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Knowledge, Attitudes, and Practices of Health Professionals Regarding Antimicrobial Resistance and Stewardship: A Cross-Sectional Study in the Pediatric Setting of Maputo Central Hospital, Mozambique

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Abstract: Background: Antimicrobial resistance (AMR) is a major public health challenge, particularly in low- and middle-income countries (LMICs), where antimicrobial stewardship (AMS) is often lacking. This study assessed the knowledge, attitudes, and practices of healthcare professionals in pediatric settings regarding AMR and AMS at Maputo Central Hospital, Mozambique. **Methods**: A cross-sectional survey was conducted among pediatric healthcare professionals using a self-administered questionnaire. Descriptive and inferential statistical analyses were performed to assess knowledge, attitudes, and practices, and their associated factors for inappropriate prescribing. **Results**: Of 108 eligible participants, 82 (76%) responded to the questionnaire. Overall, 53 (66%) correctly identified that antimicrobials do not treat viral infections, and 79 (99%) recognized factors contributing to AMR. However, only 28 (34%) were familiar with the concept of AMS programs, and participant knowledge related to empiric antibiotic selection was suboptimal. Physicians had significantly higher knowledge scores than laboratory technicians ($p = 0.036$). Prior AMS training was strongly associated with improved knowledge ($p < 0.001$) and better prescribing practices ($p = 0.005$). Despite 71 (92%) participants acknowledging AMR as a major issue, only 30 (37%) recognized their personal role in its emergence. A majority, 77 (94%), expressed interest in further AMS training. **Conclusion**: Pediatric healthcare professionals at Maputo Central Hospital are generally aware of AMR and exhibit positive attitudes toward AMS. However, notable gaps exist in their knowledge and practices. Strengthening AMS education, increasing access to treatment guidelines, and integrating AMS training into routine professional development are recommended to improve appropriate antimicrobial prescribing. These findings support interventions that are aligned with Mozambique's National Action Plan on AMR.

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1. Introduction

Antimicrobial resistance (AMR) is an escalating global health concern with profound effects on morbidity, mortality, and healthcare costs[1–4]. Factors such as inappropriate antibiotic prescribing practices and insufficient antimicrobial stewardship programs (ASP) have been shown to exacerbate the problem [5–10]. In low-and middle-income countries (LMICs), additional challenges include weak healthcare infrastructure, lack of diagnostic tools, over-the-counter availability of antibiotics, drug stock-outs, an inadequately trained healthcare workforce, weak regulatory systems, and limited or non-existent AMR surveillance programs [11–13].

Antimicrobial stewardship (AMS) involves coordinated interventions to optimize and assess the appropriate use of antimicrobials by promoting the selection of the most suitable drug, dose, duration, and route of administrations, thus serving as a critical tool in combating AMR and its associated factors [14–16]. Effective ASP includes elements such as leadership commitment and accountability; a clear definition of stakeholder roles and responsibilities; expertise in infection prevention and control; implementation of stewardship activities, education, and training; and monitoring and surveillance of antimicrobial use and resistance. Regular feedback to the stewardship team on program outcomes further strengthens these initiatives [14,17–19]. Prior studies have demonstrated that hospital-based ASPs improve awareness and knowledge of antimicrobial use and AMR, leading to more appropriate prescribing practices [18–24].

In 2015, the World Health Organization (WHO) introduced the Global Action Plan on Antimicrobial Resistance (GAP-AMR), to address AMR across multiple areas [25–27]. The WHO also urged countries to develop National Action Plans (NAPs) tailored to their local contexts. These initiatives aimed to enhance awareness, knowledge, and practices related to AMR, antimicrobial use, and AMS among healthcare professionals and the broader community, ultimately reducing the emergence and spread of AMR [22,26–28].

Mozambique adopted its NAP on AMR in 2018, with periodic monitoring and updates [29,30]. However, challenges in implementation persist, particularly due to resource constraints [31,32]. A key strategic objective and goal of Mozambique's NAP is optimizing antimicrobial use through the effective implementation of ASPs in all healthcare facilities [29].

In Mozambique's hospitals, AMR is exacerbated by high levels of inappropriate prescribing, including the excessive use of antibiotics from the WHO's "watch" list, high rates of empirical prescribing, and prolonged antibiotic use [30,31,33]. Pediatric settings are particularly concerning, where antibiotics are frequently prescribed for viral upper respiratory infections (URTI), despite their limited efficacy in such cases [33]. Understanding the factors contributing to inappropriate antimicrobial prescribing in these settings is essential. Assessing the knowledge, attitudes, and practices (KAP) of healthcare professionals working in pediatric settings regarding AMR and AMS is therefore critical, as emphasized in previous studies [24,26,34–36].

This study aims to assess health professionals' knowledge, attitudes, and practices regarding AMR and AMS in the pediatric setting of Maputo Central Hospital (*Hospital Central de Maputo, HCM)*, to identify gaps in these areas that may influence the effectiveness of AMS efforts.

2. Results

2.1. Demographic Characteristics of Participants

A self-administered questionnaire was distributed to all 108 healthcare professionals working within the pediatric inpatient departments of HCM, of which 76% (82/108) responded to the questionnaire. The majority of participants were female (n=68, 83%), with a median age of 36 years [IQR: 31-41 years] and a median of 9 years of work experience [IQR: 7-13 years]. Furthermore, the

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majority of respondents worked within the Intensive Care Unit (ICU) (n=27, 33%) or the Infectious Diseases Unit (n=15, 18%). The Microbiology section (n=7, 9%) and Respiratory Diseases section (n=8, 10%) were the least represented areas. Most participants were either nurses (n=40, 49%) or physicians (n=34, 41%), of which less than a quarter (N=20, 24%) reported receiving any prior training on AMS. Additionally, 71% (n=58/82) of participants responded negatively when asked if they had access to a standard treatment guideline for antimicrobial use in their practice setting (Table 1).

Table 1. Sociodemographic characteristics.

Characteristics (N=82)	n (%)
Sex	
Male	14 (17%)
Female	68 (83%)
Age (Median [Q1, Q3] Min, Max)	36 [31, 41] 24, 57
Years of work experience (Median [Q1, Q3] Min, Max)	9 [7, 13] 1, 30
Service Unit	
Infectious Diseases ward	15 (18%)
Intensive Care Unit	27 (33%)
General Pediatric Ward	14 (17%)
Respiratory Disease Ward	8 (10%)
Infants ward	11 (13%)
Microbiology Lab	7 (9%)
Occupation	
Nurse	40 (49%)
Pharmacist	1 (1%)
Physician	34 (41%)
Laboratory technician	7 (9%)
Education level	
Basic Laboratory Technician	1 (1%)
Intermediate Laboratory Technician	33 (40%)
Higher Education (Physician, Nurse, and Lab Technician)	33 (40%)
Pediatrician (Clinical Specialist)	13 (16%)
Master degree	2 (2.4%)
Have you received training in antibiotic stewardship?	
Yes	20 (24%)
No	62 (76%)
Do you have a Standard Treatment Guideline?	
Yes	24 (29%)
No	58 (71%)

2.2. Healthcare Professionals' Knowledge of Antimicrobial Resistance and Antimicrobial Stewardship

The knowledge of healthcare worker's regarding AMR and AMS is summariezed in Table 2. Nearly all participants (n=79, 99%), were able to positively recognize factors that contribute to the development of AMR, and roughly three-fourths (n=59, 72%) responded affirmatively that restricting antimicrobial use could help reduce AMR. However, in contrast, only roughly two-thirds (n=53, 66%) of participants correctly identified that antimicrobials do not treat viral infections. Further, only 34% (n=28) of participants were familiar with the concept of programs for antimicrobial stewardship.

When asked questions related to antibiotic prescribing practices, less than 50% of participants could adequately describe "Defined Daily Dose" (n=39, 48%) or "Days of Therapy" (n=43, 52%). Furthermore, when questioned about the empiric antibiotic treatment for different conditions, overall knowledge was insufficient, with respondents only able to answer correctly in the following proportions: pneumonia (n=17, 21%), uncomplicated urinary tract infection (n=7, 8.6%), and sepsis

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(n=41, 51%). The median overall knowledge score was 54 (out of a total possible score of 100) indicating intermediate knowledge of AMR and AMS.

Table 2. Healthcare Professionals' Knowledge of Antimicrobial Resistance and Antimicrobial Stewardship.

GENERAL KNOWLEDGE OF ANTIMICROBIAL RESISTANCE (AMR)	n (%)
Do antimicrobials treat acute viral infections? (N=80)	
Yes	27 (34%)
No	53 (66%)
Do you know the causes of common colds? (N=82)	
Yes	71 (87%)
No	11 (13%)
Do you know the factors contributing to AMR? (N=80)	
Yes	79 (99%)
No	1(1%)
Does restricting antimicrobial use reduce AMR? (N=82)	
Yes	59 (72%)
No	23 (28%)
Are you familiar with the Antimicrobial Stewardship Program (ASP)? (N= 82)	
Yes	28 (34%)
No	54 (66%)
Can you explain the term Defined Daily Dose (DDD)? (N=81)	
Yes	39 (48%)
No	42 (52%)
Can you explain the term Days of Therapy (DOT)? (N=82)	
Yes	43 (52%)
No	39 (48%)
Correctly identified the empiric treatment for pneumonia? (N=80)	
Yes	17 (21%)
No	63 (79%)
Correctly identified the empiric antibiotic for uncomplicated urinary tract infections? (N=81)	
Yes	7 (9%)
No	74 (91%)
Correctly identified the empiric antibiotic for sepsis? (N=80)	
Yes	41 (51%)
No	39 (49%)
Do you know if the frequency of MRSA* is high in your hospital? (N=81)	
Yes	35 (43%)
No	46 (57%)
Knowledge Index Score Median [Q1, Q3] Min, Max	54 [45,64] 18, 73

*MRSA = Methicillin-Resistant Staphylococcus Aureus.

2.2.1. Factors Associated with Healthcare Professionals' Knowledge Scores on Antimicrobial Resistance and Antimicrobial Stewardship.

The factors associated with health professionals' knowledge on AMR and AMS are detailed in Table 3. The Spearman correlation between age and Knowledge Index was 0.067 (p = 0.566), suggesting a very weak and non-significant association. Similarly, the correlation between years of work experience and knowledge score was 0.121 (p = 0.304), indicating no significant relationship.

The knowledge index was similar, with no statistical difference, between male and female participants, with both having a median score of 54 (IQR: 45–57 for males, 45–64 for females, p = 0.845). Participants from the Infectious Diseases unit had the highest knowledge index score (median = 64, IQR: 48–64), and the lowest knowledge index score was observed among those working in Microbiology (median = 36, IQR: 23–50). The difference in knowledge across the different service units was not statistically significant (p = 0.265). Physicians had a higher knowledge index score (median = 54, IQR: 52–64), while lab technicians had the lowest (median = 36, IQR: 23–50). The

 doi:10.20944/preprints202506.1453.v1

difference in knowledge by occupation was statistically significant (p = 0.036). Post-hoc comparison indicated that there is a significant difference between physicians and laboratory technicians (p = 0.047).

The analysis showed a trend of increasing knowledge index scores with higher educational qualifications. Basic Technicians had the lowest and most uniform scores (45 IQR: 45–45], while Intermediate Technicians scored slightly higher with greater variability (54 IQR: 36–64). Those with Higher Degrees (physicians, nurses, and lab technicians) had a similar median score (54 IQR: 45–64) but with more consistent performance. Pediatricians (Clinical Specialists) demonstrated the highest scores and the widest range (54 IQR: 45–72), indicating stronger knowledge in AMR and AMS. Although this trend was evident, the differences were not statistically significant (p = 0.375). Participants who had previously received AMS training had a significantly higher knowledge index score (median = 64, IQR: 54–73) compared to those who had not (median = 54, IQR: 36–54). Participants who had access to a Standard Treatment Guideline had a higher knowledge index score (median = 54, IQR: 45–64) compared to those who did not (54, IQR: 36–64). The difference was not statistically significant (p = 0.269).

Table 3. Factors Associated with Healthcare Professionals' Knowledge Index Scores on Antimicrobial Resistance and Antimicrobial Stewardship.

Characteristics	Knowledge Index[a] Score [IQR]	p-value
Sex		
Male	54 [45, 57]	0.845[b]
Female	54 [45, 64]	
Age (Years)	0.067[d] [95% IC: -0.1580 - 0.2945]	0.566[e]
Years of Work Experience	0.121[d] [95% IC: -0.1189 - 0.3650]	0.304[e]
Service Unit		
Infectious Diseases Ward	64 [48, 64]	0.265[c]
Intensive Care Unit	54 [45, 59]	
General Pediatric Ward	54 [45, 64]	
Respiratory Diseases Ward	54 [34, 66]	
Infants Ward	54 [45, 54]	
Microbiology Laboratory	36 [23, 50]	
Occupation		
Nurse	54 [45, 64]	0.036[c]
Pharmacist	45 [45, 45]	
Physician	54 [52, 64]	
Lab Technician	36 [23, 50]	
Educational Qualifications		
Basic Technician	45 [45, 45])	0.375[c]
Intermediate Technician	54 [36, 64]	
Higher Degree (physician, nurse, and Lab Technician)	54 [45, 64]	
Pediatrician (Clinical Specialist)	54 [45, 72]	
Received Training in ASP in the past?		
Yes	64 [54, 73]	<0.001[b]
No	54 [36, 54]	
Involved in antimicrobial prescribing?		
Yes	54 [45, 64]	0.134[b]
No	54 [36, 64]	
Do you have a Standard Treatment Guideline		
Yes	54 [45, 649	0.269[b]
No	54 [36, 64]	

[a]Knowledge Index: Median [Q1 – Q3[; [b] Wilcoxon rank sum test; [c]Kruskal-Wallis test; [d]Spearman's correlation coefficient; [e]Spearman's correlation test.

 doi:10.20944/preprints202506.1453.v1

2.3. Healthcare Professionals' Attitudes toward Antimicrobial Resistance and Antimicrobial Stewardship

Among the participants, 77 (94%) expressed a strong interest in receiving additional training on AMR and AMS. Furthermore, 61% (n=50) of participants reported the overuse of antimicrobials within their respective hospitals. However, only 37% (n=30) acknowledged that their actions as healthcare professionals could contribute to the development of AMR. Most participants perceived AMR as a major issue, both nationally in Mozambique (n=71, 92%) and within their hospitals (n=67, 89%), reflecting a high level of awareness. The median attitude score was 80 (IQR: 70–90), indicating overall positive attitudes toward efforts in addressing AMR (Table 4).

Table 4. Attitudes toward Antimicrobial Resistance and Antimicrobial Stewardship.

Healthcare Professionals' Attitudes	n/N (%)
Do you want training on AMR and antibiotic stewardship?	
Yes	77/82 (94%)
No	5/82 (6.1%)
Are antimicrobials safe medications that can be commonly prescribed?	
Yes	56/82 (68%)
No	26/82 (32%)
Do you think antibiotics are overused in your hospital?	
Yes	50/82 (61%)
No	32/82 (39%)
Do you consider that your actions may be personally contributing to AMR?	
Yes	30/82 (37%)
No	52/82 (63%)
Would you consider AMR a global problem?	
Yes	72/80 (90%)
No	8/80 (10%)
Would you consider AMR a problem in Mozambique?	
Yes	71/77 (92%)
No	6/77 (7.8%)
Would you consider AMR a problem in your hospital?	
Yes	67/75 (89%)
No	8/75 (11%)
Do you think restricting the use of antimicrobials is necessary to reduce AMR?	
Yes	59/82 (72%)
No	23/82 (28%)
Do you believe that a patient who misses doses of antibiotics contributes to the development of AMR?	
Yes	66/79 (84%)
No	13/79 (16%)
Prescribing antibiotics to a patient who does not need them can lead to an increase in adverse health effects.	
Yes	68/81 (84%)
No	13/81 (16%)
Attitude Index Score Median [Q1, Q3]) Min, Max	80 [70, 90] 30, 100

AMR = antimicrobial resistance.

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2.3.1. Factors Associated with the Healthcare Professionals' Attitude Index on Antimicrobial Resistance and Antimicrobial Stewardship

Both male and female participants had a median Attitude Index Score of 80, with overlapping interquartile ranges, and the Mann-Whitney test yielded a p-value of 0.769, indicating no statistically significant difference in attitudes based on sex. The Spearman correlation between age and Attitude Index was 0.114 (p = 0.341), suggesting a weak and non-significant association. Similarly, the correlation between years of work experience and attitude score was 0.094 (p = 0.433), further indicating no significant relationship.

Statistically significant differences in attitudes were observed across professional categories, with physicians exhibiting higher scores than nurses and laboratory technicians (p = 0.018). Furthermore, a significant difference in attitudes was found between participants involved in antimicrobial prescribing and those who were not (p = 0.033). The availability of a Standard Treatment Guideline (STG) was also associated with a statistically significant difference in attitudes (p = 0.023), with participants who had access to such guidelines demonstrating higher scores (Table 5).

Table 5. Factors Associated with the Healthcare Professionals' Attitude Index on Antimicrobial Resistance and Antimicrobial Stewardship.

Characteristic	Attitude Index[a] Score [IQR]	P-value
Sex		
Male	80 [70, 85]	0.769[b]
Female	80 [70, 90]	
Age (Years)	0.114[d] [95% IC: -0.104 - 0.331]	0.341[e]
Years of Work Experience	0.094[d] [95% IC: -0.162 - 0.318]	0.433[e]
Service Unit		
Infectious Diseases Ward	80 [80, 90]	0.482[c]
Intensive Care Unit	80 [70, 90]	
General Pediatric Ward	70 [70, 80]	
Respiratory Diseases Ward	75 [65, 90]	
Infants Ward	80 [60, 90]	
Microbiology	60 [60, 80]	
Occupation		
Nurse	70 [65, 80]	0.018[c]
Physician	90 [80, 90]	
Lab Technician	60 [60, 80]	
Received Training in ASP?		
Yes	80 [70, 90]	0.368[b]
No	80 [67, 90]	
Involved in antimicrobial prescribing?		
Yes	80 [70, 90]	0.033[b]
No	80 [60, 80]	
Have access to the Standard Treatment Guideline		
Yes	90 [75, 90]	0.023[b]
No	80 [60, 90]	

[a]Attitude index: Median [Q1 – Q3[; [b]Wilcoxon rank sum test; [c]Kruskal-Wallis test; [d]Spearman's correlation coefficient; [e]Spearman's correlation test.

 doi:10.20944/preprints202506.1453.v1

2.4. Practices Related to Antimicrobial Resistance and Antimicrobial Stewardship

The primary source of information used by our participants regarding antimicrobial use was consultation with colleagues (n=43, 52%), followed by formal sources such as guidelines or protocols (n=29, 35%). Only 24% (n=11) of participants reported sending samples for laboratory testing prior to initiating antimicrobial therapy. Empirical prescribing of antimicrobials was reported by 66% (n=33) of participants, whereas antimicrobial combination therapy was commonly employed by over 83% of participants (n=50). Furthermore, 76% (n=31) of participants indicated that they had adjusted their prescribing practices in response to antimicrobial resistance awareness, reflecting a positive shift in behavior. The median practice score was 80, with a range of 50 to 90 (Table 6).

Table 6. Practices Related to Antimicrobial Resistance and Stewardship.

Healthcare Professionals' Practices	n/N (%)
Source used to obtain information on antimicrobial use.	
Colleagues	43/82 (52%)
Mozambique Medicines Formulary	29/82 (35%)
Other*	10/82 (12%)
Do you send samples for testing for AMR to guide the selection of antimicrobial therapy?	
Yes	11/45 (24%)
No	34/45 (76%)
Do you prescribe antimicrobials based on empirical evidence?	
Yes	33/50 (66%)
No	17/50 (34%)
Do you prescribe antimicrobials when they are available?	
Yes	17/45 (38%)
No	28/45 (62%)
Do you prescribe antimicrobials at the patient's request?	
Yes	2/44 (4.5%)
No	42/44 (95%)
Do you use antibiotic combination therapy?	
Yes	50/60 (83%)
No	10/60 (17%)
Do you administer the antimicrobial considering the patient's progression?	
Yes	43/55 (78%)
No	12/55 (22%)
Do you refrain from prescribing antimicrobials in cases of uncertain diagnosis?	
Yes	46/63 (73%)
No	17/63 (27%)
Have you changed your prescribing behavior because of the worsening of AMR in recent years?	
Yes	31/41 (76%)
No	10/41 (24%)
According to the clinical condition, are IV antibiotics converted to oral form within 2-3 days?	
Yes	44/62 (71%)
No	18/62 (29%)
Practice Index Score Median [Q1, Q3] Min, Max	80 [70, 80] 50, 90

*Other = Merck Manual, Medical Journals, Medical Websites, and National Standard Treatment Guidelines.

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2.4.1. Factors Associated with the Healthcare Professionals' Practice Index on Antimicrobial Resistance and Stewardship

The Practice Index scores showed no significant difference between male and female participants, with a shared median of 80 and a p-value of 0.801 (Mann-Whitney test). The Spearman correlation between age and Practice Index was 0.351 (p = 0.015), suggesting a weak but statistically significant positive association. Conversely, the correlation with years of work experience was 0.1103 (p = 0.110), indicating no significant relationship.

Physicians exhibited the highest practice index scores, ranging from 80 to 90 (p = 0.022), while nurses attained comparatively lower index scores, ranging from 60 to 70. Moreover, participants who had received training in AMS demonstrated significantly better practice index scores compared to those who had not undergone such training (p = 0.005) (Table 7).

Table 7. Factors Associated with the Healthcare Professionals' Practice Index Score on Antimicrobial Resistance and Antimicrobial Stewardship.

Characteristics	Practices Index[a] Score [IQR]	p-value
Sex		
Male	80 [80, 80]	0.801[b]
Female	80 [70, 85]	
Age (Years)	0.507[d] [95% IC: 0.129 - 0.746]	0.015[e]
Years of Work Experience	0.351[d] [95% IC: -0.091 - 0.692]	0.1103[e]
Service Unit		
Infectious Diseases Ward	80 [75, 85]	0.874[c]
Intensive Care Unit	80 [70, 80]	
Respiratory Diseases Ward	70 [57, 82]	
Infants Ward	80 [80, 80]	
Occupation		
Nurse	70 [60, 70]	0.022[b]
Physician	80 [80, 90]	
Have you received training on AMS?		
Yes	80 [80, 90]	0.005[b]
No	80 [70, 80]	
Do you have access to Standard Treatment Guidelines		
Yes	80 [80, 90]	0.124[b]
No	80 [67, 80]	

[a]Practice Index: Median [Q1 – Q3]; [b]Wilcoxon rank sum test; [c]Kruskal-Wallis test; [d]Spearman's correlation coefficient; [e]Spearman's correlation test.

3. Discussion

This study aims to assess health professionals' knowledge, attitudes, and practices regarding AMR and AMS in the pediatric setting of a single quaternary care center in Mozambique. While the findings reflect important trends and gaps, their generalizability is limited due to the single-center nature of the study. Nevertheless, they offer valuable insights for designing targeted AMS interventions in similar low- and middle-income healthcare settings.

The overall level of knowledge about AMR and AMS among participants was moderate, with a median score of 54 out of 100. Although nearly all participants were able to recognize factors contributing to AMR, knowledge deficits were evident in more technical areas, such as understanding "Defined Daily Dose" and "Days of Therapy," as well as in identifying appropriate empiric treatment for common infections. Only one-third of participants were familiar with the concept of ASP. This finding emphasizes the importance of focusing on ongoing medical education and employing tailored interventions to strengthen physicians' and nurses' knowledge in this area.

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Improved knowledge of pediatric-specific antimicrobial susceptibility data has a significant influence on prescribers' empiric antibiotic choices, reinforcing the need for pediatric-specific antibiograms to guide treatment decisions. These findings are consistent with studies conducted in Ghana, Pakistan, the US, and South Africa, which also reported limited knowledge of AMS frameworks among frontline healthcare workers [35,37–39].

In our study, significant differences in knowledge were observed across professional categories. Physicians demonstrated higher knowledge scores than laboratory technicians ($p = 0.036$), with post-hoc analysis confirming this difference ($p = 0.047$). Furthermore, those who had received prior training in AMS scored significantly higher than those without such training ($p < 0.001$), highlighting the positive impact of educational interventions. Similar patterns have been documented in studies conducted in Ghana and Zambia, where physicians demonstrated higher levels of knowledge compared to other healthcare professionals, and prior training in ASP was associated with significantly greater knowledge scores [40,41]. These results support targeted training strategies, particularly for non-physician staff who may have less exposure to formal AMS education. Notably, professionals from the Infectious Diseases Unit exhibited the highest knowledge scores, suggesting that departmental focus may influence familiarity with AMR/AMS topics.

Attitude scores were generally positive, with a median of 80 (IQR: 70–90), indicating a strong awareness of AMR as a critical public health issue. Most participants recognized AMR as a national and institutional concern and expressed a desire for further training. However, few participants acknowledged their role in contributing to AMR, a finding also reported in studies from Ethiopia and Greece [6,42], suggesting that self-perception of accountability remains a challenge across settings.

Statistical analyses revealed significant differences in attitudes by professional category, physicians exhibiting higher scores than nurses and laboratory technicians ($p = 0.018$). Participants who were directly involved in prescribing antimicrobials had significantly ($p = 0.033$) more positive attitudes than those who were not. Participants who had access to Standard Treatment Guidelines (STGs) also showed significantly ($p = 0.023$) more positive attitudes. Professional role, involvement in antimicrobial prescribing, and access to clinical guidelines were identified as key factors influencing healthcare professionals' attitudes toward AMR and AMS. These findings underscore the need for targeted interventions, such as structured training programs and broader dissemination of standard treatment guidelines, particularly among non-prescribing staff, to promote a cohesive and well-informed approach to AMS. This is in agreement with the findings from the Ghana study, where physicians scored significantly higher on attitudes than nurses and pharmacists[40].

In terms of practice, a majority of participants reported engaging in empirical prescribing, and few utilized laboratory diagnostics before initiating antibiotic therapy. Nonetheless, 76% of participants reported modifying their prescribing behavior in response to AMR awareness, a promising indicator of responsiveness to ongoing educational efforts. Practice scores were significantly higher among physicians ($p = 0.022$) and those with AMS training ($p = 0.005$), reinforcing the importance of professional role and training in influencing behavior. Similar patterns have been reported in South Africa and Ghana, where targeted AMS programs led to improved antibiotic prescribing practices [20,40,43].

Importantly, consultation with colleagues was the most common source of information on antibiotic use, followed by formal guidelines. This reliance on peer consultation underlines the need to strengthen institutional support for evidence-based decision-making through continuous medical education and broader dissemination of local treatment protocols [18,27,44].

To our knowledge, this is one of the first studies to specifically investigate the knowledge, attitudes, and practices of healthcare professionals in pediatric settings regarding AMR and AMS in Mozambique. While existing research in sub-Saharan Africa often focuses on AMR awareness in general populations or adult healthcare services [7,24,40,41], our study offers novel, context-specific evidence highlighting not only general awareness and positive attitudes but also critical deficiencies in AMS-related knowledge and practices within pediatric care. Notably, we identified gaps such as limited awareness of AMS programs, inconsistent application of empiric antibiotic guidelines, and

 doi:10.20944/preprints202506.1453.v1

inadequate understanding of microbiological testing. These findings underscore the urgent need for pediatric-focused stewardship strategies and fill a gap in the literature by illustrating the unique challenges and training needs faced by pediatric healthcare providers in resource-limited settings.

This study has certain limitations that should be considered. It was conducted at a single tertiary hospital, which may limit the generalizability of the results to other institutions in Mozambique or similar settings. Despite a high response rate (76%) and diversity in the types of healthcare professionals represented, the modest sample size restricts broader applicability. Future multi-center studies with larger samples are recommended to confirm these findings.

Self-reported data may be subject to social desirability bias. Although the questionnaire was not formally pilot tested with the target population, it underwent rigorous internal validation by both domestic and international health experts, including pediatric and pediatric infectious disease specialists, to ensure clarity and relevance, similar to the questionnaire conducted in the cross-sectional study about Awrness and Knwoledge of AMR, ASM, and barries to implementing antimicrobial suceptibility testing among medical laboratory scientists in Nigeria [7].

Potential confounding factors related to participants' professional roles and educational backgrounds may have influenced our results. Physicians and pediatric specialists generally scored higher than laboratory technicians and nurses, reflecting differences in training and experience rather than solely intervention effects.

Our cross-sectional design limits causal inference and full control of confounders such as resource availability and institutional support, which were not fully measured. Future research should employ more controlled designs and stratified analyses to better clarify factors influencing healthcare professionals' knowledge and attitudes toward antimicrobial resistance and stewardship.

4. Materials and Methods

4.1. Study Design

This cross-sectional study was conducted exclusively at a single institution, HCM, between August and September 2024. It involved healthcare professionals from the pediatric inpatient departments and the microbiology department of the hospital's clinical laboratory. HCM was selected based on convenience, given the investigator's prior engagement with the institution through previously conducted activities, which facilitated access to relevant information. Moreover, HCM is a teaching hospital and the largest healthcare facility in the country, reinforcing its relevance as a research setting. HCM is located in Maputo, the capital city of Mozambique.

The inclusion of pediatric health care workers and microbiologists in the present study is grounded in the pivotal and complementary roles these professionals occupy in the management of infectious diseases and antimicrobial stewardship within pediatric healthcare settings.

Pediatric health care workers encompassing physicians, nurses, and pharmacists are primarily responsible for clinical decision-making related to the diagnosis, treatment, and prevention of infections in pediatric patients. Given the heightened vulnerability of the pediatric population to infectious diseases, the knowledge, attitudes, and practices of these professionals concerning AMR and AMS exert a direct influence on antimicrobial prescribing behaviors and patient outcomes. Their engagement is therefore critical to the success of any initiatives aimed at optimizing antimicrobial use and mitigating the emergence of resistance.

Microbiologists, in turn, play an indispensable role in the diagnostic support framework, providing timely and accurate identification of pathogens and antimicrobial susceptibility testing. Their contributions are essential for the development of institution-specific antibiograms, the establishment of evidence-based antimicrobial guidelines, and the early detection of resistance patterns. By informing clinical decision-making and stewardship policies, microbiologists serve as key agents in promoting rational antimicrobial use.

A self-administered paper questionnaire was distributed on-site during working hours to relevant physicians, nurses, pharmacists, and laboratory technicians. The study variables were

 doi:10.20944/preprints202506.1453.v1

categorized into three main domains to assess healthcare professionals' knowledge, attitudes, and practices regarding AMR and AMS.

4.2. Study Setting

HCM is a 1500-bed, national reference center and the flagship teaching hospital within the Mozambican National Health System. The pediatric service has a capacity of 326 beds, and its catchment area includes Maputo City and Maputo Province. Based on pediatric inpatient registries for the years 2022–2023, an average of 9,500 children were hospitalized each year, of which approximately 95% [9,025] received antibiotics during their hospitalization. The hospital currently does not have a surveillance system in place for monitoring cases of AMR. The pediatric service of HCM is comprised of several wards, however, this study focused only on five, namely the infectious diseases ward, the general pediatric ward, the infant ward, the respiratory ward, and the intensive care unit. It is important to note that the infant ward exclusively admits children aged 0 to 2 years, while the general pediatric ward accommodates patients aged 3 years and older.

4.3. Data Collection

Informed consent was obtained from each healthcare professional before they completed the questionnaire and following a detailed explanation of the study's purpose. Data were primarily collected using a structured, anonymous, self-administered questionnaire. Participants were allowed to take a hard copy of the questionnaire home and were provided with the principal investigator's contact for any clarifications or inquiries. On average, participants required 15 minutes to complete the questionnaire. The questionnaire was written in Portuguese and consisted of three sections. Section one collected data on the participants' socio-demographics.

Section two was a 14-item questionnaire designed to assess the participant's knowledge and awareness with regard to AMR and its contributing factors, as well as the participant's expertise related to clinical indications for antibiotic use and their administration. Section three was a 20-item questionnaire designed to explore current practices related to decision-making about antibiotic prescribing and the use of standard treatment guidelines, as well as advice and education provided to patients about antibiotic utilization.

The structure and content of the questionnaire were informed by an extensive literature review of similar studies related to AMR and AMS [19,37,40]. Items were selected based on their relevance to the study objectives and their demonstrated utility in assessing KAP in comparable healthcare settings.

To ensure contextual relevance, the questionnaire was adapted to the pediatric setting of HCM through a series of consultations with both domestic and international pediatric and pediatric infectious disease specialists, representing the core target group of this research. These consultations were instrumental in refining the wording and structure of the items to reflect the local clinical realities and terminologies commonly used by healthcare professionals in the study setting.

While formal psychometric validation (e.g., construct validity testing) was not conducted, content validity was strengthened through expert review, ensuring that the questions were clear, culturally appropriate, and aligned with the intended constructs. This process enhanced the overall reliability and applicability of the instrument within the local context.

To assess participants' knowledge about antibiotics, AMR, and AMS, we utilized 14 questions with either dichotomous responses "yes" or "no" or statements rated on a 5-point Likert scale "strongly disagree", "disagree", "neutral", "agree", "strongly agree". Responses were scored from 1 "strongly disagree" to 5 "strongly agree".

To explore participants' attitudes regarding the acquisition of additional information on AMR and AMS, we included a set of questions using a 4-point Likert scale. These items assessed willingness to receive further training or updates, with response options ranging from "strongly disagree" to "strongly agree."

 doi:10.20944/preprints202506.1453.v1

To evaluate current practices related to antimicrobial prescribing, we included questions also using a 4-point Likert scale "always", "sometimes", "never", "not applicable". In addition, certain items employed dichotomous "yes" or "no" response formats.

Confidence levels, although not originally listed as a separate domain, were assessed using a 5-point Likert scale "very confident", "confident", "insecure", "very insecure", "not applicable". These items reflect a dimension of attitudes, particularly self-perceived preparedness and capability regarding AMR/AMS-related tasks.

4.4. Data Analysis

Responses to questions were categorized into either a Knowledge Index Score, an Attitude Index Score, or a Practice Index Score, depending on the content of the questions, and standardized on a scale of 0% to 100%, based on the relative frequency of correct responses provided by the participants. The indexes were then calculated by assigning equal weight to each evaluated category of Knowledge, Attitude, and Practice. The questions related to practices were directed exclusively to professionals responsible for prescribing antibiotics. Therefore, services in which the participants did not perform prescriptions were excluded from the analysis, as well as those with fewer than three prescribers. Consequently, only four services were included in this domain.

Statistical analysis was performed using the R software (version 4.4.0, Vienna, Austria). Qualitative variables were described using absolute and relative frequencies, while quantitative variables were summarized using the median, first quartile (Q1), third quartile (Q3), and ranges to provide an overview.

The Shapiro–Wilk test was used to assess the normality of continuous data. Since the data were not normally distributed, non-parametric tests were applied in subsequent analyses.

Contingency tables were used to explore associations between qualitative variables and the KAP indices. Comparisons of median KAP indices between two independent groups were performed using the Mann-Whitney-Wilcoxon test, while differences among more than two groups were evaluated using the Kruskal-Wallis test. When the Kruskal-Wallis test indicated significant differences, Dunn's multiple comparison tests with Bonferroni correction were applied.

Spearman's rank correlation coefficient was used to evaluate the strength and direction of monotonic associations between KAP index scores and other ordinal or continuous variables, such as age and years of professional experience. This method was chosen due to its suitability for non-normally distributed data and its ability to capture non-linear relationships. For all analyses, a p-value < 0.05 was considered statistically significant.

5. Conclusions

This study provides novel evidence on AMS in pediatric settings in Mozambique, an area with limited prior research. While healthcare professionals at Maputo Central Hospital demonstrate general awareness of AMR and favorable attitudes toward AMS, this study uniquely identifies substantial gaps in knowledge and clinical practice. Specifically, it highlights low awareness of AMS programs and inappropriate empiric antibiotic prescribing.

The observed disparity in knowledge among professionals points to the urgent need for targeted, pediatric-specific AMS initiatives. These findings emphasize the importance of incorporating AMS training into continuous professional development and expanding access to updated treatment guidelines and microbiological diagnostics. By addressing these deficiencies, Mozambique can strengthen its response to AMR, improve patient outcomes, and advance the implementation of its National Action Plan on AMR.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of the National Committee of Bioethics in Health (CNBS) (47/CNBS/2023 10-20th-2023). Administrative approval was also obtained from the participating hospital (Ref: nº 48.024.1/DCP/HCM/23). Confidentiality and privacy of collected data were ensured by anonymizing all identifiers of the participants.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Informed consent has been obtained from the patients to publish this paper.

Data Availability Statement: The deidentified data supporting this study are available at the Open Science Framework (OSF) repository and can be accessed via the following link: https://osf.io/r2kw4/.

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Abbreviations

The following abbreviations are used in this manuscript:

AMR	Antimicrobial resistance
AMS	Antimicrobial stewardship
ASP	Antimicrobial stewardship programs
GAP-AMR	Global Action Plan on Antimicrobial Resistance
HCM	*Hospital Central de Maputo,*
KAP	Knowledge, Attitudes, and Practices
LMICs	Low-and middle-income countries
NAPs	National Action Plans
WHO	World Health Organization

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