyptian Liver Journal*, **10**, Article No. 5. <https://doi.org/10.1186/s43066-019-0016-5>
- [115] Mahmoudi, L., Sepasian, A., Firouzabadi, D. and Akbari, A. (2020) The Impact of an Antibiotic Stewardship Program on the Consumption of Specific Antimicrobials and Their Cost Burden: A Hospital-Wide Intervention. *Risk Management and Healthcare Policy*, **13**, 1701-1709. <https://doi.org/10.2147/rmhp.s265407>
- [116] Al-Omari, A., Al Mutair, A., Alhumaid, S., Salih, S., Alanazi, A., Albarsan, H., *et al.* (2020) The Impact of Antimicrobial Stewardship Program Implementation at Four Tertiary Private Hospitals: Results of a Five-Years Pre-Post Analysis. *Antimicrobial Resistance & Infection Control*, **9**, Article No. 95. <https://doi.org/10.1186/s13756-020-00751-4>
- [117] Darwish, R.M., Matar, S.G., Snaineh, A.A.A., Alsharif, M.R., Yahia, A.B., Mustafa, H.N., *et al.* (2022) Impact of Antimicrobial Stewardship on Antibigram, Consumption and Incidence of Multi Drug Resistance. *BMC Infectious Diseases*, **22**, Article No. 916. <https://doi.org/10.1186/s12879-022-07906-1>
- [118] Chukwu, E.E., Abuh, D., Idigbe, I.E., Osuolale, K.A., Chuka-Ebene, V., Awoderu, O., *et al.* (2024) Implementation of Antimicrobial Stewardship Programs: A Study of Prescribers' Perspective of Facilitators and Barriers. *PLOS ONE*, **19**, e0297472. <https://doi.org/10.1371/journal.pone.0297472>
- [119] Saleh, D., Abu Farha, R. and Alefishat, E. (2021) Impact of Educational Intervention to Promote Jordanian Community Pharmacists' Knowledge and Perception Towards Antimicrobial Stewardship: Pre-Post Interventional Study. *Infection and Drug Resistance*, **14**, 3019-3027. <https://doi.org/10.2147/idr.s324865>
- [120] Brinkmann, I. and Kibuule, D. (2020) Effectiveness of Antibiotic Stewardship Programmes in Primary Health Care Settings in Developing Countries. *Research in Social and Administrative Pharmacy*, **16**, 1309-1313. <https://doi.org/10.1016/j.sapharm.2019.03.008>
- [121] Shamseddine, J., Sadeq, A., Yousuf, K., Abukhater, R., Yahya, L.O., Espil, M.A., *et al.* (2023) Impact of Antimicrobial Stewardship Interventions on Days of Therapy and Guideline Adherence: A Comparative Point-Prevalence Survey Assessment. *Frontiers in Tropical Diseases*, **3**, Article 1050344. <https://doi.org/10.3389/fitd.2022.1050344>
- [122] Lakoh, S., Bawoh, M., Lewis, H., Jalloh, I., Thomas, C., Barlatt, S., *et al.* (2023) Establishing an Antimicrobial Stewardship Program in Sierra Leone: A Report of the Experience of a Low-Income Country in West Africa. *Antibiotics*, **12**, Article 424. <https://doi.org/10.3390/antibiotics12030424>
- [123] Pallares, C.J., Porras, J., De La Cadena, E., García-Betancur, J.C., Restrepo-Arbeláez, N., Viveros, S.M.C., *et al.* (2023) Antimicrobial Stewardship Programs in Seven Latin American Countries: Facing the Challenges. *BMC Infectious Diseases*, **23**, Article No. 463. <https://doi.org/10.1186/s12879-023-08398-3>
- [124] Cairns, K.A., Roberts, J.A., Cotta, M.O. and Cheng, A.C. (2015) Antimicrobial Stewardship in Australian Hospitals and Other Settings. *Infectious Diseases and Therapy*, **4**, 27-38. <https://doi.org/10.1007/s40121-015-0083-9>
- [125] Maraolo, A.E., Ong, D.S.Y., Cimen, C., Howard, P., Kofteridis, D.P., Schouten, J., *et al.* (2019) Organization and Training at National Level of Antimicrobial Stewardship and Infection Control Activities in Europe: An ESCMID Cross-Sectional Survey. *European Journal of Clinical Microbiology & Infectious Diseases*, **38**, 2061-2068.

- <https://doi.org/10.1007/s10096-019-03648-2>
- [126] Avent, M.L., Cosgrove, S.E., Price-Haywood, E.G. and van Driel, M.L. (2020) Antimicrobial Stewardship in the Primary Care Setting: From Dream to Reality? *BMC Family Practice*, **21**, Article No. 134. <https://doi.org/10.1186/s12875-020-01191-0>
- [127] Cotta, M.O., Robertson, M.S., Marshall, C., Thursky, K.A., Liew, D. and Buising, K.L. (2015) Implementing Antimicrobial Stewardship in the Australian Private Hospital System: A Qualitative Study. *Australian Health Review*, **39**, 315-322. <https://doi.org/10.1071/ah14111>
- [128] Alabi, A.S., Picka, S.W., Sirleaf, R., Ntirenganya, P.R., Ayebare, A., Correa, N., *et al.* (2022) Implementation of an Antimicrobial Stewardship Programme in Three Regional Hospitals in the South-East of Liberia: Lessons Learned. *JAC-Antimicrobial Resistance*, **4**, d1ac069. <https://doi.org/10.1093/jacamr/d1ac069>
- [129] Kalungia, A.C., Mwambula, H., Munkombwe, D., Marshall, S., Schellack, N., May, C., *et al.* (2019) Antimicrobial Stewardship Knowledge and Perception among Physicians and Pharmacists at Leading Tertiary Teaching Hospitals in Zambia: Implications for Future Policy and Practice. *Journal of Chemotherapy*, **31**, 378-387. <https://doi.org/10.1080/1120009x.2019.1622293>
- [130] Mudenda, S., Chabalenge, B., Daka, V., Jere, E., Sefah, I.A., Wesangula, E., *et al.* (2024) Knowledge, Awareness and Practices of Healthcare Workers Regarding Antimicrobial Use, Resistance and Stewardship in Zambia: A Multi-Facility Cross-Sectional Study. *JAC-Antimicrobial Resistance*, **6**, d1ae076. <https://doi.org/10.1093/jacamr/d1ae076>
- [131] Thomsen, J., Abdulrazzaq, N.M. and AlRand, H. (2023) Surveillance of Antimicrobial Resistance in the United Arab Emirates: The Early Implementation Phase. *Frontiers in Public Health*, **11**, Article 1247627. <https://doi.org/10.3389/fpubh.2023.1247627>
- [132] Walia, K., Madhumathi, J., Veeraraghavan, B., Chakrabarti, A., Kapil, A., Ray, P., *et al.* (2019) Establishing Antimicrobial Resistance Surveillance & Research Network in India: Journey So Far. *Indian Journal of Medical Research*, **149**, 164-179. https://doi.org/10.4103/ijmr.ijmr_226_18
- [133] World Health Organization (2024) Library of National Action Plans <https://www.who.int/teams/surveillance-prevention-control-AMR/national-action-plan-monitoring-evaluation/library-of-national-action-plans>
- [134] Gahamanyi, N., Umuhoza, T., Saeed, S.I., Mayigane, L.N. and Hakizimana, J.N. (2023) A Review of the Important Weapons against Antimicrobial Resistance in Sub-Saharan Africa. *Applied Biosciences*, **2**, 136-156. <https://doi.org/10.3390/applbiosci2020011>
- [135] Lota, M.M.M., Chua, A.Q., Azupardo, K., Lumangaya, C., Reyes, K.A.V., Villanueva, S.Y.A.M., *et al.* (2022) A Qualitative Study on the Design and Implementation of the National Action Plan on Antimicrobial Resistance in the Philippines. *Antibiotics*, **11**, Article 820. <https://doi.org/10.3390/antibiotics11060820>
- [136] Cella, E., Giovanetti, M., Benedetti, F., Scarpa, F., Johnston, C., Borsetti, A., *et al.* (2023) Joining Forces against Antibiotic Resistance: The One Health Solution. *Pathogens*, **12**, Article 1074. <https://doi.org/10.3390/pathogens12091074>
- [137] Oliveira, M., Antunes, W., Mota, S., Madureira-Carvalho, Á., Dinis-Oliveira, R.J. and Dias da Silva, D. (2024) An Overview of the Recent Advances in Antimicrobial Resistance. *Microorganisms*, **12**, Article 1920. <https://doi.org/10.3390/microorganisms12091920>
- [138] Sulis, G., Daniels, B., Kwan, A., Gandra, S., Daftary, A., Das, J., *et al.* (2020) Antibiotic

- Overuse in the Primary Health Care Setting: A Secondary Data Analysis of Standardised Patient Studies from India, China and Kenya. *BMJ Global Health*, **5**, e003393. <https://doi.org/10.1136/bmjgh-2020-003393>
- [139] Sulis, G., Adam, P., Nafade, V., Gore, G., Daniels, B., Daftary, A., *et al.* (2020) Antibiotic Prescription Practices in Primary Care in Low- and Middle-Income Countries: A Systematic Review and Meta-Analysis. *PLOS Medicine*, **17**, e1003139. <https://doi.org/10.1371/journal.pmed.1003139>
- [140] Amponsah, O.K.O., Nagaraja, S.B., Ayisi-Boateng, N.K., Nair, D., Muradyan, K., Asense, P.S., *et al.* (2022) High Levels of Outpatient Antibiotic Prescription at a District Hospital in Ghana: Results of a Cross Sectional Study. *International Journal of Environmental Research and Public Health*, **19**, Article 10286. <https://doi.org/10.3390/ijerph191610286>
- [141] Kotwani, A. and Gandra, S. (2023) Strengthening Antimicrobial Stewardship Activities in Secondary and Primary Public Healthcare Facilities in India: Insights from a Qualitative Study with Stakeholders. *Indian Journal of Medical Microbiology*, **41**, 59-63. <https://doi.org/10.1016/j.ijmmb.2022.12.011>
- [142] Saleem, Z., Godman, B., Hassali, M.A., Hashmi, F.K., Azhar, F. and Rehman, I.U. (2019) Point Prevalence Surveys of Health-Care-Associated Infections: A Systematic Review. *Pathogens and Global Health*, **113**, 191-205. <https://doi.org/10.1080/20477724.2019.1632070>
- [143] Gwebu, P.C., Meyer, J.C., Schellack, N., Matsebula-Myeni, Z.C. and Godman, B. (2022) A Web-Based Point Prevalence Survey of Antimicrobial Use and Quality Indicators at Raleigh Fitkin Memorial Hospital in the Kingdom of Eswatini and the Implications. *Hospital Practice*, **50**, 214-221. <https://doi.org/10.1080/21548331.2022.2069247>
- [144] Moja, L., Zanichelli, V., Mertz, D., Gandra, S., Cappello, B., Cooke, G.S., *et al.* (2024) Who's Essential Medicines and Aware: Recommendations on First- and Second-Choice Antibiotics for Empiric Treatment of Clinical Infections. *Clinical Microbiology and Infection*, **30**, S1-S51. <https://doi.org/10.1016/j.cmi.2024.02.003>
- [145] Hagen, T.L., Hertz, M.A., Uhrin, G.B., Dalager-Pedersen, M., Schönheyder, H.C. and Nielsen, H. (2017) Adherence to Local Antimicrobial Guidelines for Initial Treatment of Community-Acquired Infections. *Danish Medical Journal*, **64**, A5381. <https://ugeskriftet.dk/dmj/adherence-local-antimicrobial-guidelines-initial-treatment-community-acquired-infections>
- [146] Aidara-Kane, A., Angulo, F.J., Conly, J.M., Minato, Y., Silbergeld, E.K., McEwen, S.A., *et al.* (2018) World Health Organization (WHO) Guidelines on Use of Medically Important Antimicrobials in Food-Producing Animals. *Antimicrobial Resistance & Infection Control*, **7**, Article No. 7. <https://doi.org/10.1186/s13756-017-0294-9>
- [147] Ariyawansa, S., Gunawardana, K.N., Hapudeniya, M.M., Manelgamage, N.J., Karunaratne, C.R., Madalagama, R.P., *et al.* (2023) One Health Surveillance of Antimicrobial Use and Resistance: Challenges and Successes of Implementing Surveillance Programs in Sri Lanka. *Antibiotics*, **12**, Article 446. <https://doi.org/10.3390/antibiotics12030446>
- [148] Mesa Varona, O., Chaintarli, K., Muller-Pebody, B., Anjum, M.F., Eckmanns, T., Norström, M., *et al.* (2020) Monitoring Antimicrobial Resistance and Drug Usage in the Human and Livestock Sector and Foodborne Antimicrobial Resistance in Six European Countries. *Infection and Drug Resistance*, **13**, 957-993. <https://doi.org/10.2147/idr.s237038>
- [149] Bengtsson-Palme, J., Abramova, A., Berendonk, T.U., Coelho, L.P., Forslund, S.K.,

- Gschwind, R., et al. (2023) Towards Monitoring of Antimicrobial Resistance in the Environment: For What Reasons, How to Implement It, and What Are the Data Needs? *Environment International*, **178**, Article ID: 108089. <https://doi.org/10.1016/j.envint.2023.108089>
- [150] Rahman, M.M., Alam Tumpa, M.A., Zehravi, M., Sarker, M.T., Yamin, M., Islam, M.R., et al. (2022) An Overview of Antimicrobial Stewardship Optimization: The Use of Antibiotics in Humans and Animals to Prevent Resistance. *Antibiotics*, **11**, Article 667. <https://doi.org/10.3390/antibiotics11050667>
- [151] Zhao, C., Wang, Y., Mulchandani, R. and Van Boeckel, T.P. (2024) Global Surveillance of Antimicrobial Resistance in Food Animals Using Priority Drugs Maps. *Nature Communications*, **15**, Article No. 763. <https://doi.org/10.1038/s41467-024-45111-7>
- [152] Kumar, A.P. (2023) Antimicrobial Resistance (AMR) Surveillance under One Health. In: Mothadaka, M.P., Vaiyapuri, M., Rao Badireddy, M., Nagarajrao Ravishankar, C., Bhatia, R. and Jena, J., Eds., *Handbook on Antimicrobial Resistance*, Springer, 1-15. https://link.springer.com/referenceworkentry/10.1007/978-981-16-9723-4_33-1
- [153] Medic, D., Bozic Cvijan, B. and Bajcetic, M. (2023) Impact of Antibiotic Consumption on Antimicrobial Resistance to Invasive Hospital Pathogens. *Antibiotics*, **12**, Article 259. <https://doi.org/10.3390/antibiotics12020259>
- [154] Tan, S.Y., Khan, R.A., Khalid, K.E., Chong, C.W. and Bakhtiar, A. (2022) Correlation between Antibiotic Consumption and the Occurrence of Multidrug-Resistant Organisms in a Malaysian Tertiary Hospital: A 3-Year Observational Study. *Scientific Reports*, **12**, Article No. 3106. <https://doi.org/10.1038/s41598-022-07142-2>
- [155] Karakonstantis, S. and Kalemaki, D. (2019) Antimicrobial Overuse and Misuse in the Community in Greece and Link to Antimicrobial Resistance Using Methicillin-Resistant *S. aureus* as an Example. *Journal of Infection and Public Health*, **12**, 460-464. <https://doi.org/10.1016/j.jiph.2019.03.017>
- [156] Goossens, H. (2009) Antibiotic Consumption and Link to Resistance. *Clinical Microbiology and Infection*, **15**, 12-15. <https://doi.org/10.1111/j.1469-0691.2009.02725.x>
- [157] Saleem, Z., Faller, E.M., Godman, B., Malik, M.S.A., Iftikhar, A., Iqbal, S., et al. (2021) Antibiotic Consumption at Community Pharmacies: A Multicenter Repeated Prevalence Surveillance Using WHO Methodology. *Medicine Access @ Point of Care*, **5**, 1-9. <https://doi.org/10.1177/23992026211064714>
- [158] Abejew, A.A., Wubetu, G.Y. and Fenta, T.G. (2024) A Six Years Trend Analysis of Systemic Antibiotic Consumption in Northwest Ethiopia. *PLOS ONE*, **19**, e0290391. <https://doi.org/10.1371/journal.pone.0290391>
- [159] Sangeda, R.Z., Baha, A., Erick, A., Mkumbwa, S., Bitegeko, A., Sillo, H.B., et al. (2021) Consumption Trends of Antibiotic for Veterinary Use in Tanzania: A Longitudinal Retrospective Survey from 2010-2017. *Frontiers in Tropical Diseases*, **2**, Article 694082. <https://doi.org/10.3389/fitd.2021.694082>
- [160] Lim, J.M., Singh, S.R., Duong, M.C., Legido-Quigley, H., Hsu, L.Y. and Tam, C.C. (2019) Impact of National Interventions to Promote Responsible Antibiotic Use: A Systematic Review. *Journal of Antimicrobial Chemotherapy*, **75**, 14-29. <https://doi.org/10.1093/jac/dkz348>
- [161] Hou, J., Long, X., Wang, X., Li, L., Mao, D., Luo, Y., et al. (2023) Global Trend of Antimicrobial Resistance in Common Bacterial Pathogens in Response to Antibiotic Consumption. *Journal of Hazardous Materials*, **442**, Article ID: 130042. <https://doi.org/10.1016/j.jhazmat.2022.130042>

- [162] Ajulo, S. and Awosile, B. (2024) Global Antimicrobial Resistance and Use Surveillance System (GLASS 2022): Investigating the Relationship between Antimicrobial Resistance and Antimicrobial Consumption Data across the Participating Countries. *PLOS ONE*, **19**, e0297921. <https://doi.org/10.1371/journal.pone.0297921>
- [163] Chizimu, J.Y., Mudenda, S., Yamba, K., Lukwesa, C., Chanda, R., Nakazwe, R., *et al.* (2024) Antibiotic Use and Adherence to the WHO Aware Guidelines across 16 Hospitals in Zambia: A Point Prevalence Survey. *JAC-Antimicrobial Resistance*, **6**, dlae170. <https://doi.org/10.1093/jacamr/dlae170>
- [164] Mufwambi, W., Musuku, K., Hangoma, J., Muzondo, N.V., Mweetwa, L. and Mudenda, S. (2024) Community Pharmacists' Knowledge and Practices Towards Antimicrobial Stewardship: Findings and Implications. *JAC-Antimicrobial Resistance*, **6**, dlae176. <https://doi.org/10.1093/jacamr/dlae176>
- [165] Kampamba, M., Hamaambo, B., Hikaambo, C.N., Mwanza, B., Bambala, A., Mutenda, M., *et al.* (2024) Evaluation of Knowledge and Practices on Antibiotic Use: A Cross-Sectional Study on Self-Reported Adherence to Short-Term Antibiotic Utilization among Patients Visiting Level-1 Hospitals in Lusaka, Zambia. *JAC-Antimicrobial Resistance*, **6**, dlae120. <https://doi.org/10.1093/jacamr/dlae120>
- [166] Jere, E., Munkombwe, D., Mukosha, M., Mudenda, S., Kalungia, A.C. and Chabalenge, B. (2024) Quality of Antiretroviral, Antimalarial and Antituberculosis Medicines in Zambia: Findings of Routine Post-Marketing Surveillance. *The Journal of Medicine Access*, **8**, 1-11. <https://doi.org/10.1177/27550834241266755>
- [167] Ngoma, M.T., Sitali, D., Mudenda, S., Mukuma, M., Bumbangi, F.N., Bunuma, E., *et al.* (2024) Community Antibiotic Consumption and Associated Factors in Lusaka District of Zambia: Findings and Implications for Antimicrobial Resistance and Stewardship. *JAC-Antimicrobial Resistance*, **6**, dlae034. <https://doi.org/10.1093/jacamr/dlae034>
- [168] Mudenda, S., Chilimboyi, R., Matafwali, S.K., Daka, V., Mfune, R.L., Kemgne, L.A.M., *et al.* (2023) Hospital Prescribing Patterns of Antibiotics in Zambia Using the WHO Prescribing Indicators Post-Covid-19 Pandemic: Findings and Implications. *JAC-Antimicrobial Resistance*, **6**, dlae023. <https://doi.org/10.1093/jacamr/dlae023>
- [169] Mukomena, P.N., Simuunza, M., Munsaka, S., Kwenda, G., Bumbangi, F., Yamba, K., *et al.* (2024) Antimicrobial Resistance Profiles of and Associated Risk Factors for *Pseudomonas aeruginosa* Nosocomial Infection among Patients at Two Tertiary Healthcare Facilities in Lusaka and Copperbelt Provinces, Zambia. *JAC-Antimicrobial Resistance*, **6**, dlae139. <https://doi.org/10.1093/jacamr/dlae139>
- [170] Chibuye, M., Harris, V., Schultsz, C., Mwape, K., Silwamba, S., Mende, D., *et al.* (2023) PA-836 Antimicrobial Resistance Patterns and Molecular Characterisation of Shigella Isolates from Under-Five Children in Zambia. *BMJ Global Health*, **8**, A128. <https://doi.org/10.1136/bmjgh-2023-edc.315>
- [171] Yamba, K., Lukwesa-Musyani, C., Samutela, M.T., Kapesa, C., Hang'ombe, M.B., Mpabalwani, E., *et al.* (2023) Phenotypic and Genotypic Antibiotic Susceptibility Profiles of Gram-Negative Bacteria Isolated from Bloodstream Infections at a Referral Hospital, Lusaka, Zambia. *PLOS Global Public Health*, **3**, e0001414. <https://doi.org/10.1371/journal.pgph.0001414>
- [172] Mwanamoonga, L., Muleya, W., Lukwesa, C., Mukubesa, A.N., Yamba, K., Mwenya, D., *et al.* (2023) Drug-resistant Acinetobacter Species Isolated at the University Teaching Hospital, Lusaka, Zambia. *Scientific African*, **20**, e01661. <https://doi.org/10.1016/j.sciaf.2023.e01661>
- [173] Patel, S., Daka, V., Mudenda, S., Samutela, M., Chileshe, M., Chanda, W., *et al.* (2023)

- Prevalence and Antimicrobial Susceptibility Status of Gram-Negative and Gram-Positive Bacteria on Handheld Shopping Trolleys and Baskets in Supermarkets in Ndola, Zambia. *Open Journal of Epidemiology*, **13**, 235-349. <https://doi.org/10.4236/ojepi.2023.134018>
- [174] Mudenda, S., Matafwali, S.K., Mukosha, M., Daka, V., Chabalenge, B., Chizimu, J., *et al.* (2023) Antifungal Resistance and Stewardship: A Knowledge, Attitudes and Practices Survey among Pharmacy Students at the University of Zambia; Findings and Implications. *JAC-Antimicrobial Resistance*, **5**, dlac141. <https://doi.org/10.1093/jacamr/dlad141>
- [175] Nowbuth, A.A., Monteiro, F.J., Sheets, L.R. and Asombang, A.W. (2023) Assessment of the Knowledge, Attitudes and Perceived Quality of Education about Antimicrobial Use and Resistance of Medical Students in Zambia, Southern Africa. *JAC-Antimicrobial Resistance*, **5**, dlac073. <https://doi.org/10.1093/jacamr/dlad073>
- [176] Gannon, J., Greenan, K., Richards, E., Neale, T., Neale, F., Duffy, O., *et al.* (2023) Supporting Antimicrobial Stewardship Improvements in a Zambian Rural Health Post through Education and Digital Training. *Population Medicine*, **5**, A98. <https://doi.org/10.18332/popmed/164902>
- [177] Sarenje, K.L., Ngalamika, O., Maimbolwa, M.C., Siame, A., Munsaka, S.M. and Kwenda, G. (2022) Antimicrobial Resistance of Neisseria Gonorrhoeae Isolated from Patients Attending Sexually Transmitted Infection Clinics in Urban Hospitals, Lusaka, Zambia. *BMC Infectious Diseases*, **22**, Article No. 688. <https://doi.org/10.1186/s12879-022-07674-y>
- [178] Mudenda, S., Mukela, M., Matafwali, S., Banda, M., Mutati, R.K., Muungo, L.T., *et al.* (2022) Knowledge, Attitudes, and Practices Towards Antibiotic Use and Antimicrobial Resistance among Pharmacy Students at the University of Zambia: Implications for Antimicrobial Stewardship Programmes. *Scholars Academic Journal of Pharmacy*, **11**, 117-124. <https://doi.org/10.36347/sajp.2022.v11i08.002>
- [179] Mudenda, S., Mukosha, M., Godman, B., Fadare, J., Malama, S., Munyeme, M., *et al.* (2022) Knowledge, Attitudes, and Practices of Community Pharmacy Professionals on Poultry Antibiotic Dispensing, Use, and Bacterial Antimicrobial Resistance in Zambia: Implications on Antibiotic Stewardship and WHO Aware Classification of Antibiotics. *Antibiotics*, **11**, Article 1210. <https://doi.org/10.3390/antibiotics11091210>
- [180] Chabalenge, B., Jere, E., Nanyangwe, N., Hikaambo, C., Mudenda, S., Banda, M., *et al.* (2022) Substandard and Falsified Medical Product Recalls in Zambia from 2018 to 2021 and Implications on the Quality Surveillance Systems. *The Journal of Medicine Access*, **6**, 1-13. <https://doi.org/10.1177/27550834221141767>
- [181] Tembo, N., Mudenda, S., Banda, M., Chileshe, M. and Matafwali, S. (2022) Knowledge, Attitudes and Practices on Antimicrobial Resistance among Pharmacy Personnel and Nurses at a Tertiary Hospital in Ndola, Zambia: Implications for Antimicrobial Stewardship Programmes. *JAC-Antimicrobial Resistance*, **4**, dlac107. <https://doi.org/10.1093/jacamr/dlac107>
- [182] Kasanga, M., Chileshe, M., Mudenda, S., Mukosha, R., Kasanga, M., Daka, V., *et al.* (2022) Antibiotic Prescribing Patterns and Prevalence of Surgical Site Infections in Caesarean Section Deliveries at Two Tertiary Hospitals in Lusaka, Zambia. *Pharmacology & Pharmacy*, **13**, 313-330. <https://doi.org/10.4236/pp.2022.138024>
- [183] Mutalange, M., Yamba, K., Kapesa, C., Mtonga, F., Banda, M., Muma, J.B., *et al.* (2021) Vancomycin Resistance in *Staphylococcus aureus* and Enterococcus Species Isolated at the University Teaching Hospitals, Lusaka, Zambia: Should We Be Worried? *University of Zambia Journal of Agricultural and Biomedical Sciences*, **5**, 18-28.

- <https://doi.org/10.53974/unza.jabs.5.1.482>
- [184] Yeta, K.I., Michelo, C. and Jacobs, C. (2021) Antimicrobial Resistance among Pregnant Women with Urinary Tract Infections Attending Antenatal Clinic at Levy Mwanawasa University Teaching Hospital (LMUTH), Lusaka, Zambia. *International Journal of Microbiology*, **2021**, Article ID: 8884297. <https://doi.org/10.1155/2021/8884297>
- [185] Mufwambi, W., Stingl, J., Masimirembwa, C., Manasa, J., Nhachi, C., Stadler, N., et al. (2021) Healthcare Professionals' Knowledge of Pharmacogenetics and Attitudes Towards Antimicrobial Utilization in Zambia: Implications for a Precision Medicine Approach to Reducing Antimicrobial Resistance. *Frontiers in Pharmacology*, **11**, Article 551522. <https://doi.org/10.3389/fphar.2020.551522>
- [186] Mudenda, S., Hankombo, M., Saleem, Z., Sadiq, M.J., Banda, M., Munkombwe, D., et al. (2021) Knowledge, Attitude, and Practices of Community Pharmacists on Antibiotic Resistance and Antimicrobial Stewardship in Lusaka, Zambia. *Journal of Biomedical Research & Environmental Sciences*, **2**, 1005-1014. <https://doi.org/10.37871/jbres1343>
- [187] Kaluba, C.K., Samutela, M.T., Kapesa, C., Muma, J.B., Hang'ombe, B.M., Hachaambwa, L., et al. (2021) Carbapenem Resistance in *Pseudomonas Aeruginosa* and *Acinetobacter* Species at a Large Tertiary Referral Hospital in Lusaka, Zambia. *Scientific African*, **13**, e00908. <https://doi.org/10.1016/j.sciaf.2021.e00908>
- [188] Mtonga, S., Nyirenda, S.S., Mulemba, S.S., Ziba, M.W., Muuka, G.M. and Fandamu, P. (2021) Epidemiology and Antimicrobial Resistance of Pathogenic *E. coli* in Chickens from Selected Poultry Farms in Zambia. *Journal of Zoonotic Diseases*, **5**, 18-28. https://jzd.tabrizu.ac.ir/article_12711.html
- [189] Shawa, M., Furuta, Y., Mulenga, G., Mubanga, M., Mulenga, E., Zorigt, T., et al. (2021) Novel Chromosomal Insertions of *ISEcp1-Bla_{CTX-M-15}* and Diverse Antimicrobial Resistance Genes in Zambian Clinical Isolates of *Enterobacter cloacae* and *Escherichia coli*. *Antimicrobial Resistance & Infection Control*, **10**, Article No. 79. <https://doi.org/10.1186/s13756-021-00941-8>
- [190] Sitali, L., Mwenda, M.C., Miller, J.M., Bridges, D.J., Hawela, M.B., Hamainza, B., et al. (2021) Data on Selected Antimalarial Drug Resistance Markers in Zambia. *Data in Brief*, **34**, Article ID: 106650. <https://doi.org/10.1016/j.dib.2020.106650>
- [191] Kasanga, M., Mudenda, S., Siyanga, M., Chileshe, M., Mwiikisa, M.J., Kasanga, M., et al. (2020) Antimicrobial Susceptibility Patterns of Bacteria That Commonly Cause Bacteremia at a Tertiary Hospital in Zambia. *Future Microbiology*, **15**, 1735-1745. <https://doi.org/10.2217/fmb-2020-0250>
- [192] Mwape, K., Kwenda, G., Kalonda, A., Mwaba, J., Lukwesa-Musyani, C., Ngulube, J., et al. (2020) Characterisation of *Vibrio cholerae* Isolates from the 2009, 2010 and 2016 Cholera Outbreaks in Lusaka Province, Zambia. *Pan African Medical Journal*, **35**, Article 32. <https://doi.org/10.11604/pamj.2020.35.32.18853>
- [193] Zulu, A., Matafwali, S.K., Banda, M. and Mudenda, S. (2020) Assessment of Knowledge, Attitude and Practices on Antibiotic Resistance among Undergraduate Medical Students in the School of Medicine at the University of Zambia. *International Journal of Basic & Clinical Pharmacology*, **9**, 263-270. <https://doi.org/10.18203/2319-2003.ijbcp20200174>
- [194] Mudenda, S. (2020) Antibiotic Prescribing Patterns in Paediatric Patients at Levy Mwanawasa University Teaching Hospital in Lusaka, Zambia. *International Journal of Pharmaceutics & Pharmacology*, **4**, 1-9. <https://doi.org/10.31531/2581-3080.1000138>

- [195] Chanda, W., Manyepa, M., Chikwanda, E., Daka, V., Chileshe, J., Tembo, M., *et al.* (2019) Evaluation of Antibiotic Susceptibility Patterns of Pathogens Isolated from Routine Laboratory Specimens at Ndola Teaching Hospital: A Retrospective Study. *PLOS ONE*, **14**, e0226676. <https://doi.org/10.1371/journal.pone.0226676>
- [196] Sirohi, S., Bangara, F.F., Sitali, J. and Banda, M. (2019) Knowledge, Attitude, and Practices on Antibiotic Resistance among Pharmacists at the University Teaching Hospitals in Lusaka, Zambia. *Journal of Harmonized Research in Pharmacy*, **8**, 12-24. <https://doi.org/10.30876/johr.8.2.2019.12-24>
- [197] Nagelkerke, M.M.B., Sikwewa, K., Makowa, D., de Vries, I., Chisi, S. and Dorigo-Zetsma, J.W. (2017) Prevalence of Antimicrobial Drug Resistant Bacteria Carried by In- and Outpatients Attending a Secondary Care Hospital in Zambia. *BMC Research Notes*, **10**, Article No. 378. <https://doi.org/10.1186/s13104-017-2710-x>
- [198] Chibwe, B., Simuyandi, M., Ojok, D., Chilengi, R. and Kruuner, A. (2017) Antibiotic Resistance Patterns of Potential Pathogens Isolated from Two Major Hospitals in Lusaka and Ndola. *BMJ Global Health*, **2**, A51.3-A52. <https://doi.org/10.1136/bmjgh-2016-000260.137>
- [199] Matundwelo, N. and Mwansasu, C.S. (2016) Bacteriology of Chronic Suppurative Otitis Media among Children at the Arthur Davidson Children's Hospital, Ndola, Zambia. *Medical Journal of Zambia*, **43**, 36-40. <https://doi.org/10.55320/mjz.43.1.314>
- [200] Songe, M., Hang'ombe, B., Knight-Jones, T. and Grace, D. (2016) Antimicrobial Resistant *Enteropathogenic Escherichia coli* and *Salmonella* spp. in Houseflies Infesting Fish in Food Markets in Zambia. *International Journal of Environmental Research and Public Health*, **14**, Article 21. <https://doi.org/10.3390/ijerph14010021>
- [201] Kapata, N., Chanda-Kapata, P., Ngosa, W., Metitiri, M., Klinkenberg, E., Kalisvaart, N., *et al.* (2016) The Prevalence of Tuberculosis in Zambia: Results from the First National TB Prevalence Survey, 2013-2014. *PLOS ONE*, **11**, e0146392. <https://doi.org/10.1371/journal.pone.0146392>
- [202] Mwamungule, S., Chimana, H.M., Malama, S., Mainda, G., Kwenda, G. and Muma, J.B. (2015) Contamination of Health Care Workers' Coats at the University Teaching Hospital in Lusaka, Zambia: The Nosocomial Risk. *Journal of Occupational Medicine and Toxicology*, **10**, Article No. 34. <https://doi.org/10.1186/s12995-015-0077-2>
- [203] Hendriksen, R.S., Leekitcharoenphon, P., Lukjancenکو, O., Lukwesa-Musyani, C., Tambatamba, B., Mwaba, J., *et al.* (2015) Genomic Signature of Multidrug-Resistant *Salmonella* Enterica Serovar Typhi Isolates Related to a Massive Outbreak in Zambia between 2010 and 2012. *Journal of Clinical Microbiology*, **53**, 262-272. <https://doi.org/10.1128/jcm.02026-14>
- [204] Kapata, N., Mbulo, G., Cobelens, F., de Haas, P., Schaap, A., Mwamba, P., *et al.* (2015) The Second Zambian National Tuberculosis Drug Resistance Survey—A Comparison of Conventional and Molecular Methods. *Tropical Medicine & International Health*, **20**, 1492-1500. <https://doi.org/10.1111/tmi.12581>
- [205] Kapata, N., Chanda-Kapata, P., O'Grady, J., Schwank, S., Bates, M., Mukonka, V., *et al.* (2011) Trends of Zambia's Tuberculosis Burden over the Past Two Decades. *Tropical Medicine & International Health*, **16**, 1404-1409. <https://doi.org/10.1111/j.1365-3156.2011.02849.x>
- [206] Kapatamoyo, B., Andrews, B. and Bowa, K. (2010) Association of HIV with Breast Abscess and Altered Microbial Susceptibility Patterns. *Medical Journal of Zambia*, **37**, 58-63. <https://www.ajol.info/index.php/mjz/article/view/75656>
- [207] Mulenga, C., Chonde, A., Bwalya, I.C., Kapata, N., Kakungu-Simpungwe, M., Docx, S., *et al.* (2010) Low Occurrence of Tuberculosis Drug Resistance among Pulmonary

- Tuberculosis Patients from an Urban Setting, with a Long-Running DOTS Program in Zambia. *Tuberculosis Research and Treatment*, **2010**, Article ID: 938178. <https://doi.org/10.1155/2010/938178>
- [208] Gill, C. (2008) Effect of Presumptive Co-Trimoxazole Prophylaxis on Pneumococcal Colonization Rates, Seroepidemiology and Antibiotic Resistance in Zambian Infants: A Longitudinal Cohort Study. *Bulletin of the World Health Organization*, **86**, 929-938. <https://doi.org/10.2471/blt.07.049668>
- [209] Bijl, H.M., Kager, J., Koetsier, D.W. and van der Werf, T.S. (2000) Chloroquine- and Sulfadoxine-Pyrimethamine-Resistant *Falciparum* Malaria *in Vivo*—A Pilot Study in Rural Zambia. *Tropical Medicine & International Health*, **5**, 692-695. <https://doi.org/10.1046/j.1365-3156.2000.00629.x>
- [210] Chilawa, S., Mudenda, S., Daka, V., Chileshe, M., Matafwali, S., Chabalenge, B., *et al.* (2023) Knowledge, Attitudes, and Practices of Poultry Farmers on Antimicrobial Use and Resistance in Kitwe, Zambia: Implications on Antimicrobial Stewardship. *Open Journal of Animal Sciences*, **13**, 60-81. <https://doi.org/10.4236/ojas.2023.131005>
- [211] Mpundu, P., Muma, J.B., Mukubesa, A.N., Kainga, H., Mudenda, S., Bumbangi, F.N., *et al.* (2022) Antibiotic Resistance Patterns of *Listeria* Species Isolated from Broiler Abattoirs in Lusaka, Zambia. *Antibiotics*, **11**, Article 591. <https://doi.org/10.3390/antibiotics11050591>
- [212] Kabali, E., Pandey, G.S., Munyeme, M., Kapila, P., Mukubesa, A.N., Ndebe, J., *et al.* (2021) Identification of *Escherichia coli* and Related *Enterobacteriaceae* and Examination of Their Phenotypic Antimicrobial Resistance Patterns: A Pilot Study at a Wildlife-Livestock Interface in Lusaka, Zambia. *Antibiotics*, **10**, Article 238. <https://doi.org/10.3390/antibiotics10030238>
- [213] Kaonga, N., Hang'ombe, B.M., Lupindu, A.M. and Hoza, A.S. (2021) Detection of CTX-M-Type Extended-Spectrum β -Lactamase Producing *Salmonella* Typhimurium in Commercial Poultry Farms in Copperbelt Province, Zambia. *German Journal of Veterinary Research*, **1**, 27-34. <https://doi.org/10.51585/gjvr.2021.2.0011>
- [214] Shawa, M., Furuta, Y., Paudel, A., Kabunda, O., Mulenga, E., Mubanga, M., *et al.* (2022) Clonal Relationship between Multidrug-Resistant *Escherichia coli* ST69 from Poultry and Humans in Lusaka, Zambia. *FEMS Microbiology Letters*, **368**, fnac004. <https://doi.org/10.1093/femsle/fnac004>
- [215] Mainda, G., Lupolova, N., Sikakwa, L., Richardson, E., Bessell, P.R., Malama, S.K., *et al.* (2019) Whole Genome Sequence Analysis Reveals Lower Diversity and Frequency of Acquired Antimicrobial Resistance (AMR) Genes in *E. Coli* from Dairy Herds Compared with Human Isolates from the Same Region of Central Zambia. *Frontiers in Microbiology*, **10**, Article 1114. <https://doi.org/10.3389/fmicb.2019.01114>
- [216] Mainda, G., Bessell, P.R., Muma, J.B., McAteer, S.P., Chase-Topping, M.E., Gibbons, J., *et al.* (2015) Prevalence and Patterns of Antimicrobial Resistance among *Escherichia coli* Isolated from Zambian Dairy Cattle across Different Production Systems. *Scientific Reports*, **5**, Article No. 12439. <https://doi.org/10.1038/srep12439>
- [217] Phiri, B.S.J., Hang'ombe, B.M., Mulenga, E., Mubanga, M., Maurischat, S., Wichmann-Schauer, H., *et al.* (2022) Prevalence and Diversity of *Staphylococcus aureus* in the Zambian Dairy Value Chain: A Public Health Concern. *International Journal of Food Microbiology*, **375**, Article ID: 109737. <https://doi.org/10.1016/j.ijfoodmicro.2022.109737>
- [218] Youn, J., Park, Y.H., Hang'ombe, B. and Sugimoto, C. (2014) Prevalence and Characterization of *Staphylococcus aureus* and *Staphylococcus pseudintermedius* Isolated from Companion Animals and Environment in the Veterinary Teaching Hospital in Zambia, Africa. *Comparative Immunology, Microbiology and Infectious Diseases*, **37**, 123-130. <https://doi.org/10.1016/j.cimid.2014.01.003>

- [219] Mukomena, P.N., Munsaka, S., Simunza, M., Kwenda, G., Yamba, K., Kabwe, J., *et al.* (2023) Nosocomial Infections and Associated Risk Factors at Two Tertiary Healthcare Facilities in Lusaka and Copperbelt Provinces, Zambia. *Scientific African*, **20**, e01644. <https://doi.org/10.1016/j.sciaf.2023.e01644>
- [220] Mukwato, K., Ngoma, C. and Maimbolwa, M. (2009) Compliance with Infection Prevention Guidelines by Health Care Workers at Ronald Ross General Hospital Mufulira District. *Medical Journal of Zambia*, **35**, 110-116. <https://doi.org/10.4314/mjz.v35i3.46530>
- [221] Mudenda, S., Daka, V., Matafwali, S.K., Kanaan, M.H.G., Abdullah, S.S., Mohamed, S., *et al.* (2023) Prevalence of Self-Medication and Associated Factors among Healthcare Students during the COVID-19 Pandemic: A Cross-Sectional Study at the University of Zambia. *Open Journal of Social Sciences*, **11**, 340-363. <https://doi.org/10.4236/jss.2023.1110021>
- [222] Banda, O., Vlahakis, P.A., Daka, V. and Matafwali, S.K. (2021) Self-Medication among Medical Students at the Copperbelt University, Zambia: A Cross-Sectional Study. *Saudi Pharmaceutical Journal*, **29**, 1233-1237. <https://doi.org/10.1016/j.jsps.2021.10.005>
- [223] Mudenda, S., Daka, V. and Matafwali, S.K. (2023) World Health Organization Aware Framework for Antibiotic Stewardship: Where Are We Now and Where Do We Need to Go? An Expert Viewpoint. *Antimicrobial Stewardship & Healthcare Epidemiology*, **3**, e84. <https://doi.org/10.1017/ash.2023.164>
- [224] Mudenda, S., Chizimu, J., Chabalenge, B., Kasanga, M., Matafwali, S.K., Daka, V., *et al.* (2023) Knowledge, Attitude, and Practices toward Infection Prevention and Control among Undergraduate Pharmacy Students in Zambia: Findings and Implications. *Antimicrobial Stewardship & Healthcare Epidemiology*, **3**, e154. <https://doi.org/10.1017/ash.2023.428>
- [225] Mudenda, S. (2024) Global Burden of Fungal Infections and Antifungal Resistance from 1961 to 2024: Findings and Future Implications. *Pharmacology & Pharmacy*, **15**, 81-112. <https://doi.org/10.4236/pp.2024.154007>
- [226] Mutati, R.K., Mwila, C., Mudenda, S., Munkombwe, D., Mufwambi, W., Muungo, L.T., *et al.* (2022) Continuing Professional Development Needs of Pharmacy Professionals in Zambia: Findings and Future Directions. *Pharmacy Education*, **22**, 301-311. <https://doi.org/10.46542/pe.2022.221.301311>
- [227] Mudenda, S., Banda, M., Mohamed, S. and Chabalenge, B. (2023) Phytochemical Composition and Antibacterial Activities of *Azadirachta indica* (Neem): Significance of Traditional Medicine in Combating Infectious Diseases and Antimicrobial Resistance. *Journal of Pharmacognosy and Phytochemistry*, **12**, 256-263. <https://doi.org/10.22271/phyto.2023.v12.i5c.14733>
- [228] Mudenda, S., Hikaambo, C.N.A., Chabalenge, B., Mfuno, R.L., Mufwambi, W., Ngazimbi, M., *et al.* (2023) Antibacterial Activities of Honey against *Escherichia coli* and *Staphylococcus aureus*: A Potential Treatment for Bacterial Infections and Alternative to Antibiotics. *Journal of Pharmacognosy and Phytochemistry*, **12**, 6-13. <https://doi.org/10.22271/phyto.2023.v12.i3a.14655>
- [229] Hikaambo, C.N., Chilala, P., Ndubi, F., Mayoka, G., Kampamba, M., Kabuka, R., *et al.* (2023) Antimicrobial Activities of *Solanum aculeastrum* Fruit Extract against *Escherichia coli*, *Staphylococcus aureus* and *Candida Albicans*: Significance of African Traditional Medicine in Combating Infections and Attaining Universal Health Coverage. *Pharmacology & Pharmacy*, **14**, 176-188. <https://doi.org/10.4236/pp.2023.145013>
- [230] Hikaambo, C.N., Kaacha, L., Mudenda, S., Nyambe, M.N., Chabalenge, B., Phiri, M.,

- et al.* (2022) Phytochemical Analysis and Antibacterial Activity of *Azadirachta indica* Leaf Extracts against *Escherichia coli*. *Pharmacology & Pharmacy*, **13**, 1-10. <https://doi.org/10.4236/pp.2022.131001>
- [231] Kabuka, R., Mudenda, S., Kampamba, M., Chulu, M., Chimombe, T. and Hikaambo, C.N. (2022) Phytochemical Analysis of Leaf, Stem Bark, and Root Extracts of *Cassia abbreviata* Grown in Zambia. *Pharmacology & Pharmacy*, **13**, 119-128. <https://doi.org/10.4236/pp.2022.135009>
- [232] Mudenda, S., Chalwe, R., Kabuka, R. and Chabalenge, B. (2024) Antibacterial Activity of *Cassia abbreviata* Oliv Roots against *Neisseria gonorrhoeae*: A Potential Traditional Medicine for the Treatment of Sexually Transmitted Infections. *Journal of Medicinal Plants Studies*, **12**, 121-126. <https://doi.org/10.22271/plants.2024.v12.i1b.1632>
- [233] Gulumbe, B.H., Haruna, U.A., Almazan, J., Ibrahim, I.H., Faggo, A.A. and Bazata, A.Y. (2022) Combating the Menace of Antimicrobial Resistance in Africa: A Review on Stewardship, Surveillance and Diagnostic Strategies. *Biological Procedures Online*, **24**, Article No. 19. <https://doi.org/10.1186/s12575-022-00182-y>
- [234] Gulumbe, B.H., Danlami, M.B. and Abdulrahim, A. (2024) Closing the Antimicrobial Stewardship Gap—A Call for LMICs to Embrace the Global Antimicrobial Stewardship Accreditation Scheme. *Antimicrobial Resistance & Infection Control*, **13**, Article No. 19. <https://doi.org/10.1186/s13756-024-01371-y>
- [235] Solomon, H., Moraes, A.N., Williams, D.B., Fotso, A.S., Duong, Y.T., Ndongmo, C.B., *et al.* (2020) Prevalence and Correlates of Active Syphilis and HIV Co-Infection among Sexually Active Persons Aged 15-59 Years in Zambia: Results from the Zambia Population-Based HIV Impact Assessment (ZAMPHIA) 2016. *PLOS ONE*, **15**, e0236501. <https://doi.org/10.1371/journal.pone.0236501>
- [236] Republic of Zambia Ministry of Health (2022) National Tuberculosis and Leprosy Programme: Consolidated Tuberculosis Guidelines. https://www.moh.gov.zm/wp-content/uploads/filebase/guidelines/tb_guidelines/4.-Consolidated-TB-Guidelines-for-Zambia-Final-Version.pdf
- [237] Lungu, P., Kasapo, C., Mihova, R., Chimzizi, R., Sikazwe, L., Banda, I., *et al.* (2022) A 10-Year Review of TB Notifications and Mortality Trends Using a Joint Point Analysis in Zambia—A High TB Burden Country. *International Journal of Infectious Diseases*, **124**, S30-S40. <https://doi.org/10.1016/j.ijid.2022.03.046>
- [238] Hudson, F.P., Mulenga, L., Westfall, A.O., Warriar, R., Mweemba, A., Saag, M.S., *et al.* (2018) Evolution of HIV-1 Drug Resistance after Virological Failure of First-Line Antiretroviral Therapy in Lusaka, Zambia. *Antiviral Therapy*, **24**, 291-300. <https://doi.org/10.3851/imp3299>
- [239] Seu, L., Mulenga, L.B., Siwingwa, M., Sikazwe, I., Lambwe, N., Guffey, M.B., *et al.* (2015) Characterization of HIV Drug Resistance Mutations among Patients Failing First-Line Antiretroviral Therapy from a Tertiary Referral Center in Lusaka, Zambia. *Journal of Medical Virology*, **87**, 1149-1157. <https://doi.org/10.1002/jmv.24162>
- [240] Simusika, P., Bateman, A.C., Theo, A., Kwenda, G., Mfula, C., Chentulo, E., *et al.* (2015) Identification of Viral and Bacterial Pathogens from Hospitalized Children with Severe Acute Respiratory Illness in Lusaka, Zambia, 2011-2012: A Cross-Sectional Study. *BMC Infectious Diseases*, **15**, Article No. 52. <https://doi.org/10.1186/s12879-015-0779-1>
- [241] Loevinsohn, G., Hardick, J., Sinywimaanzi, P., Fenstermacher, K.Z.J., Shaw-Saliba, K., Monze, M., *et al.* (2021) Respiratory Pathogen Diversity and Co-Infections in Rural Zambia. *International Journal of Infectious Diseases*, **102**, 291-298. <https://doi.org/10.1016/j.ijid.2020.10.054>

- [242] Loevinsohn, G., Hamahuwa, M., Hardick, J., Sinywimaanzi, P., Fenstermacher, K.Z.J., Munachoonga, P., et al. (2022) Respiratory Viruses in Rural Zambia before and during the Covid-19 Pandemic. *Tropical Medicine & International Health*, **27**, 647-654. <https://doi.org/10.1111/tmi.13781>
- [243] Sutcliffe, C.G., Hamahuwa, M., Miller, E., Sinywimaanzi, P., Hardick, J., Morales, J., et al. (2023) Respiratory Viruses in Rural Zambia during the Second Year of the COVID-19 Pandemic. *IJID Regions*, **8**, 90-94. <https://doi.org/10.1016/j.ijregi.2023.07.003>
- [244] Gill, C.J., Mwananyanda, L., MacLeod, W.B., Kwenda, G., Pieciak, R., Mupila, Z., et al. (2022) Infant Deaths from Respiratory Syncytial Virus in Lusaka, Zambia from the ZPRIME Study: A 3-Year, Systematic, Post-Mortem Surveillance Project. *The Lancet Global Health*, **10**, e269-e277. [https://doi.org/10.1016/s2214-109x\(21\)00518-0](https://doi.org/10.1016/s2214-109x(21)00518-0)
- [245] Franklin, S., Mouliom, A., Sinkala, E., Kanunga, A., Helova, A., Dionne-Odom, J., et al. (2018) Hepatitis B Virus Contact Disclosure and Testing in Lusaka, Zambia: A Mixed-Methods Study. *BMJ Open*, **8**, e022522. <https://doi.org/10.1136/bmjopen-2018-022522>
- [246] Yasamineh, S., Kalajahi, H.G., Yasamineh, P., Yazdani, Y., Gholizadeh, O., Tabatabaie, R., et al. (2022) An Overview on Nanoparticle-Based Strategies to Fight Viral Infections with a Focus on COVID-19. *Journal of Nanobiotechnology*, **20**, Article No. 440. <https://doi.org/10.1186/s12951-022-01625-0>
- [247] Tompa, D.R., Immanuel, A., Srikanth, S. and Kadhirvel, S. (2021) Trends and Strategies to Combat Viral Infections: A Review on FDA Approved Antiviral Drugs. *International Journal of Biological Macromolecules*, **172**, 524-541. <https://doi.org/10.1016/j.ijbiomac.2021.01.076>
- [248] Pantaleo, G., Correia, B., Fenwick, C., Joo, V.S. and Perez, L. (2022) Antibodies to Combat Viral Infections: Development Strategies and Progress. *Nature Reviews Drug Discovery*, **21**, 676-696. <https://doi.org/10.1038/s41573-022-00495-3>
- [249] Nawa, M., Hangoma, P., Morse, A.P. and Michelo, C. (2019) Investigating the Up-surge of Malaria Prevalence in Zambia between 2010 and 2015: A Decomposition of Determinants. *Malaria Journal*, **18**, Article No. 61. <https://doi.org/10.1186/s12936-019-2698-x>
- [250] Fola, A.A., He, Q., Xie, S., Thimmapuram, J., Bhide, K.P., Dorman, J., et al. (2024) Genomics Reveals Heterogeneous *Plasmodium falciparum* Transmission and Selection Signals in Zambia. *Communications Medicine*, **4**, Article No. 67. <https://doi.org/10.1038/s43856-024-00498-8>
- [251] Ekue, J.M., Ulrich, A.M. and Njelesani, E.K. (1983) Plasmodium Malaria Resistant to chloroquine in a Zambian living in Zambia. *BMJ*, **286**, 1315-1316. <https://doi.org/10.1136/bmj.286.6374.1315-a>
- [252] Rolfe, M. (1988) Multiple Drug Resistant *Plasmodium falciparum* Malaria in a Pregnant Indigenous Zambian Woman. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **82**, 554-557. [https://doi.org/10.1016/0035-9203\(88\)90502-0](https://doi.org/10.1016/0035-9203(88)90502-0)
- [253] Mwanza, S., Joshi, S., Nambozi, M., Chileshe, J., Malunga, P., Kabuya, J.B., et al. (2016) The Return of Chloroquine-Susceptible *Plasmodium falciparum* Malaria in Zambia. *Malaria Journal*, **15**, Article No. 584. <https://doi.org/10.1186/s12936-016-1637-3>
- [254] Chanda, E., Kamuliwo, M., Steketee, R.W., Macdonald, M.B., Babaniyi, O. and Mukonka, V.M. (2013) An Overview of the Malaria Control Programme in Zambia. *ISRN Preventive Medicine*, **2013**, Article ID: 495037. <https://doi.org/10.5402/2013/495037>

- [255] Masaninga, F., Mwendaweli, M., Mweetwa, B., Mweemba, N., Songolo, P., Kagulula, S., *et al.* (2016) Impact of the WHO Technical Support Towards Malaria Elimination in Zambia. *Medical Journal of Zambia*, **43**, 76-81. <https://doi.org/10.55320/mjz.43.2.339>
- [256] Sitali, L., Mwenda, M.C., Miller, J.M., Bridges, D.J., Hawela, M.B., Hamainza, B., *et al.* (2020) Surveillance of Molecular Markers for Antimalarial Resistance in Zambia: Polymorphism of Pfk13, Pfmdr1 and Pfdhfr/Pfdhps Genes. *Acta Tropica*, **212**, Article ID: 105704. <https://doi.org/10.1016/j.actatropica.2020.105704>
- [257] Sitali, L., Mwenda, M.C., Miller, J.M., Bridges, D.J., Hawela, M.B., Chizema-Kawesha, E., *et al.* (2019) En-Route to the 'elimination' of Genotypic Chloroquine Resistance in Western and Southern Zambia, 14 Years after Chloroquine Withdrawal. *Malaria Journal*, **18**, Article No. 391. <https://doi.org/10.1186/s12936-019-3031-4>
- [258] Mudenda, S., Chabalenge, B., Kasanga, M., Mufwambi, W., Mfunu, R.L., Daka, V., *et al.* (2023) Antifungal Resistance and Stewardship: A Call to Action in Zambia. *Pan African Medical Journal*, **45**, Article 152. <https://doi.org/10.11604/pamj.2023.45.152.41232>
- [259] Urbancic, K.F., Thursky, K., Kong, D.C.M., Johnson, P.D.R. and Slavin, M.A. (2018) Antifungal Stewardship: Developments in the Field. *Current Opinion in Infectious Diseases*, **31**, 490-498. <https://doi.org/10.1097/qco.0000000000000497>
- [260] Valerio, M., Muñoz, P., Rodríguez-González, C., Sanjurjo, M., Guinea, J. and Bouza, E. (2015) Training Should Be the First Step toward an Antifungal Stewardship Program. *Enfermedades Infecciosas y Microbiología Clínica*, **33**, 221-227. <https://doi.org/10.1016/j.eimc.2014.04.016>
- [261] Hamdy, R.F., Zaoutis, T.E. and Seo, S.K. (2016) Antifungal Stewardship Considerations for Adults and Pediatrics. *Virulence*, **8**, 658-672. <https://doi.org/10.1080/21505594.2016.1226721>
- [262] Micallef, C., Aliyu, S.H., Santos, R., Brown, N.M., Rosembert, D. and Enoch, D.A. (2015) Introduction of an Antifungal Stewardship Programme Targeting High-Cost Antifungals at a Tertiary Hospital in Cambridge, England. *Journal of Antimicrobial Chemotherapy*, **70**, 1908-1911. <https://doi.org/10.1093/jac/dkv040>
- [263] Valerio, M., Muñoz, P., Rodríguez, C.G., Caliz, B., Padilla, B., Fernández-Cruz, A., *et al.* (2015) Antifungal Stewardship in a Tertiary-Care Institution: A Bedside Intervention. *Clinical Microbiology and Infection*, **21**, 492.e1-492.e9. <https://doi.org/10.1016/j.cmi.2015.01.013>
- [264] Albahar, F., Alhamad, H., Abu Assab, M., Abu-Farha, R., Alawi, L. and Khaleel, S. (2023) The Impact of Antifungal Stewardship on Clinical and Performance Measures: A Global Systematic Review. *Tropical Medicine and Infectious Disease*, **9**, Article 8. <https://doi.org/10.3390/tropicalmed9010008>
- [265] Agrawal, S., Barnes, R., Brüggemann, R.J., Rautemaa-Richardson, R. and Warris, A. (2016) The Role of the Multidisciplinary Team in Antifungal Stewardship. *Journal of Antimicrobial Chemotherapy*, **71**, ii37-ii42. <https://doi.org/10.1093/jac/dkw395>
- [266] Kara, E., Metan, G., Bayraktar-Ekincioglu, A., Gulmez, D., Arikan-Akdagli, S., Demirkazik, F., *et al.* (2021) Implementation of Pharmacist-Driven Antifungal Stewardship Program in a Tertiary Care Hospital. *Antimicrobial Agents and Chemotherapy*, **65**, e00629-21. <https://doi.org/10.1128/aac.00629-21>
- [267] Gulumbe, B.H. and Adesola, R.O. (2023) Revisiting the Blind Spot of Substandard and Fake Drugs as Drivers of Antimicrobial Resistance in LMICs. *Annals of Medicine & Surgery*, **85**, 122-123. <https://doi.org/10.1097/ms9.0000000000000113>
- [268] Harun, M.G.D., Anwar, M.M.U., Sumon, S.A., Hassan, M.Z., Mohona, T.M.,

- Rahman, A., *et al.* (2022) Rationale and Guidance for Strengthening Infection Prevention and Control Measures and Antimicrobial Stewardship Programs in Bangladesh: A Study Protocol. *BMC Health Services Research*, **22**, Article No. 1239. <https://doi.org/10.1186/s12913-022-08603-0>
- [269] Ackers, L., Ackers-Johnson, G., Welsh, J., Kibombo, D. and Opio, S. (2020) Infection Prevention Control (IPC) and Antimicrobial Resistance (AMR). In: Ackers, L., Ackers-Johnson, G., Welsh, J., Kibombo, D. and Opio, S., Eds., *Anti-Microbial Resistance in Global Perspective*, Springer, 53-80. https://doi.org/10.1007/978-3-030-62662-4_4
- [270] Bernatchez, S.F. (2023) Reducing Antimicrobial Resistance by Practicing Better Infection Prevention and Control. *American Journal of Infection Control*, **51**, 1063-1066. <https://doi.org/10.1016/j.ajic.2023.02.014>
- [271] Moyo, P., Moyo, E., Mangoya, D., Mhango, M., Mashe, T., Imran, M., *et al.* (2023) Prevention of Antimicrobial Resistance in Sub-Saharan Africa: What Has Worked? What Still Needs to Be Done? *Journal of Infection and Public Health*, **16**, 632-639. <https://doi.org/10.1016/j.jiph.2023.02.020>
- [272] Tsioutis, C., Birgand, G., Bathoorn, E., Deptula, A., ten Horn, L., Castro-Sánchez, E., *et al.* (2020) Education and Training Programmes for Infection Prevention and Control Professionals: Mapping the Current Opportunities and Local Needs in European Countries. *Antimicrobial Resistance & Infection Control*, **9**, Article No. 183. <https://doi.org/10.1186/s13756-020-00835-1>
- [273] Abreu, R., Semedo-Lemsaddek, T., Cunha, E., Tavares, L. and Oliveira, M. (2023) Antimicrobial Drug Resistance in Poultry Production: Current Status and Innovative Strategies for Bacterial Control. *Microorganisms*, **11**, Article 953. <https://doi.org/10.3390/microorganisms11040953>
- [274] Semedo-Lemsaddek, T., Bettencourt Cota, J., Ribeiro, T., Pimentel, A., Tavares, L., Bernardo, F., *et al.* (2021) Resistance and Virulence Distribution in Enterococci Isolated from Broilers Reared in Two Farming Systems. *Irish Veterinary Journal*, **74**, Article No. 22. <https://doi.org/10.1186/s13620-021-00201-6>
- [275] Monteiro Marques, J., Coelho, M., Santana, A.R., Pinto, D. and Semedo-Lemsaddek, T. (2023) Dissemination of Enterococcal Genetic Lineages: A One Health Perspective. *Antibiotics*, **12**, Article 1140. <https://doi.org/10.3390/antibiotics12071140>
- [276] Gunasekara, Y., Kottawatta, S., Nisansala, T., Silva-Fletcher, A. and Kalupahana, R. (2023) Tackling Antimicrobial Resistance Needs One Health Approach. In: Vithanage, M. and Vara Prasad, M.N., Eds., *One Health: Human, Animal, and Environment Triad*, John Wiley & Sons, Ltd., 309-323. <https://onlinelibrary.wiley.com/doi/full/10.1002/9781119867333.ch22>
- [277] Rubiola, S., Chiesa, F., Dalmasso, A., Di Ciccio, P. and Civera, T. (2020) Detection of Antimicrobial Resistance Genes in the Milk Production Environment: Impact of Host DNA and Sequencing Depth. *Frontiers in Microbiology*, **11**, Article 1983. <https://doi.org/10.3389/fmicb.2020.01983>
- [278] Tóth, A.G., Csabai, I., Krikó, E., Tózsér, D., Maróti, G., Patai, Á.V., *et al.* (2020) Antimicrobial Resistance Genes in Raw Milk for Human Consumption. *Scientific Reports*, **10**, Article No. 7464. <https://doi.org/10.1038/s41598-020-63675-4>
- [279] Liu, J., Zhu, Y., Jay-Russell, M., Lemay, D.G. and Mills, D.A. (2020) Reservoirs of Antimicrobial Resistance Genes in Retail Raw Milk. *Microbiome*, **8**, Article No. 558. <https://doi.org/10.1186/s40168-020-00861-6>
- [280] He, Y., Yuan, Q., Mathieu, J., Stadler, L., Senehi, N., Sun, R., *et al.* (2020) Antibiotic Resistance Genes from Livestock Waste: Occurrence, Dissemination, and Treatment. *NPJ Clean Water*, **3**, Article No. 4. <https://doi.org/10.1038/s41545-020-0051-0>

- [281] Cassim, J., Essack, S.Y. and Chetty, S. (2024) Building an Antimicrobial Stewardship Model for a Public-Sector Hospital: A Pre-Implementation Study. *Journal of Medical Microbiology*, **73**, Article ID: 001853. <https://doi.org/10.1099/jmm.0.001853>
- [282] Stewart Williams, J. and Wall, S. (2019) The AMR Emergency: Multi-Sector Collaboration and Collective Global Policy Action Is Needed Now. *Global Health Action*, **12**, Article ID: 1855831. <https://doi.org/10.1080/16549716.2019.1855831>
- [283] Seale, A.C., Gordon, N.C., Islam, J., Peacock, S.J. and Scott, J.A.G. (2017) AMR Surveillance in Low and Middle-Income Settings—A Roadmap for Participation in the Global Antimicrobial Surveillance System (GLASS). *Wellcome Open Research*, **2**, Article 92. <https://doi.org/10.12688/wellcomeopenres.12527.1>
- [284] Ferdinand, A.S., McEwan, C., Lin, C., Betham, K., Kandan, K., Tamolsaian, G., *et al.* (2024) Development of a Cross-Sectoral Antimicrobial Resistance Capability Assessment Framework. *BMJ Global Health*, **9**, e013280. <https://doi.org/10.1136/bmjgh-2023-013280>
- [285] Ashiru-Oredope, D., Langford, B.J., Bonaconsa, C., Nampoothiri, V., Charani, E. and Goff, D.A. (2023) Global Collaborations in Antimicrobial Stewardship: All Hands on Deck. *Antimicrobial Stewardship & Healthcare Epidemiology*, **3**, e66. <https://doi.org/10.1017/ash.2023.122>
- [286] Otieno, P.A., Campbell, S., Maley, S., Obinju Arunga, T. and Otieno Okumu, M. (2022) A Systematic Review of Pharmacist-Led Antimicrobial Stewardship Programs in Sub-Saharan Africa. *International Journal of Clinical Practice*, **2022**, Article ID: 3639943. <https://doi.org/10.1155/2022/3639943>
- [287] Veepanattu, P., Singh, S., Mendelson, M., Nampoothiri, V., Edathadatil, F., Surendran, S., *et al.* (2020) Building Resilient and Responsive Research Collaborations to Tackle Antimicrobial Resistance—Lessons Learnt from India, South Africa, and UK. *International Journal of Infectious Diseases*, **100**, 278-282. <https://doi.org/10.1016/j.ijid.2020.08.057>
- [288] Sefah, I.A., Chetty, S., Yamoah, P., Godman, B. and Bangalee, V. (2024) An Assessment of the Current Level of Implementation of the Core Elements of Antimicrobial Stewardship Programs in Public Hospitals in Ghana. *Hospital Pharmacy*, **59**, 367-377. <https://doi.org/10.1177/00185787231224066>
- [289] Hassan, S.K., Dahmash, E.Z., Madi, T., Tarawneh, O., Jomhawi, T., Alkhob, W., *et al.* (2023) Four Years after the Implementation of Antimicrobial Stewardship Program in Jordan: Evaluation of Program's Core Elements. *Frontiers in Public Health*, **11**, Article 1078596. <https://doi.org/10.3389/fpubh.2023.1078596>
- [290] Steinmann, K.E., Lehnick, D., Buettcher, M., Schwendener-Scholl, K., Daetwyler, K., Fontana, M., *et al.* (2018) Impact of Empowering Leadership on Antimicrobial Stewardship: A Single Center Study in a Neonatal and Pediatric Intensive Care Unit and a Literature Review. *Frontiers in Pediatrics*, **6**, Article 294. <https://doi.org/10.3389/fped.2018.00294>
- [291] Scheepers, L.N., Niesing, C.M. and Bester, P. (2023) Facilitators and Barriers to Implementing Antimicrobial Stewardship Programs in Public South African Hospitals. *Antimicrobial Stewardship & Healthcare Epidemiology*, **3**, e34. <https://doi.org/10.1017/ash.2022.355>
- [292] Ruckert, A., Fafard, P., Hindmarch, S., Morris, A., Packer, C., Patrick, D., *et al.* (2020) Governing Antimicrobial Resistance: A Narrative Review of Global Governance Mechanisms. *Journal of Public Health Policy*, **41**, 515-528. <https://doi.org/10.1057/s41271-020-00248-9>
- [293] Baekkeskov, E. and Pierre, J. (2024) More than Medicine: Antimicrobial Resistance

- (AMR) as a Social and Political Challenge That Can Be Overcome. *Journal of European Public Policy*, **31**, 3941-3956. <https://doi.org/10.1080/13501763.2024.2410919>
- [294] Bhatia, R., Katoch, V. and Inoue, H. (2019) Creating Political Commitment for Antimicrobial Resistance in Developing Countries. *Indian Journal of Medical Research*, **149**, 83-86. https://doi.org/10.4103/ijmr.ijmr_1980_17
- [295] Shabangu, K., Essack, S.Y. and Duma, S.E. (2023) Barriers to Implementing National Action Plans on Antimicrobial Resistance Using a One Health Approach: Policymakers' Perspectives from South Africa and Eswatini. *Journal of Global Antimicrobial Resistance*, **33**, 130-136. <https://doi.org/10.1016/j.jgar.2023.02.007>
- [296] Rogers Van Katwyk, S., Danik, M.É., Pantis, I., Smith, R., Røttingen, J. and Hoffman, S.J. (2016) Developing an Approach to Assessing the Political Feasibility of Global Collective Action and an International Agreement on Antimicrobial Resistance. *Global Health Research and Policy*, **1**, Article No. 20. <https://doi.org/10.1186/s41256-016-0020-9>
- [297] Rogers Van Katwyk, S., Grimshaw, J.M., Nkangu, M., Nagi, R., Mendelson, M., Taljaard, M., et al. (2019) Government Policy Interventions to Reduce Human Antimicrobial Use: A Systematic Review and Evidence Map. *PLOS Medicine*, **16**, e1002819. <https://doi.org/10.1371/journal.pmed.1002819>
- [298] World Health Organization (2018) WHO Competency Framework for Health Workers' Education and Training on Antimicrobial Resistance. <https://www.who.int/publications/i/item/who-competency-framework-for-health-workers'-education-and-training-on-antimicrobial-resistance>
- [299] Fwoloshi, S., Chola, U., Nakazwe, R., Tatila, T., Mateee, T., Kabaso, M., et al. (2023) Why Local Antibiotic Resistance Data Matters—Informing Empiric Prescribing through Local Data Collation, App Design and Engagement in Zambia. *Journal of Infection and Public Health*, **16**, 69-77. <https://doi.org/10.1016/j.jiph.2023.11.007>
- [300] Albano, G.D., Midiri, M., Zerbo, S., Matteini, E., Passavanti, G., Curcio, R., et al. (2023) Implementation of a Year-Long Antimicrobial Stewardship Program in a 227-Bed Community Hospital in Southern Italy. *International Journal of Environmental Research and Public Health*, **20**, Article 996. <https://doi.org/10.3390/ijerph20020996>
- [301] Naghavi, M., Emil Vollset, S., Ikuta, K.S., Swetschinski, L.R., Gray, A.P., Wool, E.E., et al. (2024) Global Burden of Bacterial Antimicrobial Resistance 1990-2021: A Systematic Analysis with Forecasts to 2050. *The Lancet*, **40**, 1199-1226. <http://www.thelancet.com/article/S0140673624018671/fulltext>
- [302] Musoke, D., Kitutu, F.E., Mugisha, L., Amir, S., Brandish, C., Ikhile, D., et al. (2020) A One Health Approach to Strengthening Antimicrobial Stewardship in Wakiso District, Uganda. *Antibiotics*, **9**, Article 764. <https://doi.org/10.3390/antibiotics9110764>
- [303] Villanueva, P., Coffin, S.E., Mekasha, A., McMullan, B., Cotton, M.F. and Bryant, P.A. (2022) Comparison of Antimicrobial Stewardship and Infection Prevention and Control Activities and Resources between Low-/Middle- and High-Income Countries. *Pediatric Infectious Disease Journal*, **41**, S3-S9. <https://doi.org/10.1097/inf.0000000000003318>
- [304] Gilbert, G.L. and Kerridge, I. (2020) Hospital Infection Prevention and Control (IPC) and Antimicrobial Stewardship (AMS): Dual Strategies to Reduce Antibiotic Resistance (ABR) in Hospitals. In: Jamrozik, E. and Selgelid, M., Eds., *Ethics and Drug Resistance: Collective Responsibility for Global Public Health*, Springer, 89-108. https://doi.org/10.1007/978-3-030-27874-8_6
- [305] Ashiru-Oredope, D., Garraghan, F., Olaoye, O., Krockow, E.M., Matuluko, A., Nambatya, W., et al. (2022) Development and Implementation of an Antimicrobial

- Stewardship Checklist in Sub-Saharan Africa: A Co-Creation Consensus Approach. *Healthcare*, **10**, Article 1706. <https://doi.org/10.3390/healthcare10091706>
- [306] Sneddon, J., Cooper, L., Afriyie, D.K., Sefah, I.A., Cockburn, A., Kerr, F., *et al.* (2020) Supporting Antimicrobial Stewardship in Ghana: Evaluation of the Impact of Training on Knowledge and Attitudes of Healthcare Professionals in Two Hospitals. *JAC-Antimicrobial Resistance*, **2**, dlaa092. <https://doi.org/10.1093/jacamr/dlaa092>
- [307] Bertagnolio, S., Dobрева, Z., Centner, C.M., Oлару, I.D., Donà, D., Burzo, S., *et al.* (2024) WHO Global Research Priorities for Antimicrobial Resistance in Human Health. *The Lancet Microbe*, **5**, Article ID: 100902. <http://www.thelancet.com/article/S2666524724001344/fulltext>
- [308] Shrestha, P., He, S. and Legido-Quigley, H. (2022) Antimicrobial Resistance Research Collaborations in Asia: Challenges and Opportunities to Equitable Partnerships. *Antibiotics*, **11**, Article 755. <https://doi.org/10.3390/antibiotics11060755>
- [309] He, S., Shrestha, P., Henry, A.D. and Legido-Quigley, H. (2023) Leveraging Collaborative Research Networks against Antimicrobial Resistance in Asia. *Frontiers in Public Health*, **11**, Article 1191036. <https://doi.org/10.3389/fpubh.2023.1191036>
- [310] Sneddon, J., Guise, T., Jenkins, D., Mpundu, M., Van Dongen, M., Schouten, J., *et al.* (2022) Introducing the Global Antimicrobial Stewardship Partnership Hub (GASPH): Creating Conditions for Successful Global Partnership Collaboration. *JAC-Antimicrobial Resistance*, **4**, dlac115. <https://doi.org/10.1093/jacamr/dlac115>
- [311] Weier, N., Nathwani, D., Thursky, K., Tängdén, T., Vlahović-Palčevski, V., Dyar, O., *et al.* (2021) An International Inventory of Antimicrobial Stewardship (AMS) Training Programmes for AMS Teams. *Journal of Antimicrobial Chemotherapy*, **76**, 1633-1640. <https://doi.org/10.1093/jac/dkab053>
- [312] Prescott, G.M., Jonkman, L., Crutchley, R.D., Dey, S., Hong, L.T., Malhotra, J., *et al.* (2023) Characteristics of Successful International Pharmacy Partnerships. *Pharmacy*, **11**, Article 7. <https://doi.org/10.3390/pharmacy11010007>