"Physician Knowledge, Attitudes, and Perceptions of Facility-Wide Antibiograms in
Southern Sri Lanka: A Pre-Implementation Study"
by

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Duke University

Date: March 20th, 2024

Approved:

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Thesis submitted in partial fulfillment of
the requirements for the degree of
Master of Science in the Duke Global Health Institute
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ABSTRACT

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Abstract

Antimicrobial resistance (AMR) is among the top ten public health threats, disproportionately threatening low- and middle-income countries (LMICs), where microbiologic diagnostic capacity and antimicrobial susceptibility testing are limited. Antibiograms are practical, paper-based, or electronic tools that display summary data of local antibiotic susceptibility trends. Antibiograms can guide physicians in identifying appropriate empiric antimicrobial treatment when microbiologic culture data are not available. There is limited literature regarding the development and implementation of antibiograms in low-resource settings. The primary aim of this qualitative study was to explore physicians' knowledge, attitudes, and perceptions (KAP) to determine factors that could impact the development and implementation of antibiograms in a tertiary care center in southern Sri Lanka. This qualitative study was conducted from June to August 2023 at the largest, public tertiary care hospital in the Southern Province. Our research team used convenience sampling to recruit physicians working in the pediatric and adult medical wards of the hospital. Participants were asked a total of 30 questions on four topics: Antibiotic Prescribing Practices, Knowledge of Antimicrobial Resistance, Attitudes towards Antimicrobial Resistance, and Knowledge of Antibiograms, as assessed in three stages. The interviews were recorded and transcribed in English. A sample antibiogram was utilized during the last section to understand how physicians interacted with and used the antibiogram. Thematic codes based on the structure and content of the interview guide were created and two research team members independently reviewed interviews using NVivo software (Release 1.0, 2020) to identify themes. Any emerging themes were noted and any discrepancies in coding were resolved. The study enrolled 31 critical informant physicians, including 20 adult physicians and 11 pediatricians. The

majority (21, 68%) were male, had graduated medical school in the 2010s (16, 52%), and had practiced medicine for less than ten years (18, 58%). The findings that the physicians strongly receptive to antibiograms, would find them a valuable tool in their practice, and are open to being trained on using them in their prescribing practice. Variations in antibiotic prescribing practices and knowledge of antibiograms were observed across the physician's specialties and experience levels, indicating a need for targeted educational interventions to enhance antibiotic stewardship. Physicians had mixed attitudes towards future antibiogram training were identified, with some expressing enthusiasm and others citing time and resource constraints. Addressing these concerns and fostering a culture of lifelong learning will be crucial in promoting optimal prescribing practices and combating antimicrobial resistance in low-resource settings like Sri Lanka's Southern Province. This research contributes valuable insights for future interventions aimed at improving antibiotic stewardship and preserving antimicrobial effectiveness.

Dedication

To my dearest supporters,

Mom, Adriana E. Garcia-Bochas, Brother, Andie Ray Garcia-Bochas, and my late Grandmother, Alba E. Justiniani Woodrow,

The unwavering love, encouragement, and support that each of you has generously poured into my journey at Duke University are beyond measure. Mom, your tireless encouragement, and unwavering belief in me have been my wellspring of strength and solace during my most difficult moments. Little Brother, your ceaseless laughter and infectious smile inspired me to scale new heights and prioritize the little things in life. My beloved Grandmother, your profound wisdom and the tales of our family's history have enriched my comprehension of life's intricate tapestry. I know you are proud of me and that your legacy continues to live through me.

Each of you has played a memorable, irreplaceable role in shaping my journey at Duke University. With profound love and heartfelt appreciation, I dedicate this work to you.

With all the love in my heart,

Lorenna Cristal Garcia-Bochas

Table of Contents

List of Tables

Acknowledgements

1. Introduction

1.1 Antimicrobial Resistance

Antimicrobial resistance (AMR) is recognized as one of the world's top ten public health threats, disproportionately jeopardizing the prevention and treatment of common infectious diseases in low- and middle-income countries (LMICs)(WHO, 2023). AMR occurs when microbes, such as bacteria and viruses, evolve and develop resistance against previously effective antimicrobial medications (WHO, 2023). The emerging antimicrobial resistance of pathogens has led to drug inefficiency, prolonged morbidity, higher healthcare costs, and an increased risk of transmission and mortality (Hay et al., 2018). This burden of AMR is exacerbated in LMICs due to highly prevalent infections, availability of nonprescription antimicrobials, low awareness of antimicrobial resistance, inadequate antimicrobial regulations, and limited resources such as microbiology laboratories and diagnostic tools needed for antimicrobial susceptibility testing (Abera et al., 2014).

1.2 Antimicrobial Stewardship

One of the many drivers of AMR is the misuse and overuse of antimicrobials for human health. Antimicrobial stewardship programs (ASPs) are an important strategy to improve the rational use of antimicrobials and prevent the emergence of resistance (Mathew et al., 2020). The US Joint Commission recommend that all acute care facilities have an ASP, which usually consists of a team of individuals such as an infectious diseases physician, a pharmacist, a nurse, and a hospital laboratory-based microbiologist, who work together to improve antibiotic use (WHO, 2023). ASPs generally focus on five major goals: 1) to work with healthcare providers to prescribe antimicrobial therapy which consists of the right drug, correct dose, right drug route,

suitable duration, and timely de-escalation (Shrestha et al., 2024), 2) to prevent antimicrobial overuse, misuse, and abuse in inpatient, outpatient, and community settings (Shrestha et al., 2024), 3) to reduce antibiotic-related adverse effects, 4) to minimize resistance, and 5) to reduce healthcare-associated costs (Shrestha et al., 2024). ASPs have been shown to reduce the emergence of AMR by significantly decreasing antimicrobial consumption, cost, reducing infections, and overall hospital stay (Al-Omari et al., 2020).

1.3 Antibiograms

An important component of an ASP's toolkit is the hospital antibiogram, which help improve the prescribing of antimicrobials when a microbiologic etiology or antibiotic susceptibility of an organism is unknown. Antibiograms are summaries that display local susceptibility trends of common bacterial or fungal organisms and guide physicians in identifying and prescribing the most appropriate empiric antimicrobial treatment, even when microbiology culture results are unavailable. Data for building an antibiogram can be obtained from the facility's microbiology laboratory and analyzed to display the total number of isolates within a specific timeframe, usually six months to a year. The percentages of the microbial isolates that are susceptible to commonly available antimicrobial agents are also displayed (Janet A. Hindler et al., 2014).

Antibiograms have effectively improved empirical antibiotic prescribing in high-income countries, where they are easily accessible and act as crucial facilitators in selecting antibiotics according to facility resistance (Furuno et al., 2014; Velez et al., 2017). Due to the rise of AMR, the World Health Organization (WHO) has proposed the Global Action Plan on Antimicrobial Resistance, calling on healthcare institutions

worldwide to implement strategies to combat antimicrobial resistance; developing and distributing antibiograms to physicians is one such strategy (WHO, 2016).

Despite these recommendations, research suggests that antibiograms and the technical expertise required for antibiogram development are not widely available in low-resource settings. The lack of technical expertise has contributed to the limited literature regarding developing and implementing antibiograms in these settings. While developing and implementing antibiograms may require a lengthy data collection process, prescribing practices, and hospital-specific guidelines can be improved by providing educational training to physicians concerning AMR and antibiogram use (Hill et al., 2015). Especially in LMICs, antibiograms could prove valuable as many treatment decisions are made without culture data for a specific patient.

1.4 Sri Lanka

While cases of AMR continue to rise globally, there is a high prevalence of drug-resistant pathogens in South Asia, where most countries lack efficient surveillance systems to detect AMR trends (Murray et al., 2022). Recent studies have reported the highest rates of deaths attributable to AMR in South Asia. This burden is fueled by a burgeoning incidence of critical infections and limited resources that increase misdiagnoses and antibiotic over prescription (Murray et al., 2022).

Sri Lanka is a South Asian, lower-middle-income economy where AMR is a prominent public health problem. High rates of antibiotic use at first contact are a well-recognized issue in Sri Lanka (Premaratna et al., 2005). A past study in a tertiary care hospital in Sri Lanka found that physicians perceived high costs and lack of antimicrobial drugs, distrust in microbiology lab results, and low receptiveness to prescribing practice changes as challenges to the appropriate prescription of antimicrobials (Rolfe et al.,

2021). In addition, high patient volume and fear of bacterial superinfections have been cited as reasons for antibiotic overuse in Sri Lanka (Tillekeratne et al., 2017). Sri Lanka has the 58th highest age-standardized mortality rate per 100,000 population associated with AMR across 204 countries (IHME, 2022).

In Sri Lanka in 2019, there were 2,300 deaths attributable (likely caused by) to AMR and 8,800 deaths associated (connected to) with AMR (IHME, 2022). The number of AMR deaths in Sri Lanka is higher than deaths from respiratory infections and tuberculosis, self-harm and interpersonal violence, neurological disorders, digestive diseases, and unintentional injuries (IHME, 2022). Doctors are the primary prescribers in Sri Lanka. In addition to the high workload and lack of facilities limiting the opportunities to deliver evidence-based care (Westerling et al., 2020), a prescriber's decision may also be influenced by factors such as lack of updated knowledge (Remesh et al., 2013), fear of losing patients and lack of information on rational antibiotic use (Shrestha et al., 2024).

1.5 Study Objective

Limited literature exists on current knowledge and perceptions of antibiograms among significant stakeholders in Sri Lanka. To contain AMR and improve antimicrobial prescribing patterns, it is imperative to better understand physician knowledge, attitudes, and practices (KAP) on antibiograms. This qualitative study using semi-structured interviews was conducted to understand physician KAP towards antibiograms and inform upcoming interventions to implement antibiograms. The general objective of the research is to examine current physicians' knowledge and utilization of antibiograms and use this information to develop antibiogram training strategies.

2. Methods

2.1 Setting

This qualitative study was conducted from June to August 2023 at the largest (1800-bed) public, tertiary care hospital in Southern Province, Sri Lanka. All care in the inpatient and outpatient setting is provided free of charge in the public hospital. Data storage and analysis were conducted at the Ruhuna-Duke Centre for Infectious Diseases (RDCID), an official Centre of the Faculty of Medicine at the University of Ruhuna in Galle, Sri Lanka.

2.2 Participants

Our research team used convenience sampling to recruit participants. Participants could participate if they were physicians practicing in the tertiary care hospital's pediatric or adult medical wards.

2.3 Ethical Approval

Written informed consent in English, the language used in the professional medical setting, was obtained from all participants. Ethical approval for this research study was acquired from the Ethical Review Committee of the Faculty of Medicine, University of Ruhuna (Sri Lanka) and the Duke University Institutional Review Board (USA).

2.4 Interview Guide

The research team consisting of Sri Lankan and US investigators developed the interview guide to explore current antibiotic prescribing practices, knowledge of antibiograms, and attitudes toward future antibiogram training. Participants were asked 30 questions within the interview guide. 5 questions used a 5-point Likert scale (Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree). A Likert scale is a rating scale that assesses opinions, attitudes, or behaviors quantitatively. The first section examined

antibiotic prescribing practices when physicians did not have access to culture data and antibiograms. The second section of the interview guide examined knowledge and attitudes toward antimicrobial resistance; a scenario was presented during this section tailored to either an adult or pediatric physician. The third section examined knowledge regarding antibiograms; a sample antibiogram was provided during this section, and participants were asked how this information could alter their prescribing decisions. The fourth section of the interview guide explored physician receptiveness to future antibiogram training. Examples of follow-up probing questions were also included in the interview guide. Trained research team members pre-tested the guide with two pilot interviews to improve comprehension and flow, and adjustments were made accordingly.

2.5 Interview Procedures

Face-to-face, semi-structured interviews in English were conducted in private areas of the hospital by trained research team members. Interviews took approximately 20-30 minutes. Sociodemographic information, including name, age, gender, medical specialty, working position, and medical school graduation year, was collected from all participants. Interviews were audio-recorded by the research team and then transcribed in English.

2.6 Data Analysis

Descriptive statistical methods were used to summarize sociodemographic characteristics. Thematic content analysis was used to summarize the interview data. First, thematic codes based on the structure and content of the interview guide were created. Then, two research team members (LGB and SN) independently reviewed interviews using NVivo software (Release 1.0, 2020) to identify themes. Any emerging themes were noted. Any discrepancies in coding were discussed between the two team

members and resolved. Next, two transcript memos of the interviews were created: one for the adult physicians and one for the pediatricians. Topics relevant to each inquiry domain were summarized (*e.g.*, barriers to antibiogram development and opportunities for intervention), and representative quotes from transcripts were identified.

3. Results

A total of 31 interviews were conducted, but only 30 were included in data analysis due to one interviewed physician later joining the study team. The ages of participants ranged from 28 to 60 years, with most physicians being in their 30s (18, 60.0%; Table 1). A total of 20 (66.7%) participants were male, and 10 (33.3%) were female. Among participants, 7 were Consultant Physicians (attending-level doctors), 6 were Senior Registrars, 10 were Registrars, and 7 were House Officers.

3.1 Study Demographics

3.1.1 Overall Study Cohort

Table 1: Sociodemographic characteristics of physicians interviewed in the tertiary care facility in the Southern Province, Sri Lanka			
Variable	Characteristics	Frequency (N=30)	Percent
Age (years)	20-29	3	10.0
	30-39	18	60.0
	40-49	3	10.0
	50-59	5	16.7
	60-69	1	3.3
Sex	Male	20	66.7
	Female	10	33.3
Specialty	Pediatrics	11	36.7
	General Medicine	6	20.0
	Internal Medicine	6	20.0
	Non-Specialty	1	3.3
	No Answer	6	20.0
Classification	Consultant Physician	7	23.3
	Senior Registrar	6	20.0
	Registrar	10	33.3

	House Officer/Senior House Officer	7	23.3
Years Practicing Medicine	0-5	7	23.3
	6-10	11	36.7
	11-15	3	10.0
	16-20	2	6.7
	21+	7	23.3
Medical School Graduation Decade	1990s	5	16.7
	2000s	5	16.7
	2010s	15	50.0
	2020s	4	13.3
	No Answer	1	3.3

3.1.2 Pediatricians

A total of 11 interviews were conducted with pediatricians. The participants ranged from 29 to 55 years, with most being in their 30s (Table 2). A total of 36.7% (4) of the participants were males, and 63.6% (7) were females. There were (3) three Consultant Physicians, (1) one Senior Registrar, (5) five Registrars, and (2) two House Officers. Most physicians graduated from medical school in the 2010s. The average number of years practicing medicine was 11.7. Most Physicians graduated from medical school in the 2010s (6 total) (54.5%).

Table 2: Pediatricians interviewed in the tertiary care facility in the Southern Province, Sri Lanka			
Variable	Characteristics	Frequency (N=11)	Percent
Age (years)	20-29	1	9.1
	30-39	6	54.5
	40-49	1	9.1
	50-59	3	27.3
	60-69	0	0.0
Sex	Male	4	36.4
	Female	7	63.6
Specialty	Pediatrics	11	100.0
Classification	Consultant Physician	3	27.3
	Senior Registrar	1	9.1
	Registrar	5	45.5
	House Officer/Senior House Officer	2	18.2
Years Practicing Medicine	0-5	3	27.3
	6-10	5	45.5
	11-15	0	0.0
	16-20	0	0.0

	21+	3	27.3
Medical School Graduation Decade	1990s	2	18.2
	2000s	1	9.1
	2010s	6	54.5
	2020s	2	18.2

3.1.3 Adult Physicians

A total of 19 interviews were conducted with adult/ internal medicine physicians. The ages ranged from 28 to 60 years, with most being in their 30s (Table 3). Females comprised 15.8% (3), and males comprised 84.2% (16) of adult participants. The specialties were 31.6% (6) General Medicine, 31.6% (6) Internal Medicine, 5.3% (1) Non-Specialty, and (6) 31.2% No Answer. There were (4) four Consultant Physicians, (5) five Senior Registrars, (5) five registrars, and (5) five house Officers. The average number of years practicing medicine was 11.4 years, and most physicians graduated from medical school in the 2010s.

Table 3: Adult Physicians interviewed in the tertiary care facility in the Southern Province, Sri Lanka			
Variable	Characteristics	Frequency (N=19)	Percent
Age	20-29	3	15.8
	30-39	11	57.9
	40-49	3	15.8
	50-59	2	10.5
	60-69	1	5.3
Sex	Male	16	84.2
	Female	3	15.8
Specialty	General Medicine	6	31.6
	Internal Medicine	6	31.6

	Non-Speciality	1	5.3
	No Answer	6	31.6
Classification	Consultant Physician	4	21.1
	Senior Registrar	5	26.3
	Registrar	5	26.3
	House Officer/Senior House Officer	5	26.3
Years Practicing Medicine	0-5	5	26.3
	6-10	7	36.8
	11-15	5	26.3
	16-20	2	10.5
	21+	1	5.3
Medical School Graduation Decade	1990s	3	15.8
	2000s	5	26.3
	2010s	10	52.6
	2020s	1	5.3

3.2 Study Findings

3.2.1 Antibiotic Prescribing Practices

Factors considered when selecting a specific antibiotic

Pediatricians provided multifaceted reasons for selecting specific antibiotics for patients. Patient-centric considerations formed a cornerstone of their decision-making process, encompassing factors such as the patient's clinical condition, severity of illness, and individual characteristics like age and renal function. Additionally, nuances such as the impact on the gut microbiota, patient compliance, and antibiotic side effects were highlighted by some physicians, reflecting a holistic approach to treatment. Neonatal specialists emphasized unique considerations for this population, including preterm or term status. Results from diagnostic tests were pivotal in guiding antibiotic selection.

Moreover, antibiotic availability and sensitivity patterns emerged as critical factors influencing decision-making, with eight physicians considering these.

Adult physicians also considered multiple factors when selecting specific antibiotics for patients, with patient-related factors being a primary consideration. For example, Physician 1 emphasized that age, symptoms, cause and severity of illness, comorbidities, and previous illnesses factored into their decision-making process. Physician 29 integrated suspected conditions, patient history, culture reports, sensitivity patterns, and clinical sepsis into their decision-making process. Regarding infection and severity, multiple physicians (3, 5, 6, 11, 18, 20, 22, 23, 27, 30, and 31) considered factors such as the nature and severity of the disease, diagnostic results, and the site of infection. Additionally, antibiotic availability played a role in decision-making for some physicians (1, 2, 10, and 22), considering antibiotic sensitivity patterns, availability in the country, and guidelines.

Deciding on an antibiotic when culture data were not available

For pediatricians, the decision-making process for selecting antibiotics when culture data were not available included several key considerations. First, patient-related factors played a significant role, with physicians like Physician 8 highlighting the importance of patient stability and medical history. They tended to opt for oral antibiotics, particularly second-generation cephalosporins, for stable patients, reserving intravenous (IV) antibiotics for those who were severely ill or had complex medical backgrounds. Similarly, Physician 28 emphasized the role of experience and knowledge in making informed antibiotic choices when culture reports were not available. Prior culture data also informed antibiotic selection, as mentioned by Physician 15. This physician discussed the utility of the patient's history of culture reports in identifying the most likely causative agents, allowing for the initiation of empiric antibiotics while awaiting culture

6

results. Hospital policies also influenced antibiotic selection, with Physician 7 adhering to established protocols favoring IV cefotaxime and oral co-amoxiclav. Interestingly, none of the pediatricians mentioned seeking advice from colleagues or senior physicians in decision-making. This suggests that individual experience and knowledge were primary drivers when selecting antibiotics in the absence of culture data.

Adult physicians also underscored the intricate balance between patient-specific factors, clinical judgment, and available guidelines when making decisions when culture data were not available. Adult physicians emphasized the pivotal role of patient-related factors such as comorbidities, the severity of the condition, and the patient's history of previous culture reports in guiding antibiotic selection. Moreover, the accessibility and affordability of antibiotics were noted as practical considerations influencing decision-making. Furthermore, the importance of seeking advice from senior consultants, particularly in microbiology, was underscored, reflecting the recognition of the expertise and experience they bring to the decision-making process.

3.2.2 Knowledge and Attitudes towards Antimicrobial Resistance

Concerns about adverse effects or negative consequences when prescribing antibiotics

Among the pediatricians, discussions around antibiotic resistance were prevalent. Physician 7 expressed worries about cefotaxime resistance due to its long-term usage in the ward, highlighting the need for vigilance in antibiotic stewardship practices. Similarly, Physician 15 emphasized the implications of antibiotic resistance for the individual patient and their family members, underscoring the importance of considering long-term consequences in antibiotic prescribing decisions.

Adult physicians also raised concerns about antibiotic resistance, with physicians emphasizing the need for judicious prescribing practices to mitigate the risk of treatment failure and combat the growing problem of antibiotic resistance.

Antibiotic-resistant organisms and patterns in the wards and hospital

The Adult Physicians provided insights into the prevalence of antibiotic-resistant organisms in their departments, highlighting key findings. Common resistant organisms included 1) bacteria with ESBLs (Extended Spectrum Beta-Lactamases), which were frequently cited as challenging, particularly in urinary tract infections (UTIs), 2) MRSA (Methicillin-Resistant *Staphylococcus Aureus*), 3) Coliform Bacteria (*Enterobacteriaceae*), which were noted for multi-drug resistance, particularly in UTIs, 4) *Acinetobacter* spp, which was noted to have significant resistance, especially in the ICU setting, and 5) *Pseudomonas* spp, which were noted for resistance especially in cases of pneumonia. ESBL and MRSA were identified as the most challenging resistances encountered. Acinetobacter's multi-drug resistance and spread to wards were also noted.

Pediatricians also observed similar antibiotic resistance patterns in their departments. Common Resistant Organisms included 1) Acinetobacter species, 2) bacteria with ESBLs, 3) Escherichia coli (E. coli), 4) MRSA, and 5) Klebsiella species were noted for resistance.

Antibiotic prescribing patterns when faced with antibiotic-resistant organisms

All pediatricians acknowledged concerns about increasing resistance and the importance of strategic antibiotic use. When making prescribing decisions for antibiotic-resistant organisms, Physician 7 demonstrated a proactive approach by relying on microbiology opinions when encountering resistant organisms, indicating a willingness to seek expert guidance in prescribing decisions. In contrast, Physician 16 emphasized

patient treatment responses over culture reports. Physician 14 highlighted the significant influence of senior consultants in decision-making, indicating a hierarchical structure where junior physicians defer to senior colleagues for guidance on prescribing in the face of antibiotic resistance.

Adult physicians highlighted multiple challenges associated with empiric treatment of antibiotic-resistant organisms, emphasizing factors such as antibiotic availability, toxicity, patient history, and collaboration with microbiology departments to make inform decisions regarding broad-spectrum antibiotics. Physician 1, for instance, underscored the challenge of the limited availability of high-level (*i.e.*, broad-spectrum) antibiotics and considered the patient's previous culture results, particularly for resistant organisms like ESBLs and MRSA in antibiotic choice. Similarly, Physician 3 relied on clinical experience when microbiology results were unavailable, often opting for broad-spectrum antibiotics like meropenem or piperacillin-tazobactam in the absence of alternatives. The study also revealed varying approaches among physicians when faced with antibiotic resistance reports. For instance, Physician 11 sometimes disregarded culture reports if patients showed clinical improvement, while Physician 31 emphasized the importance of recent awareness gained from educational lectures on antibiotic resistance patterns. Physician 2 expressed difficulty in answering how resistance patterns affect their prescriptions—noting that seniors usually prescribe higher antibiotics, sometimes without awareness of new resistance patterns.

3.2.3 Knowledge of Antibiograms

Antibiogram Knowledge

Adult physicians revealed varying degrees of awareness and understanding of antibiograms. Physician 1 demonstrated a comprehensive understanding of antibiograms, describing it as a locally adapted policy based on susceptibility data. This

physician's familiarity extended to its implementation and consideration of cultural and epidemiological factors, with prior utilization experience in the UK. Nine (47%) Physicians (3, 4, 6, 10, 18, 20, 21, 23, and 31) acknowledged familiarity with the term "antibiogram" but had never seen one in person. Nine (47%) Physicians (2, 5, 11, 17, 19, 22, 27, 29, and 30) reported no prior knowledge or exposure to the concept of an antibiogram.

Pediatricians had a spectrum of knowledge regarding antibiograms. Three (27%) Physicians 9, 24 and 28 notably were familiar with antibiograms, indicating a depth of understanding or experience with these analytical tools. Conversely, eight (72%) physicians, including 7, 8, 13, 14, 15, 16, 25, and 26, lacked knowledge of antibiograms.

Comfort level with prescribing ciprofloxacin when 50% of the *Escherichia coli* isolates were resistant to ciprofloxacin

The Adult Physicians' comfort levels with prescribing ciprofloxacin in the context of 50% resistance among E. coli isolates varied significantly. Four physicians (4) were very uncomfortable; 21, 22, 23, and 31 expressed being very uncomfortable with this scenario. Physician 21 cited a 50% chance of treatment failure, while Physician 22 preferred a broader-spectrum antibiotic. Physician 23 questioned the rationale behind prescribing Ciprofloxacin with a 50% resistance rate, and Physician 31 emphasized the high likelihood of treatment failure and preferred alternative drugs.

Two physicians (2) were uncomfortable; 1 and 10 felt uncomfortable with this scenario. Physician 1 expressed discomfort due to the lack of recent patient cultures and considering Ciprofloxacin as a second-line drug for tuberculosis. Physician 10's comfort level depended on the severity of the patient's condition.

Two physicians (2) were neutral; 6 and 29 remained neutral. Physician 6's decision depended on the patient's clinical condition, while Physician 29 considered the prevalence of tuberculosis and would hesitate before prescribing Ciprofloxacin.

Eleven physicians (11) were comfortable; 2, 3, 4, 5, 11, 17, 18, 19, 20, 27, and 30 expressed comfort with prescribing ciprofloxacin despite the 50% resistance rate. Their comfort was based on various factors, including clinical context, documented antibiotic sensitivity patterns, in vitro versus in vivo effects, cost-effectiveness, and limited alternative options.

Pediatricians also showed varied comfort levels with prescribing ciprofloxacin in the context of 50% resistance among *E. coli* isolates. Six physicians (6) were uncomfortable; 7, 8, 14, 16, 26, and 28 expressed discomfort with this scenario. Reasons included potential side effects, especially in children under 2 years (Physician 7), concerns about side effects and efficacy (Physicians 8, 16, 26), and a general preference for other antibiotics in pediatric wards (Physician 28). Three physicians (3) were neutral; 9, 13, and 25 remained neutral, considering factors such as the 50-50 chance of effectiveness, absence of alternative tests, and reliance on clinical picture and investigations. Two physicians (2) were comfortable; 24 and 15 expressed comfort with prescribing ciprofloxacin given the 50% susceptibility rate among E. coli isolates. Physician 15 preferred not to use high-end antibiotics immediately, while Physician 24 found comfort in the susceptibility rate.

3.2.4 Stage 1: Scenario without antibiogram

Empiric antibiotic for treating UTI scenario

Adult Physicians faced with the task of selecting empiric antibiotics for treating UTI scenarios provided a diverse range of choices, including nitrofurantoin, ciprofloxacin, cefuroxime, co-amoxiclav, cefixime, co-trimoxazole, trimethoprim, and IV gentamicin.

The rationale behind their antibiotic selections was multifaceted, considering drug characteristics, coverage spectrum, and cost considerations. Nitrofurantoin was favored for its concentration in urine and good gram-negative coverage, while co-amoxiclav and cephalosporins were selected for their effectiveness against both gram-negative and gram-positive organisms. Co-trimoxazole and trimethoprim were also mentioned, reflecting considerations of their urinary excretion and resistance patterns. Some physicians factored in cost when making their antibiotic selections. Cefixime was chosen for its favorable coverage against gram-negative rods and cost-effectiveness. Nitrofurantoin was preferred by some for its affordability and availability, while others considered antibiotics like co-amoxiclav as cost-effective options. Physicians also considered alternative antibiotics for the UTI scenario, including ciprofloxacin, ceftriaxone, norfloxacin, and nalidixic acid, reflecting the range of options available for empiric treatment.

Pediatricians similarly selected a variety of oral and IV antibiotics for treating UTI scenarios in children. Choices included co-amoxiclav, cefuroxime, ciprofloxacin, cephalexin, cefixime, and cefotaxime, with considerations of drug characteristics, coverage spectrum, and ease of administration. Pediatricians opted for antibiotics that were effective against both gram-positive and gram-negative bacteria, ensuring broad coverage for potential pathogens causing UTIs. Choices were made based on the effectiveness of antibiotics against common UTI-causing organisms. In addition to the chosen antibiotics, pediatricians considered alternative options such as nitrofurantoin.

3.2.5 Stage 2: Scenario with antibiogram but no threshold values
How the information presented in an antibiogram informs prescribing decisions

All participants were provided with a definition and a sample antibiogram during the interview. The sample antibiogram contained gram negative bacteria for five (5)

organisms and thirteen (13) antibiotics which were both oral and IV. The sample antibiogram is listed in the appendix.

Adult physicians universally felt that antibiograms could play a pivotal role in informing their antibiotic prescribing decisions. Across the sample, physicians (1, 2, 3, 4, 5, 6, 10, 17, 18, 19, 20, 21, 22, 23, 27, 30, and 31) expressed favorable opinions towards antibiograms, emphasizing their utility and importance in clinical practice. They highlighted various aspects of antibiograms that could aid decision-making, such as understanding local sensitivity patterns, initiating antibiotics empirically, and making informed choices without culture reports. Physicians particularly appreciated the clarity and evidence-based nature of antibiograms, which guided the selection of the most suitable antibiotics for specific infections. None of the physicians identified any potential negative influences of antibiograms on prescribing decisions. Instead, they uniformly endorsed antibiograms as having the potential to enhance antibiotic stewardship and improve patient care by facilitating the judicious use of antibiotics based on local susceptibility patterns.

Pediatricians uniformly emphasized the critical role of antibiograms in guiding prescribing decisions, citing both positive influences and an absence of negative factors. They acknowledged the invaluable insights antibiograms provided into local sensitivity patterns of bacteria, facilitating the selection of optimal antibiotics for effective treatment. Physician 13 underscored the utility of antibiograms, noting that they prevent haphazard prescribing and offer an enhanced understanding of disease progression with specific antibiotics. Moreover, Physician 28 underscored the necessity of separate antibiograms for pediatric and adult wards due to variations in prevalent organisms across different age groups. Despite the complexity of managing pediatric patients, none of the

physicians identified any negative aspects associated with antibiograms, emphasizing their unequivocal value in guiding prescribing decisions.

Empiric antibiotic choice after seeing the antibiogram

Following a review of the sample antibiogram, adult physicians provided insights into their choices for empiric antibiotic treatment. Key antibiotics considered included amikacin (70.0%), ciprofloxacin (50.0%), imipenem (95.0%), piperacillin-tazobactam (85.0%), co-amoxiclav (65.0%), ceftriaxone (70.0%)/cefixime (65.0%), co-trimoxazole (80.0%), gentamicin (82.0%), nitrofurantoin (65.0%), meropenem (90.0%), and cefotaxime (70.0%). Physician preferences varied based on factors such as patient condition, clinical context, antibiotic availability, and cost-effectiveness.

Pediatricians presented a range of empiric antibiotic options, including co-trimoxazole (80.0%), ceftriaxone (70.0%), nitrofurantoin (65.0%), meropenem (90.0%), co-amoxiclav (65.0%), cefixime (65.0%), ciprofloxacin (50.0%), and amikacin (70.0%). Their antibiotic choices were influenced by considerations such as age, drug susceptibility, patient history, and the specific characteristics of the infection being treated.

Ease of understanding antibiogram

The feedback from adult physicians regarding the clarity of the antibiogram indicates a consensus that the presented information was easily comprehensible. Most physicians found the antibiogram straightforward, with only Physician 17 initially expressing some difficulty but later acknowledging its utility after closer examination. Physician 31 provided a specific suggestion to enhance clarity by recommending the categorization of IV and oral antibiotic information separately, which could potentially aid in easier comprehension for healthcare professionals.

Among pediatricians, there was unanimous agreement regarding the ease of understanding the antibiogram. All physicians expressed confidence in the clarity of the presented information. Responses ranged from succinct affirmations of "yes" to more detailed endorsements, such as those from Physician 16, who described the antibiogram as "quite easy" and "very good." While there was overwhelming agreement, Physician 24 offered a slightly nuanced perspective, indicating the antibiogram was "somewhat" easy to understand, suggesting a minor room for improvement in terms of clarity. Overall, pediatricians found the antibiogram to be accessible and comprehensible, highlighting its effectiveness as a tool for guiding antibiotic prescribing practices in pediatric settings.

Recommendations for antibiogram

In discussions regarding additional information to enhance the usefulness of the antibiogram, several suggestions were put forth by adult physicians. Recommendations regarding antibiotics focused on both oral and intravenous (IV) formulations. Physicians highlighted the importance of including a broader range of oral antibiotics such as ampicillin, cefixime, ciprofloxacin, co-amoxiclav, co-trimoxazole, cefuroxime, and nitrofurantoin to provide clinicians with more options for outpatient treatment.

Additionally, there were suggestions to emphasize common IV antibiotics like imipenem, as well as proposals for color-coding and separating IV and oral antibiotics to facilitate interpretation. Regarding microbial coverage, suggestions included expanding the antibiogram to include common gram-positive organisms like *Staphylococcus* and *Streptococcus*, alongside existing focus on gram-negative bacteria. Physicians also emphasized the importance of specifying sample types (urine, blood) and considering local drug availability to tailor the antibiogram to the specific needs of the healthcare setting.

Pediatricians offered various recommendations to enhance the effectiveness of the antibiogram in pediatric settings. Suggestions included the addition of antibiotics like cephalexin and cefuroxime to reflect their expected availability and usage in pediatric populations. Furthermore, there were proposals to provide information on whether listed antibiotics were effective against gram-negative or gram-positive microorganisms, along with considerations of regional resistance percentages and antibiotic cost and availability. Expansion of the microbial coverage in the antibiogram to include multi-drug resistant organisms was also recommended to better guide pediatric antibiotic prescribing practices.

Additionally, suggestions were made to incorporate information specific to respiratory and urinary tract infections, utilize visual aids like color-coding for clarity, and ensure regular updates to reflect changing patterns in antibiotic resistance and availability. Some pediatricians expressed uncertainty about the availability of antibiogram information tailored to specific age groups, highlighting a potential area for improvement in pediatric antibiogram development and implementation.

3.2.6 Stage 3: Scenario with threshold values

Alter decision of antibiotic choice in scenario due to standard threshold being 80%

Several adult physicians demonstrated a willingness to modify their antibiotic choices when informed that a standard threshold when choosing an empiric antibiogram was 80% susceptibility. They emphasized the importance of aligning treatment decisions with the level of susceptibility to optimize patient outcomes. These physicians recognized the significance of selecting antibiotics with higher susceptibility rates to ensure effective treatment while minimizing the risk of resistance development.

However, some physicians maintained their initial antibiotic choices despite the threshold not reaching 80%, citing various reasons such as practical constraints, patient factors, and the adequacy of the selected antibiotic's coverage. Furthermore, considerations regarding the availability of alternative antibiotics and the feasibility of oral administration were also highlighted as factors influencing decision-making processes. Overall, while adherence to the 80% susceptibility threshold was deemed crucial by some physicians for guiding antibiotic selection, others emphasized the importance of a nuanced approach, considering a range of clinical and practical considerations.

Pediatricians displayed varying responses concerning the alteration of antibiotic choices based on the 80% susceptibility threshold. Many pediatricians expressed a readiness to adjust their antibiotic selections in accordance with the threshold, recognizing it as a valuable tool for guiding treatment decisions and ensuring optimal patient care. They emphasized the importance of selecting antibiotics with high susceptibility rates to maximize efficacy and minimize the risk of treatment failure.

Conversely, some pediatricians questioned the strict adherence to the 80% threshold, advocating for a more nuanced approach that considers individual patient factors, clinical judgment, and the overall clinical context. Additionally, the consideration of oral medications emerged as a significant factor among pediatricians, reflecting the unique challenges and considerations inherent in pediatric antibiotic therapy. Overall, the responses of pediatricians underscored the complex nature of antibiotic decision-making in pediatric settings, balancing evidence-based practices with patient-centered care principles to achieve the best possible outcomes for young patients.

3.2.7 Receptiveness Towards Antibiogram Training and Implementation

Antibiogram training and implementation

Pediatricians endorsed unanimous support towards receiving training and guidance on using antibiograms in prescribing practices. Seven pediatricians (63.6%) agreed, and four pediatricians (36.4%) strongly agreed with the statement "*I would be open to receiving training and advice regarding antibiogram use in prescribing practices.*" Physician 26 expressed enthusiasm about learning more, considering it valuable information upon initial exposure to the sample antibiogram. Lastly, Physician 28 highlighted the potential of antibiogram training to refine antibiotic prescriptions. The Physicians did not provide specific information about what kinds of training would be helpful or how the training should be conducted.

Most of the adult physicians, including Physicians 1, 2, 3, 4, 6, 10, 11, 18, 19, 20, 21, 22, 23, 27, 29, 30, and 31, expressed agreement or strong agreement with the statement, "*I would be open to receiving training and advice regarding antibiogram use in prescribing practices*. However, Physician 17 remained neutral, neither expressing agreement nor disagreement about receiving training and advice regarding antibiogram use in prescribing practices.

The form of antibiogram training

The Adult Physicians 1, 3, 11, 18, and 29 favored small group workshops or sessions for antibiogram training. They highlighted the benefits of interactive discussions and practical scenarios involving both microbiologists and physicians to enhance understanding and application of antibiotic susceptibility and resistance data. Physicians 6 and 10 expressed a preference for large group training sessions. They emphasized the simplicity of using an antibiogram and the importance of considering local factors like

antibiotic availability and cost in a broader training setting. Physicians 4, 5, 17, 19, and 20 recommended Zoom meetings for antibiogram training due to convenience, accessibility, and the ability to involve experts both within and outside the hospital setting. They emphasized the need for focused discussions on antibiotics and species knowledge, despite the remote format.

Pediatricians like 7, 24, 25, and 26 preferred small group discussions for antibiogram training. They believed that smaller groups fostered more intimate discussions and allowed for better interaction and engagement among participants. Pediatricians 8, 9, 14, 15, and 28 preferred Zoom discussions for antibiogram training. They found this format ideal for its simplicity and broad accessibility, making it easier to involve a wider range of participants in the training process.

Pediatricians 9 and 24 suggested including all medical staff, including intern house officers, in small group discussions for antibiogram training. This approach ensures that all healthcare professionals involved in patient care have a comprehensive understanding of antibiotic susceptibility patterns. Pediatrician 16 proposed disseminating antibiogram information through media or leaflets, suggesting alternative methods to ensure widespread access to training materials and promote awareness of antibiotic resistance patterns.

Antibiotic training components

The suggestions for components of antibiogram training among adult physicians varied, reflecting a range of perspectives on effective training strategies. Physician 29 recommended small group scenario-based teaching to bridge the gap between microbiologists and physicians. This approach allows for interactive learning and practical application of antibiogram data in clinical scenarios. Physician 30 advocated for including hospital antibiogram data in training sessions. Integrating real-time data from

the hospital setting provides clinicians with up-to-date information on local antibiotic resistance patterns, enhancing the relevance and effectiveness of the training. Physician 21 emphasized the importance of discussing implementation strategies during antibiogram training. They suggested a collaborative effort between microbiologists and clinicians to ensure effective implementation of antibiogram recommendations into clinical practice. Physician 10 proposed involving a diverse group of trainers, including clinicians, microbiologists, and pharmacists, in antibiogram training. This multi-disciplinary approach ensures comprehensive coverage of relevant topics and perspectives, enriching the learning experience for participants.

Similarly, pediatricians offered suggestions for components of antibiogram training tailored to their specific needs and contexts. Physicians like 7, 14, and 16 emphasized the importance of understanding local resistance patterns and their implications for antibiotic prescribing. This includes learning about commonly isolated organisms, related disease conditions, and antibiotic susceptibility patterns specific to the local pediatric population. Physician 16 specifically proposed organizing a scientific forum led by the microbiology department to facilitate knowledge sharing on antibiotic sensitivity patterns.

Antibiogram training instructors

The preferences regarding the involvement of instructors in antibiogram training among adult physicians varied, with some expressing a preference for microbiologist involvement, others advocating for clinician involvement, and some having no specific preference. Physicians 5, 17, 22, 23, and 30 expressed a preference for involving microbiologists in antibiogram training. They recognized the expertise of microbiologists in interpreting antibiogram data and guiding antibiotic prescribing practices. In contrast, physicians like 2, 10, 21, and 31 preferred clinician involvement in antibiogram training.

20

They emphasized the importance of clinicians understanding antibiogram data directly relevant to their clinical practice and patient care decisions. A significant number of physicians (1, 3, 4, 6, 11, 18, 19, 20, 27, and 29) did not express a specific preference for the type of instructor involved in antibiogram training. They may be open to various approaches depending on the institutional context and available expertise.

Similarly, pediatricians also presented varied preferences for antibiogram training instructors, reflecting a diversity of opinions regarding the most effective approach. Pediatricians 14, 16, and 24 suggested involving microbiologists in antibiogram training. They highlighted the importance of leveraging the expertise of microbiology departments to provide comprehensive training on antibiotic sensitivity patterns. Pediatricians like 8, 13, 26, and 28 advocated for a multidisciplinary approach to antibiogram training. They recommended involving a combination of clinicians, microbiologists, consultants, and infection control nurses to ensure comprehensive coverage of relevant topics and enhance acceptance of antibiogram data among healthcare professionals.

Antibiogram information divided by syndrome

The organization of antibiogram information, whether by syndrome, organism, or system, elicited diverse opinions among adult physicians, reflecting various preferences and considerations. Several physicians (3, 11, 17, 18, 20, 29, and 31) advocated for a system-wise approach to organize antibiogram information. They suggested categorizing data based on systems such as the gastrointestinal tract, lungs, and skin, emphasizing its practicality and ease of organization, especially for frequently treated conditions like urinary tract infections and pneumonia. Conversely, a group of physicians (1, 2, 6, 10, 22, and 23) expressed a preference for a syndrome-wise approach, aligning with clinical conditions and common diseases. They argued that such an approach facilitates targeted antibiotic selection and decision-making based on prevalent syndromes like

urinary tract infections and respiratory tract infections. Some physicians suggested alternative approaches, such as organizing information by species, bacteria, or antibiotics (4), training based on clinical presentations and disease types (19), or categorizing by specific conditions to avoid confusion in culture reports (21).

Pediatricians also expressed diverse opinions regarding the organization of antibiogram information. Some pediatricians (9, 14, 15, 26, and 28) advocated for a syndrome-wise organization, emphasizing its practicality and relevance in addressing specific clinical presentations and facilitating quicker decision-making based on prevalent syndromes like urinary tract infections and pneumonia. Other pediatricians (7, 16, 24, and 25) favored an organism-wise organization, highlighting the importance of tailoring treatment decisions to the characteristics of specific pathogens and considering conditions like renal and liver failure. Two pediatricians (8 and 13) presented mixed opinions, with one leaning towards a system-wise approach and the other preferring disease-wise categorization without explicit support for syndrome or organism organization.

I would be open to using an antibiogram every time I prescribe antibiotics.

Pediatricians' attitudes towards the universal use of an antibiogram in clinical practice, were an antibiogram available, varied significantly. A notable portion, comprising Physicians 15, 16, 24, and 25 (36.4%), expressed disagreement with the idea of utilizing antibiograms extensively. They argued that frequent reference to such data might be unnecessary, suggesting that practitioners could rely on their memory and consult the antibiogram only as needed. In contrast, Physicians 7, 8, 9, and 13 (36.36%) advocated for the regular use of antibiograms in antibiotic prescribing, citing the importance of statistical data in improving patient outcomes. However, they also voiced

concerns about the time-consuming nature of referring to antibiograms for every patient, especially in busy clinical settings. Notably, Physician 28 (9.1%) strongly supported using antibiograms, emphasizing their benefits for patients, hospitals, and the prevention of antibiotic resistance. Reasons for differing opinions were multifaceted. For instance, Physician 7 highlighted concerns about workload, acknowledging the utility of antibiograms but expressing apprehension about the time required to consult them consistently. On the other hand, physicians 16, 24, and 25 emphasized their experience and familiarity with patient cases as reasons for relying less on antibiograms. Physician 26 adopted a neutral stance, recognizing the need for flexibility in decision-making based on individual clinical scenarios. None of the physicians mentioned concerns regarding the cost implications of developing an antibiogram to use.

The attitudes of adult physicians towards using antibiograms every time antibiotics are prescribed varied considerably. One (5%) physician strongly agreed with this practice, emphasizing the rational use of antibiotics supported by evidence. Eight (42.1%) Physicians agreed, citing reasons such as reliance on clinical knowledge and literature, comfort, and preference for using antibiograms, and the ability to choose appropriate antibiotics. However, a neutral stance was taken by three (15.79%) physicians who suggested reliance on experience to reduce the need for constant reference or expressed concerns about time constraints in critical situations. Conversely, seven (36.8%) physicians disagreed and had differing views about using antibiograms consistently, citing practical constraints, the importance of clinical sense, and the management of common infections through practice. Despite this diversity in attitudes, there were common themes among those open to using antibiograms every time antibiotics are prescribed. These included evidence-based decision-making, optimizing treatment, supporting antibiotic stewardship practices, and the importance of regular

23

updates to reflect current resistance patterns. Conversely, physicians not open to this practice highlighted practical constraints, reliance on clinical experience, cost considerations, pattern recognition, and the preference for selective use in special cases.

It is important to develop an antibiogram for this facility to reduce inappropriate antibiotic use.

When pediatricians were asked about the importance of developing an antibiogram to reduce inappropriate antibiotic use in the facility, 54.6% strongly agreed, while 45.5% agreed. None of the physicians disagreed. None of the physicians mentioned local guidelines as a factor influencing their views. Regarding the cost implications, Physician 7 strongly supported the development of an antibiogram, citing benefits for patients, reduced antibiotic resistance, shorter hospital stays, and lower costs. The potential for misuse of antibiotics was a recurring concern among physicians. Physician 8 stressed the importance of preventing unnecessary antibiotics to avoid intravenous treatments. In contrast, Physicians 9, 13, 14, 15, 16, 24, 25, 26, and 28 highlighted the role of an antibiogram in reducing antibiotic resistance and ensuring appropriate antibiotic prescribing practices. Despite the significance of patient volume in healthcare settings, none of the physicians addressed its potential impact on the need for an antibiogram.

Adult physicians also widely agreed that developing an antibiogram was crucial for reducing inappropriate antibiotic use, curbing antibiotic resistance, and fostering a more systematic approach to prescribing practices in their facility. Physicians practicing across various healthcare settings emphasized the necessity of antibiograms to provide valuable data on antibiotic sensitivity patterns, enabling informed antibiotic choices. One significant factor driving the importance of developing an antibiogram was the absence of recent local antibiotic treatment guidelines. Physicians 1 and 21 underscored the

potential consequences of lacking clear guidelines, such as increased antibiotic misuse and resistance. They stressed the need for antibiograms and institutional guidance to standardize antibiotic selection effectively. Additionally, cost considerations played a crucial role in physicians' perspectives. Physicians 6, 18, and 20 highlighted the potential cost savings and economic benefits of implementing antibiograms. They emphasized the importance of preventing unnecessary costs and rationalizing antibiotic usage to address economic constraints effectively. The misuse of antibiotics was another prevalent concern among physicians. They express worries about managing resistant infections and emphasized the role of antibiograms in guiding empirical treatment, minimizing irrational antibiotic use, and preventing disastrous outcomes. Moreover, patient volume emerged as a factor influencing the necessity of developing an antibiogram. Physicians 3, 6, 10, 19, and 29 associated high patient volume with increased antibiotic resistance and irrational prescribing practices. They indicated that strategies like antibiograms are essential to effectively address the challenges posed by patient volume.

It would be feasible for my facility to have a system in which antibiograms are developed and updated annually.

Based on the input gathered from pediatricians, there was notable consensus regarding the feasibility of implementing a system for developing and updating antibiograms annually within the facility. Among the surveyed pediatricians, a significant portion, 27.3%, strongly supported the proposed system, emphasizing its potential benefits for optimizing antibiotic usage and patient outcomes. Additionally, a majority, constituting 54.6% of the physicians, expressed agreement with the proposal, citing the need for a systematic approach to antibiotic prescription in response to increasing microbial resistance. However, a small percentage, representing 18.2% of the

physicians, adopted a neutral stance, with concerns raised regarding the practicality of annual development based on facility setup, staffing, and financial considerations.

Adult physicians also significantly supported the facility's feasibility of developing and updating antibiograms annually. A consensus emerged among physicians regarding the ample availability of resources, including a well-equipped microbiology department and the necessary infrastructure for this undertaking. This resource availability, as emphasized by physicians such as 1, 3, 10, 18, and 22, formed a foundational pillar supporting the feasibility of the proposed system. The positive impact on health outcomes, highlighted by Physician 3, also served as a compelling justification for the investment required despite potential costs. As suggested by Physicians 4, 11, 19, and 30, the notion of annual data collection was deemed practical and essential for creating effective antibiograms, further enhancing feasibility. Collaborative hospital structures, cited by Physician 1, and the emphasis on knowledge updating and microbiology expertise, indicated a conducive environment for implementing and updating antibiograms. However, concerns were voiced by Physician 5 regarding the time and cost-intensive nature of the endeavor, suggesting potential challenges. As expressed by Physician 2, uncertainty about proper implementation and acknowledgment of a gap in antibiotic prescription by Physician 29 added complexity to the feasibility assessment. Nevertheless, despite these concerns, the consensus among physicians leaned towards the feasibility of developing and updating antibiograms annually, driven by the perceived benefits for patient care and the presence of essential resources and collaborative structures within the facility.

Negative consequences of implementing an antibiogram

The responses from both adult physicians and pediatricians regarding the implementation of an antibiogram showcased a diversity of perspectives and considerations.

Adult physicians offered varied viewpoints on the utility of antibiograms. While some physicians expressed confidence in the tool's ability to rationalize antibiotic usage and improve patient care, others raised concerns regarding potential negative consequences. These concerns included challenges to clinical decisions, the risk of antibiotic resistance, and the limitation of relying solely on antibiogram recommendations. Many physicians emphasized the need for a balanced approach that integrates both clinical judgment and the information provided by the antibiogram. Additionally, there was consensus among physicians regarding the importance of regularly updating the antibiogram to maintain its relevance and effectiveness.

In contrast, pediatricians' opinions regarding the implementation of an antibiogram were also mixed. While a subset of pediatricians acknowledged potential negative consequences, such as the development of antibiotic resistance and challenges in clinical decision-making, the majority expressed confidence in the benefits of implementing an antibiogram. These pediatricians highlighted the tool's role in guiding antibiotic decisions, preventing haphazard antibiotic prescriptions, and improving overall patient care. Overall, pediatricians demonstrated a strong belief in the usefulness and objectivity of antibiograms in guiding antibiotic selection, with only a minority expressing reservations about its implementation.

Potential barriers to developing an antibiogram

Antibiotic availability emerges as a primary concern for both adult physicians and pediatricians regarding the feasibility of developing and implementing an antibiogram.

27

Adult physicians, notably Physicians 1 and 5, emphasized the challenges posed by the accessibility of certain antibiotics, potentially hindering the creation of a comprehensive antibiogram. Similarly, pediatricians expressed varying opinions on antibiotic availability, with some, like Physician 7, advocating for antibiogram use to enhance patient care, while others, such as Physicians 8, 15, and 28, cite economic factors and resistance as potential barriers.

Hospital workload emerged as another significant barrier identified by both adult physicians and pediatricians. Physicians 2, 5, and 29 among the adult physicians expressed concerns about the heavy workload impacting the effective implementation of an antibiogram within the facility. Pediatricians, such as Physicians 7 and 8, also acknowledged workload-related challenges, particularly in the context of respiratory infections and the influence of over-the-counter antibiotics on sensitivity patterns.

Economic considerations presented additional hurdles in both settings. Adult physicians, including Physicians 3, 5, and 29, expressed uncertainties regarding potential cost barriers, while pediatricians, notably Physicians 15 and 28, highlighted economic factors as significant obstacles to developing and implementing antibiograms, along with resistance from registrars and consultants.

Conflicts among staff emerged as a notable barrier, with adult physicians like Physicians 17 and 20 pointing out potential issues with sample collections and conflicts among consultants and doctors. Pediatricians, exemplified by Physician 16, raised concerns about the practical applicability of antibiograms, citing conflicts between laboratory choices and actual patient scenarios.

Issues with sample collection and culture posed additional challenges, as highlighted by both adult physicians and pediatricians. Physicians 21, 22, 29, and 30

stressed various challenges ranging from proper isolation of organisms to resource

limitations impacting blood culture collection and supplies.

Resource constraints, as identified by Physician 27 among adult physicians and

Physicians 15 and 28 among pediatricians, further compounded these challenges.

Finally, documentation problems, mentioned by Physician 31 among adult physicians,

added to the complexity of implementing effective antibiogram strategies.

4. Discussion

The purpose of this study was to gain a new understanding of Sri Lankan physicians; KAP towards antibiograms to inform future interventions to implement antibiograms. The information gained from this study could be adapted and deployed across other LMICs to improve antimicrobial prescribing patterns and decrease the burden AMR.

4.1 Key Findings and Interpretations

4.1.1 Demographics

The predominance of physicians who graduated from medical school in the 2010s and being in their 30s underscores the importance of adapting medical education curricula to meet the evolving needs of contemporary healthcare systems. As newer generations of physicians enter the workforce, medical training programs must incorporate emerging medical knowledge, technological advancements, and evolving healthcare delivery models to ensure that physicians are equipped to address current and future healthcare challenges effectively.

4.1.2 Antibiotic prescribing practices

Patient-centric factors emerged as primary drivers in decision-making across both adult physicians and pediatricians, with a focus on individual clinical conditions, severity of illness, and unique patient characteristics such as age and renal function. Our findings showcased limited knowledge of AMR and of appropriate drug use across a range of levels and specialty which is supported by previous studies across multiple LMICs (Wilkinson et al., 2019). All physicians mentioned structural issues that impleaded their ability to prescribe appropriate antibiotics such as ongoing antibiotic unavailability

which is supported by previous studies in Jordan (Al-Azzam et al., 2012) and India (Kotwani et al., 2012).

4.1.3 Understanding antibiograms

Lack of knowledge of antibiograms was high among all physicians which is supported by a previous study in the Midwestern US (Cooper et al., 2022). All physicians recognized the value of antibiograms in providing insights into local susceptibility patterns, facilitating the selection of appropriate antibiotics, and optimizing patient outcomes. The unanimous endorsement of antibiograms underscores their potential to enhance antibiotic stewardship efforts and improve patient care by guiding judicious antibiotic use based on local resistance profiles.

4.1.4 Attitudes towards future antibiogram training

All Physicians demonstrated a strong willingness to receive training and guidance on antibiogram use, emphasizing its potential to refine antibiotic prescriptions and improve patient care, which is supported by a previous 2016 study (Spiekerman et al., 2016). The importance of developing antibiograms to reduce inappropriate antibiotic use was widely recognized among both pediatricians and adult physicians. They emphasized its role in curbing antibiotic resistance and fostering a systematic approach to prescribing practices.

4.2 Study Implications

Firstly, the findings can inform policy decisions by providing insights into healthcare providers' attitudes and knowledge gaps regarding antimicrobial stewardship. Policymakers can utilize this information to prioritize resources and develop targeted interventions to promote rational antibiotic use and enhance diagnostic capabilities in healthcare facilities. Moreover, healthcare practitioners can benefit from a better

understanding of physician attitudes towards antibiograms, facilitating the development of educational programs and clinical guidelines to improve antibiotic prescribing practices and optimize patient care.

Additionally, the study underscores the importance of interdisciplinary collaboration and community engagement in addressing AMR, highlighting the need for collaborative efforts among healthcare professionals, researchers, policymakers, and local communities. By leveraging the study's findings, stakeholders can work together to develop evidence-based strategies for AMR management and healthcare delivery improvement in resource-limited settings, ultimately contributing to the global effort to combat antimicrobial resistance.

The study adds to the limited literature on antibiogram development and implementation in LMICs, where AMR poses significant challenges. Previous research has primarily focused on high-income countries, and studies need to examine the feasibility and effectiveness of antibiograms in resource-limited settings. By exploring physician attitudes and perceptions towards antibiograms in Southern Sri Lanka, this study fills an important gap in the literature. It provides valuable insights into the potential barriers and facilitators to antibiogram implementation in LMICs.

4.3 Lessons Learned and Recommendations

One key lesson learned is the importance of context-specific approaches tailored to the unique needs and challenges of each setting, like the tertiary care hospital in Sri Lanka. This underscores the necessity of understanding local healthcare infrastructure, cultural norms, and resource limitations when designing interventions to promote rational antibiotic use and enhance diagnostic capabilities.

One recommendation is that future initiatives prioritize education and training programs to improve awareness and understanding of antimicrobial resistance among healthcare providers. Investments in laboratory infrastructure and antimicrobial susceptibility testing capabilities are also essential for supporting the widespread implementation of antibiograms in Sri Lanka's resource-limited settings.

4.4 Study Strengths and Limitations

This study had some strengths. Research on developing and implementing antibiograms in low-resource settings, particularly in combating AMR, provided valuable insights. Using physician KAP as a focus, the study addresses a critical public health issue, aligning with global efforts to tackle AMR, which poses significant challenges in low- and middle-income countries. Through in-depth exploration facilitated by qualitative methods, the study provides nuanced insights into the receptiveness of physicians towards antibiograms, highlighting their potential role as practical diagnostic tools in clinical practice.

This study had some limitations. Convenience sampling was conducted to identify participants, and the small sample size as typical of other qualitative studies may introduce bias and limit the generalizability of findings. However, were enrolled until data saturation was reached, minimizing bias. Focusing solely on perspectives from physicians practicing in the clinical setting may have overlooked other key stakeholders (i.e., nurses, microbiologists) whose insights are essential for successful antibiogram implementation. Despite these limitations, the study underscores the importance of context-specific research in LMICs and lays the groundwork for designing targeted interventions to combat AMR and promote rational antibiotic use. Addressing the identified limitations and incorporating perspectives from diverse stakeholders can

enhance the validity and applicability of findings, ultimately contributing to more effective

strategies for combating AMR in resource-limited settings like Southern Sri Lanka.

4.5 Implications for Policy and Practice

From a policy perspective, the study underscores the importance of prioritizing

resources and support for antimicrobial stewardship programs, including establishing

antibiogram protocols, in LMICs. Policymakers should recognize the value of qualitative

research in understanding local contexts and tailor interventions accordingly. This could

involve funding capacity-building initiatives to train healthcare professionals on

antibiogram utilization and antimicrobial stewardship principles.

Additionally, policymakers and healthcare leaders should prioritize investments in

laboratory infrastructure and antimicrobial susceptibility testing capabilities in LMICs to

support the widespread implementation of antibiograms. This may require partnerships

with international organizations, donor agencies, and private sector stakeholders to

overcome resource constraints and ensure sustainable access to essential diagnostic

tools.

In terms of practice, the study highlights the need for comprehensive and

context-specific strategies to promote the adoption of antibiograms among physicians.

Healthcare institutions in LMICs should consider integrating antibiogram-based decision

support tools into clinical practice guidelines and electronic health record systems.

Moreover, continuing medical education programs should prioritize training on rational

antibiotic prescribing practices and interpretation of antibiogram data.

Furthermore, the study emphasizes the importance of multidisciplinary

collaboration among healthcare professionals, including physicians, microbiologists,

pharmacists, and administrators, in implementing effective antimicrobial stewardship

initiatives. This could involve establishing interdisciplinary antimicrobial stewardship

committees tasked with developing and monitoring antibiogram-based treatment guidelines and antimicrobial use policies.

4.6 Implications for Further Research

Future research should explore the perspectives and experiences of additional stakeholders beyond physicians, such as microbiologists, pharmacists, nurses, and healthcare administrators. Understanding the perspectives of these diverse stakeholders is crucial for developing comprehensive and collaborative approaches to antimicrobial stewardship and antibiogram implementation.

The antibiogram needs to be developed and implemented as a crucial next step. Longitudinal studies are needed to assess the long-term impact of antibiogram implementation on antimicrobial prescribing practices, patient outcomes, and the prevalence of AMR in LMICs. Longitudinal research can provide valuable insights into the sustainability and effectiveness of antibiogram-based interventions over time.

Additionally, research on innovative approaches to overcome barriers to antibiogram implementation, such as limited laboratory infrastructure and human resources, is warranted. This could include studies evaluating the feasibility and effectiveness of point-of-care testing technologies or digital health solutions for generating and disseminating antibiogram data in resource-limited settings.

Lastly, qualitative studies exploring patient perspectives and experiences related to antibiotic use, AMR, and antibiogram awareness can provide valuable insights into the broader socio-cultural factors influencing antibiotic prescribing practices and patient-provider communication.

5. Conclusion

In conclusion, this study examined antibiotic prescribing practices, knowledge of antibiograms, and attitudes towards future antibiogram training among physicians in a tertiary care hospital in the Southern Province of Sri Lanka. Interviews with 30 adult physicians and pediatricians revealed a predominantly young workforce, emphasizing the importance of continuous medical education. Variations in antibiotic prescribing practices and knowledge of antibiograms were observed across specialties and experience levels, indicating a need for targeted educational interventions to enhance antibiotic stewardship. Mixed attitudes towards future antibiogram training were identified, with some expressing enthusiasm and others citing time and resource constraints. Addressing these concerns and fostering a culture of lifelong learning will be crucial in promoting optimal prescribing practices and combating antimicrobial resistance in low-resource settings like Sri Lanka's Southern Province. This research contributes valuable insights for future interventions aimed at improving antibiotic stewardship and preserving antimicrobial effectiveness.

Appendix A

Data Collection Instruments

Philips - VoiceTracer Digital Voice Recorder 8 GB DVT1160

iPhone 13 - iOS 17.2.1

Appendix B

Study Interview Guide

Interview Questionnaire (20-30 min)

The aim of this project is to study how physicians at this hospital make decisions about prescribing antibiotics and how they feel about implementing tools that could help improve the prescribing of antibiotics in the future. We want to identify resources you currently use to prescribe antibiotics and any barriers you face to appropriately prescribing antibiotics. We also would like to present a sample tool called an antibiogram and learn how having this diagnostic tool at your hospital may inform your prescribing decisions. Lastly, we would like to know your thoughts about receiving future training to learn how to use this tool effectively.

This interview will be audio-recorded, transcribed verbatim, and analyzed by our team of researchers. The tape recording will be stored at the conclusion of the study for at least 3 years. All your information will remain confidential, and your name will not be linked to the recording or transcript of your interview. You have the right to withdraw from the study at any point until the study has been published.

- Do you have any questions about the information I presented to you?

- If you have understood and ready to participate, please sign the consent form.

Thank you for participating in our study. We truly appreciate it.

Demographics

1. Please tell me your age, gender, medical specialty, working position, duration of practicing at current workstation and medical school graduation year.

Antibiotic Prescribing Practices

2. If you decide to prescribe an antibiotic for a patient, what factors do you consider when selecting a specific antibiotic?

3. In the last 2-4 weeks, which antibiotics were not available to prescribe?

4. Are there specific antibiotics that most physicians prescribe in this hospital? What about in your department?

5. How do you decide which antibiotic to prescribe when culture data are not available?

- Does this vary based on the type of infection? For example, when treating pneumonia vs, a urinary tract infection?

Knowledge and Attitudes Towards Antimicrobial Resistance

6. What concerns, if any, do you have regarding adverse effects or negative consequences when prescribing antibiotics?

7. What kind of organisms have shown the most resistance to antibiotics in the department you serve? Have you observed any resistance patterns in this hospital?

8. How does knowledge of resistance in this area or hospital influence your prescribing patterns?

Knowledge of Antibiograms

Now I'm going to give you a hypothetical scenario, and I'd like your thoughts. There is no right or wrong answer.

9.   Assuming that you have no recent microbiological susceptibility results; The last year, when all E. coli isolates collected and were tested against the antibiotic ciprofloxacin, 50% of the isolates were susceptible to ciprofloxacin. How comfortable would you feel using ciprofloxacin for a patient presenting with an infection due to E. coli?

- Very uncomfortable, uncomfortable, neutral, comfortable, or very comfortable.

- Please explain why you chose that answer.

10.   What minimum percentage of antibiotic susceptibility to ciprofloxacin would you feel comfortable with when treating an E. coli infection?

- 30%, 50%, 80%, or 95%.

- Please explain why you chose that answer.

Stage 1: Scenario without antibiogram

We would like to present a scenario and ask you how you would prescribe antibiotics.

* Present one of the following scenarios:

·   Adult example:

A 25-year-old healthy female presents to the emergency department with increased urinary frequency and burning during urination. She has not had blood in her urine,

fevers, flank pain, or vaginal discharge. She has no prior history of infections and is on no other medications. She is afebrile with normal vital sign parameters. On the physical exam, she has mild abdominal discomfort with palpation. Urine analysis shows > 50 white blood cells. Urine culture shows Gram-negative rods.

· Pediatric example:

A 2-year-old healthy female presents to the emergency department with fever and increased urinary frequency. Her mother has not noticed cough, congestion, vomiting, diarrhea, or blood in her urine. She has no prior history of infections, was born full-term without complications, and is on no other medications. She is febrile to 38.5°C without hypotension or tachycardia. On the physical exam, she has mild abdominal discomfort with palpation with normal tympanic membranes, no upper respiratory symptoms, and normal lung exam. Urine analysis shows > 50 white blood cells. Urine culture shows Gram- negative rods.

11.   In this situation, without further information about susceptibilities, what would you typically choose as your empiric antibiotic?

12.   Why would you choose that antibiotic?

- Are there any other antibiotics you may consider using for this scenario?

- What factors did you consider ruling out the other antibiotics?

Stage 2: Scenario with antibiogram but no threshold values

13. Have you ever heard of an antibiogram? If so, can you describe what it is? Have you ever used one before?

Antibiograms are tools that help providers select the most appropriate empiric antibiotic treatment when microbiological data are not yet available. They are used to monitor local susceptibility trends and track changes in antimicrobial resistance. Antibiograms are created using microbiology data from the hospital's microbiology laboratory. When antibiograms are first made, they show at least six months of data. It is recommended that they eventually reflect one year of data and are updated yearly.

Presenting sample antibiogram - This is a sample antibiogram. The first column lists the organisms organized by Gram-negative or Gram-positive results. The second column shows the total number of isolates from patients in your facility within a specific timeframe (e.g., six months or a year). The next columns show the antibiotics tested and the susceptibility percentages for the organisms listed. A score of 0 suggests that all isolates were resistant and 100 indicates that all isolates were susceptible. To use an antibiogram, you first locate the organism of interest and select the appropriate empiric antibiotic based on the susceptibility scores.

14.   Do you have any questions about the antibiogram or what information is presented in it?

15.   How do you think the information presented in antibiograms might inform your prescribing decisions?

16.   Let's go back to the UTI scenario. What antibiotics might you select with the additional information from the antibiogram?

17.   Is the information presented in the antibiogram easy to understand?

18.   Do you have recommendations for additional information that could be included in the antibiogram?

Stage 3: Scenario with threshold values

19. In standard practice in the U.S., the threshold that is generally selected is 80% susceptibility in terms of when an antibiotic is recommended to be used empirically against an organism. Now, going back to the scenario, would knowledge of this threshold alter your decision change?

- Why or why not?

20. Given this additional information, what antibiotic would you prescribe empirically?

Receptiveness Towards Antibiogram Training and Implementation Feasibility

21. Please select the appropriate response about receiving training on antibiograms: I would be open to receiving training and advice regarding antibiogram use in prescribing practices.

(1) Strongly disagree - (2) Disagree - (3) Neither agree nor disagree - (4) Agree - (5) Strongly agree

22. What form of training would you prefer? Are there any specific components you would like the training to include? Who would you like to deliver the training?

23. If an antibiogram was developed at your facility, would you like the information to be divided by syndrome? (If they do not comprehend, prompt with the following — for example, by urinary tract infection or pneumonia - diseases?)

- Yes or no? If yes, what syndromes?

24. How often would you want an antibiogram to be updated in order for you to feel comfortable using it in your prescribing decisions?

- Every six months, every year, or other?

- Please explain your answer.

25. Is there any other information that would be helpful when making empiric prescribing decisions?

26. Please select the appropriate response about utilizing antibiograms:

I would be open to using an antibiogram every time I prescribe antibiotics.

(1) Strongly disagree - (2) Disagree - (3) Neither agree nor disagree - (4) Agree - (5) Strongly agree

- Please explain your answer.

27. Please select the appropriate response about implementing antibiograms:

a. It is important to develop an antibiogram for this facility to reduce inappropriate antibiotic use.

(1) Strongly disagree - (2) Disagree - (3) Neither agree nor disagree - (4) Agree - (5) Strongly agree

- Please explain your answer.

b. It would be feasible for my facility to have a system in which antibiograms are

developed and updated annually.

(1) Strongly disagree - (2) Disagree - (3) Neither agree nor disagree - (4) Agree - (5)

Strongly agree

- Please explain your answer.

28.   Do you think there could be negative consequences in implementing an

antibiogram in this facility? Please explain your answer.

29.   Are there any potential barriers to developing and implementing an antibiogram

in this facility?

30.   Is there anything else you would like to say regarding this topic before we finish

this interview?
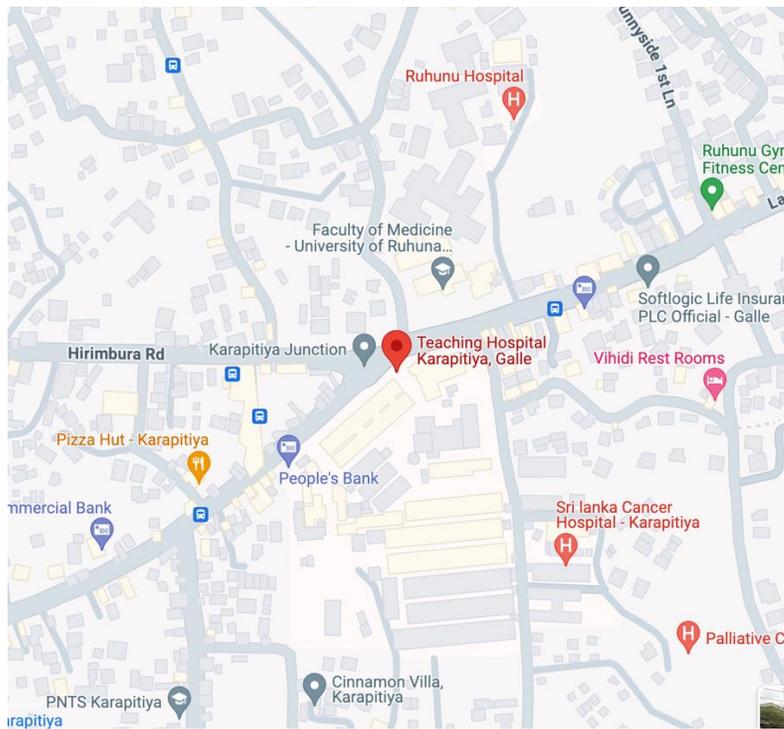
Thank you very much for your time.

Appendix C

Sample Antibiogram

	SAMPLE ANTIBIOGRAM	Antibiotic Susceptibility Patterns of Commonly Isolated Bacteria for 2023												
		Numbers below represent **percent of susceptible isolates**												
		Amikacin	Ampicillin	Cefixime	Cefotaxime	Ceftriaxone	Ciprofloxacin	Co-amoxiclav	Co-trimoxazole	Gentamicin	Imipenem	Meropenem	Nitrofurantion	Piperacillin-tazobactam
Gram Negative Bacteria	*Acinetobacter spp.*	80	0	0	/	/	0	0	22	0	70	80	/	/
	Enterobacter spp.	80	0	/	40	20	50	0	57	69	72	80	65	72
	Eshcerichia coli	70	15	65	70	65	50	65	80	82	95	90	65	85
	Klebsiella pneumoniae	63	12	60	65	60	50	60	75	75	90	90	65	80
	Pseudomonas spp.	86	0	/	50	/	79	/	/	80	78	90	0	89

Appendix D

Study site map and description

The Teaching Hospital Karapitiya (THK) is the largest Tertiary care center in Southern Province, and it was established in 1982. THK is the main clinical training institute for the Faculty of Medicine, Karapitiya.

References

Abera, B., Kibret, M., & Mulu, W. (2014). Knowledge and beliefs on antimicrobial resistance among physicians and nurses in hospitals in Amhara Region, Ethiopia. *BMC Pharmacology and Toxicology*, *15*(1), 26. https://doi.org/10.1186/2050-6511-15-26

Al-Azzam, S. I., Alzoubi, K. H., Mhaidat, N. M., Haddadin, R. D., Masadeh, M. M., Tumah, H. N., Magableh, A., & Maraqa, N. K. (2012). Preoperative antibiotic prophylaxis practice and guideline adherence in Jordan: A multi-centre study in Jordanian hospitals. *The Journal of Infection in Developing Countries*, *6*(10), 715–720.

Al-Omari, A., Al Mutair, A., Alhumaid, S., Salih, S., Alanazi, A., Albarsan, H., Abourayan, M., & Al Subaie, M. (2020). The impact of antimicrobial stewardship program implementation at four tertiary private hospitals: Results of a five-years pre-post analysis. *Antimicrobial Resistance and Infection Control*, *9*, 95. https://doi.org/10.1186/s13756-020-00751-4

Cooper, S. J., Destache, C. J., & Vivekanandan, R. (2022). Improving understanding and utilization of the antibiogram among medical residents. *Antimicrobial Stewardship & Healthcare Epidemiology : ASHE*, *2*(1), e142. https://doi.org/10.1017/ash.2022.275

Furuno, J. P., Comer, A. C., Johnson, J. K., Rosenberg, J. H., Moore, S. L., MacKenzie, T. D., Hall, K. K., & Hirshon, J. M. (2014). Using Antibiograms to Improve Antibiotic Prescribing in Skilled Nursing Facilities. *Infection Control & Hospital Epidemiology*, *35*(S3), S56–S61. https://doi.org/10.1086/677818

Hay, S. I., Rao, P. C., Dolecek, C., Day, N. P. J., Stergachis, A., Lopez, A. D., & Murray, C. J. L. (2018). Measuring and mapping the global burden of antimicrobial resistance. *BMC Medicine*, *16*(1), 78. https://doi.org/10.1186/s12916-018-1073-z

Hill, J. N., Suda, K. J., Ramanathan, S., & Evans, C. T. (2015). Development of a unit-specific antibiogram and planning for implementation: Preimplementation findings. *American Journal of Infection Control*, *43*(11), 1264–1267. https://doi.org/10.1016/j.ajic.2015.06.020

IHME. (2022). *The burden of antimicrobial resistance (AMR) in Sri Lanka* (p. 4). INSTITUTE FOR HEALTH METRICS AND EVALUATION. https://www.healthdata.org/antimicrobial-resistance/policy-briefings

Janet A. Hindler, Michael Barton, & Sharon M. Erdman. (2014). *Analysis and Presentation of Cumulative Antimicrobial Susceptibility Test Data; Approved Guideline—Fourth Edition*. Clinical and Laboratory Standards Institute.

Kotwani, A., Wattal, C., Joshi, P. C., & Holloway, K. (2012). Irrational use of antibiotics and role of the pharmacist: An insight from a qualitative study in New Delhi, India. *Journal of Clinical Pharmacy and Therapeutics*, *37*(3), 308–312.

Mathew, P., Ranjalkar, J., & Chandy, S. J. (2020). Challenges in Implementing Antimicrobial Stewardship Programmes at Secondary Level Hospitals in India: An Exploratory Study. *Frontiers in Public Health*, *8*, 493904. https://doi.org/10.3389/fpubh.2020.493904

Murray, C. J. L., Ikuta, K. S., Sharara, F., Swetschinski, L., Robles Aguilar, G., Gray, A., Han, C., Bisignano, C., Rao, P., Wool, E., Johnson, S. C., Browne, A. J., Chipeta, M. G., Fell, F., Hackett, S., Haines-Woodhouse, G., Kashef Hamadani, B. H., Kumaran, E. A. P., McManigal, B., … Naghavi, M. (2022). Global burden of bacterial antimicrobial resistance in 2019: A systematic analysis. *The Lancet*, *399*(10325), 629–655. https://doi.org/10.1016/S0140-6736(21)02724-0

Premaratna, R., Halambarachchige, L., Thilakaratne, Y., & Gunatilake, S. B. (2005). *Misuse of antibiotics for viral fevers by first contact doctors*.

Remesh, A., Gayathri, A. M., Singh, R., & Retnavally, K. G. (2013). The knowledge, attitude and the perception of prescribers on the rational use of antibiotics and the need for an antibiotic policy–a cross sectional survey in a tertiary care hospital. *Journal of Clinical and Diagnostic Research: JCDR*, *7*(4), 675.

Rolfe, R., Kwobah, C., Muro, F., Ruwanpathirana, A., Lyamuya, F., Bodinayake, C., Nagahawatte, A., Piyasiri, B., Sheng, T., Bollinger, J., Zhang, C., Ostbye, T., Ali, S., Drew, R., Kussin, P., Anderson, D. J., Woods, C. W., Watt, M. H., Mmbaga, B. T., & Tillekeratne, L. G. (2021). Barriers to implementing antimicrobial stewardship programs in three low- and middle-income country tertiary care settings: Findings from a multi-site qualitative study. *Antimicrobial Resistance & Infection Control*, *10*(1), 60. https://doi.org/10.1186/s13756-021-00929-4

Shrestha, J., Zahra, F., & Cannady, J. (2024). Antimicrobial Stewardship. In *StatPearls*. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK572068/

Spiekerman, K. M., Patel, S. J., Patel, R., & Kociolek, L. K. (2016). Availability, perceptions, and characteristics of antibiograms among Illinois pediatricians. *Infection and Drug Resistance*, *9*, 269–274. https://doi.org/10.2147/IDR.S122879

Tillekeratne, L. G., Bodinayake, C. K., Dabrera, T., Nagahawatte, A., Arachchi, W. K., Sooriyaarachchi, A., Stewart, K., Watt, M., Østbye, T., & Woods, C. W. (2017). Antibiotic overuse for acute respiratory tract infections in Sri Lanka: A qualitative study of outpatients and their physicians. *BMC Family Practice*, *18*(1), 1–10.

Velez, R., Richmond, E., & Dudley-Brown, S. (2017). Antibiogram, Clinical Practice Guidelines, and Treatment of Urinary Tract Infection. *The Journal for Nurse Practitioners*, *13*(9), 617–622. https://doi.org/10.1016/j.nurpra.2017.07.016

Westerling, R., Daryani, A., Gershuni, O., Czabanowska, K., Brand, H., Erdsiek, F., Aksakal, T., Uner, S., Karadag Caman, O., & Ozcebe, H. (2020). Promoting rational antibiotic use in Turkey and among Turkish migrants in Europe–implications of a qualitative study in four countries. *Globalization and Health*, *16*(1), 1–9.

WHO. (2016, January 1). *Global action plan on antimicrobial resistance*. https://www.who.int/publications-detail-redirect/9789241509763

WHO. (2023, November 21). *Antimicrobial resistance*. https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance

Wilkinson, A., Ebata, A., & MacGregor, H. (2019). Interventions to Reduce Antibiotic Prescribing in LMICs: A Scoping Review of Evidence from Human and Animal Health Systems. *Antibiotics*, *8*(1), Article 1. https://doi.org/10.3390/antibiotics8010002