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REVIEW

Current Antibiotic Use Among Hospitals in the sub-Saharan Africa Region; Findings and Implications

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Background: The rapid rise in antimicrobial resistance (AMR) globally, impacting on morbidity, mortality and costs with sub-Saharan African countries reporting the greatest burden is a concern. Instigation of antimicrobial stewardship programs (ASPs) can improve antibiotic use in hospitals and reduce AMR. Implementing ASPs requires knowledge of antibiotic utilization against agreed quality indicators with the data obtained from point prevalence surveys (PPS), hence the need to document antibiotic utilization patterns in sub-Saharan Africa.

Methods: A narrative review to document current utilization patterns, challenges, indicators and ASPs across sub-Saharan Africa based on previous reviews by the authors, supplemented by the considerable knowledge and experience of the co-authors.

Results: Results from multiple PPS studies showed a high prevalence of antibiotic use among hospitals, mostly over 50%. Prevalence rates ranged from as low as 37.7% in South Africa to as high as 80.1% in Nigeria. There was also considerable prescribing of broad-spectrum antibiotics which could be due to lack of facilities within hospitals, alongside concerns with co-payments to perform microbiological tests, resulting in empiric prescribing. This is a concern alongside lack of guidelines or adherence to guidelines, which was as low as 4% in one study. Another concern was the high rates of extended prophylaxis to prevent surgical site infections (SSIs), with antibiotics often prescribed for longer than 24 hours, usually multiple doses. Several quality indicators have been used to evaluate antibiotic utilization providing exemplars for the future. Among the initiatives being instigated to improve antibiotic use, ASPs have proved effective. For ASPs to be successful objectives and indicators must be agreed, and regular audits undertaken.

Conclusion: Antibiotic prescribing across Africa is characterised by high prevalence, usually empirical. Various prescribing and quality indicators are being employed to assess antibiotic use, and ASPs have shown to improve antibiotic prescribing providing direction to reduce AMR.

Keywords: antibiotic use, sub-Saharan Africa, point prevalence surveys, quality indicators, surgical site infections, antimicrobial stewardship programs

Introduction

There are increasing concerns with the growth in antimicrobial resistance (AMR) globally, impacting morbidity, mortality and costs.[1] Recent estimates suggest that globally in 2019, 4.95 million deaths were associated with bacterial AMR, with the greatest number of deaths per head of population in sub-Saharan Africa.[2] These high rates in Africa are driven by high inappropriate use of antimicrobials coupled with poor infection prevention and control among health-care facilities, a lack of inexpensive and rapid diagnostic tests, and patient demand.[1,3,4]

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According to the 2015 Global Point Prevalence Survey (PPS) on antimicrobial consumption, prevalence rates were highest among participating hospitals in Africa, ranging from 27.8% to 74.7% of patients among the hospitals surveyed.[5] The high prevalence of antibiotic use among hospitals in Africa, including extended antibiotic prescribing post-operatively to prevent surgical site infections (SSIs), is due to a number of factors. These include a lack of appropriate diagnostic services, limited institutional groups including infection, prevention and control (IPC) committees as well as antimicrobial stewardship groups to improve prescribing, concerns with the cleanliness of operating theatres and wards, and limited ongoing ASPs with issues of resources.[6–10] The high rates of empiric prescribing across Africa, often with broad-spectrum antibiotics, is exacerbated by a lack of facilities for diagnostic testing and co-payment issues.[4,10,11] However, we are beginning to see the appropriateness of antibiotic prescribing improve among hospitals across Africa through the implementation of ASPs.[12,13]

This includes encouraging greater adherence to national guidelines, which can reduce antimicrobial use, reduce hospital stay, improve clinical outcomes and reduce AMR.[4,7,13,14]

The instigation of ASPs is important given current high rates of AMR in Africa and the continued increase in antibiotic utilization among low- and middle-income countries (LMICs), including among African countries. This includes an appreciable increase in the utilization of "Watch" antibiotics, among hospitals across Africa, which are antibiotics recommended only for specific indications due to a greater chance of resistance potential with their overuse.[15,16] There have though been concerns with the implementation of ASPs among LMICs due to resource issues and knowledge concerns among key stakeholder groups,[6,8,17] along with other identified barriers (Table S1). However, this is now changing.[12,13]

A key part of World Health Organization (WHO) activities to reduce AMR is the development of National Action Plans (NAPs) which are now being instigated across Africa.[4,18,19] A key component of NAPs among hospitals is undertaking PPS studies to ascertain current utilization patterns as a basis for instigating targeted quality improvement programs.[4] Potential activities to improve future prescribing include monitoring future prescribing against agreed quality indicators as part of ASPs, with adherence to guidelines increasingly seen as demonstrating appropriate utilization of antimicrobials.[5,20,21] However, the guidelines need to be robust and evidence-based given concerns with a number of national guidelines across Africa advocating the prescribing of antibiotics in patients with COVID-19 despite very limited bacterial infections or co-infections.[22–26] Key targets for ASPs in hospital include reducing the extent of considerable prescribing of antibiotics post operatively to prevent surgical site infections (SSIs) as this increases costs, adverse events and AMR without improving patient outcomes.[9] Consequently, there is a need to document current findings regarding antibiotic utilization patterns among hospitals across Africa, alongside documented examples of antibiotic prescribing indicators and ASPs given current concerns with high levels of inappropriate prescribing including "Watch" and "Reserve" antibiotics.[16,27] The findings can be used to suggest future initiatives and activities across sub-Saharan Africa to reduce rising AMR rates given concerns about inappropriate antimicrobial prescribing.[7,28] Consequently, the aim of this review is to document current antibiotic utilization among hospitals across sub-Saharan Africa to guide future initiatives to improve antibiotic utilization in the region.

Materials and Methods

This is a narrative review to document current utilization patterns, challenges, indicators and ASP across sub-Saharan Africa. The included studies will be obtained from previous reviews by the authors to supplement efforts to improve antibiotic utilization in sub-Saharan Africa.[7,9,13,20] As such, include the findings from PPS studies undertaken among a range of African countries. PPS studies document the extent of antimicrobial prescribing among all in-patients in hospital on the morning of the survey, eg, 0800.[5] This will be supplemented by the considerable experience and activities of the co-authors and is similar to the approaches adopted in other publications.[4,7,9] In a recent review by the authors, quality indicators being used to improve antibiotic prescribing were reviewed.[20] These will be summarized alongside their inclusion in the sourced papers to provide future guidance. The development of prescribing or quality indicators enables antimicrobial stewardship teams within hospitals to determine which activities and areas to prioritize as part of ASPs along the prescribing pathway and assess their progress to improve future prescribing. Subsequently, targets can be agreed upon among all key stakeholders in the hospital to improve future prescribing and be monitored. Various studies

have now shown that monitoring prescribing against agreed indicators has an appreciable impact on treatment outcomes and can lower AMR.[7,29]

We have not undertaken a systematic review since the objective of this study is to document the current situation and exemplars across Africa to provide future guidance. This will be based on the considerable experiences of the co-authors, who have already undertaken reviews across Africa and beyond to document current antimicrobial utilization patterns in hospitals as well as prescribing and quality indicators being used and the outcomes from ASPs across Africa.

Results

The results from the PPS studies showed that there is high prevalence of antibiotic use among hospitals across sub-Saharan Africa. Antibiotic use is characterized by the use of broad-spectrum antibiotics especially the penicillins and cephalosporins. The reasons for antibiotic use were documented in most cases; however, guidelines and the use of microbiological tests were typically lacking. As a result, antibiotics were mostly prescribed empirically. Antibiotics for surgical prophylaxis were mostly prescribed for more than 24 hours, which is not in line with recommended guidelines. Table 1 documents the findings from a range of PPS studies conducted across Africa, building on the African hospitals within the Global PPS study.[5]

A range of quality indicators have been used across Africa to seek to improve future antibiotic prescribing. These are captured in Table 2 alongside Table S2. The most reported quality indicators include antibiotic use prevalence and the use

Table 1 Findings from Point Prevalence Studies on Antibiotic Use

Study	Findings
Abubakar 2020,[31] Nigeria (3 hospitals) A teaching hospital and two general hospitals approximately 850 beds in each, 321 patients	• Antibiotic use prevalence was 80.1% • Most of the patients surveyed had two antibiotic agents • Community-acquired infections (38.7%) and surgical prophylaxis (22.5%) were the most common indications • Antibiotic prescribing for surgical prophylaxis was for more than 24 hours in all cases • 56% of the antibiotic prescriptions were intravenous • Documentation for antibiotic use was recorded in 75.8% of the cases • The most prescribed classes of antibiotic were nitroimidazoles (28.5%), third-generation cephalosporins (18.9%), and fluoroquinolones (13.6%)
Afriyie et al 2020,[10] Ghana (2 hospitals) Keta Municipal Hospital (KMH), a 110 bed capacity Ghana Police Hospital (GPH), a 100 bed hospital	• The prevalence of antibiotic use was 65.0% in GPH and 82.0% in KMH • Penicillins and other b-lactam antibiotics were the most frequently prescribed in both hospitals, with third-generation cephalosporins mainly used in GPH • Antibiotic treatment was mainly empiric and commonly administered intravenously; duration was generally short with timely oral switching • There was good documentation of the indications for antibiotic use in both hospitals • 50.0–66.7% guideline compliance (although for many indications no guideline existed) • Almost all prescribed antibiotics had stop dates and no missed doses • No treatment was based on microbiology data in GPH and it was only used for one patient in KMH (2.2%) • Duration of use for surgical prophylaxis was generally more than one day (69.0% in GPH and 77.0% in KMH)
Anand Paramadhas et al 2019,[41] Botswana (10 Hospitals) All hospital sectors, 773 inpatients. 4991 total beds	• Antibiotic use prevalence 70.6% • Cefotaxime and amoxicillin were the most commonly prescribed antibiotics • Use of intravenous antibiotics was quite prevalent • The duration of surgical prophylaxis also varied. This was typically greater than one day across the surveyed facilities • Culture and sensitivity tests were rarely ordered, with most being requested in the specialist and primary hospitals • Botswana essential medicines list and guidelines were routinely updated, but not all hospitals had them available for use and decision support tools such as the antibiogram were generally unavailable to guide empiric antibiotic use across hospitals
Bediako-Bowan et al 2019,[44] Ghana (10 hospitals) 4208 total bed capacity. 540 admitted patients	• Antibiotic use prevalence, 70.7% • Average number of antibiotics, 1.66 • Surgical prophylaxis was administered for longer than the recommended one day in 107 of 144 (88.4%) patients. • Only 3.7% of patients had microbiological analysis done on clinical samples • Frequently prescribed antibiotics were nitroimidazoles, 2nd and 3rd generations cephalosporins, β-lactam /βlactamase inhibitors, fluoroquinolones and lincosamides • Patients were prescribed antibiotics for treatment of infections or for prophylaxis, and for 14 patients there were no recorded reason for antibiotic therapy • The contribution of surgical prophylaxis to the total antibiotic usage was 32%. For surgical prophylaxis, 88.4% of the patients received antibiotics for more than one day • Antibiotics were administered mostly intravenously (54%)
Chijioke et al 2016,[49] Nigeria (9 hospitals) 1585 of all admitted patients	• Antibiotic use prevalence, 55.9% • Most of the patients (61.9%) received combination therapy • Most of the patients were prescribed penicillins

(*Continued*)

Table 1 (Continued).

Study	Findings
Dlamini et al 2019,[30] South Africa (1 Hospital) 1650-bed hospital, 512 inpatients	• Antibiotic use prevalence, 37.7% • Beta lactamase inhibitors and antimicrobials for tuberculosis were the most prevalent antimicrobials • 98% of antimicrobials prescribed were contained within the current essential medicines list/standard treatment guidelines • 46% of patients were on intravenous antibiotics • Lack of intravenous to oral switch even though some patients appeared to be suitable candidates based on their notes, • 37% of patients' files, culture and sensitivity tests results were recorded. • 17 antimicrobials (5.6%) had no defined infection site for their use documented in the patient records with no evidence of infection and in 5.2% of occasions antibiotics were prescribed other than for treatment
Fowotade et al 2020,[40] Nigeria (1 hospitals) 850 bed capacity hospital, 451 inpatients	• Antibiotic prevalence was at 59.6% • Most prescribed antibiotics were, Cephalosporins, followed by penicillins and fluoroquinolones • 69.9% of the patients were on intravenous antibiotics • Only 21.3% of all antibiotics had documented stop and review date • 100% of all surgical prophylaxis antibiotics were given for more than one day • Reason for antibiotic use was recorded in 92.4% of cases • Targeted therapy was only in 6.35 of cases and 93.7% cases were treated empirically • Use of biomarkers was only in 2.2% of the patients • No compliance to antibiotic guidelines exacerbated by no local antibiotic guidelines
Horumpende et al 2020,[33] Tanzania (3 hospitals) 1 tertiary hospital, 1 regional and district hospital with 640, 300 and 100 bed capacity, respectively. 399 patients	• Overall, prevalence of antibiotic use was 38% at Kilimanjaro Christian Medical Centre, 59% in Mawenzi and 63% in St. Joseph. • Ceftriaxone (n = 94; 28.5%), metronidazole (n = 79, 23.9%) and penicillins (n = 89; 26.9%) were the most commonly • Indications for antibiotics were treatment of a community acquired infection (n = 79; 42%), an acute hospital acquired infection (n = 19; 10%), surgical prophylaxis (n = 57; 30%) or medical prophylaxis (n = 1; 0.5%) and unknown reason (n = 21; 11%) • All patients except one received multiple doses of antibiotics and surgical prophylaxis was continued >3 days in more than half of patients • Overall, 36% of the antibiotics were given to cases in whom a bacterial infection was deemed unlikely • Biomarkers of inflammation, relevant radiology or a microbiology test were performed, respectively, in 13 (15%), 21 (24%) and 12 (14%) patients. • Only 3% (n = 3) of the treatment was targeted, ie, based on the result of a bacterial culture
Labi et al 2018,[50] Ghana (3 hospital) 4208 bed capacity. 716 pediatric inpatients	• Antibiotic use prevalence, 70.6% • Majority of patients were prescribed 2 antibiotics • Mostly prescribed antibiotics were 3rd cephalosporins, followed by aminogylcosides amd 2nd gen cephalosporins • 83.5%nof patients were prescribed intravenous antibiotics
Maina et al 2020,[42] Kenya (14 hospitals) 4152 total capacity, 3590 hospitalized patients	• Antibiotic use prevalence, 46.7% • Most patients had 2 antibiotics • Commonly prescribed antibiotics were the cephalosporins, followed by nitroimidazole • Two patients (0.1%) had treatment based on available antibiotic susceptibility tests • Appropriate treatment was assessed in 1502 patients who had a single diagnosis. Of these, 805 (53.6%) received appropriate treatment • Physical availability of treatment guidelines increased the odds of receiving appropriate treatment
Momanyi et al 2019,[32] Kenya (1 hospital) 532 bed tertiary hospital, 179 patients	• Antibiotic use prevalence, was 54.7% • Most antibiotics were prescribed for treatment (75.4%) as opposed to prophylaxis (29%) • Surgical prophylaxis was >24 hours in 76.9% of the cases with only 9.6% on a single dose as per current guidelines • Penicillins (46.9%) followed by cephalosporins (44.7%) were the most prescribed antibiotic classes • The indication for antibiotic use was documented in only 37.3% of encounters • Generic prescribing was 62.5% and empiric prescribing was seen in 82.6% of encounters • Guideline compliance was 45.8% • Majority of patients were on combination therapy
Oduyebo.et al 201,[39] Nigeria (4 Hospitals) All wards, 828 hospitalized patients	• Antibiotic use prevalence was 69.7%, most prescribed antibiotics being cephalosporins, followed by nitroimidazoles and quinolones • Indication for antibiotic use was recorded in 61.8% of the cases • Start and stop dates were indicated in 27.8 of the cases • Guidelines were present, and adherence to guidelines was at 7% for medical cases and 4% for surgical cases • Biomarkers were utilized in 1% of the cases. Targeted treatment was recorded for 14.9% of medical cases and 11.3% of surgical cases • 48% of the antibiotics were used for Surgical prophylaxis and in 95% of the cases surgical prophylaxis was indicated for more 24hours
Ogunleye.et al 2021,[27] Nigeria (2 hospitals) One hospital had a bed capacity of 774 and the other had 250 bed capacity, a total of 491 hospitalized patients	• Antibiotic use prevalance, 80.6% • Mostly used antibiotics in the secondary hospital were parenteral metronidazole (32.4%), ceftriaxone (27.5%) and amoxicillin + clavulanate (8.2%) while the mostly used in the tertiary hospital were ceftriaxone (25.3%), parenteral metronidazole (19.1%) and Amoxicillin +Clavulanate (9.3%). • Considerable lack of specific functional capacities, policies and processes to promote appropriate antimicrobial use

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Table 1 (Continued).

Study	Findings
Seni.et al 2019,[51] Tanzania (6 hospitals) 553 total capacity, 948 all admitted patients	• Antibiotic use prevalence, 62.3% • The overall adherence of antibiotic prescriptions to the Tanzania STG was high (84.0%) • Only 2 of 591 patients were prescribed antibiotics based on culture and antimicrobial susceptibility testing results. • Majority of patients were on 2 antibiotics • Most antibiotics were used for community-associated infections (36.7%), followed by Surgical prophylaxis (30.2%) and medical prophylaxis (24.0%) • Antibiotic use for a purpose other than treatment was reported in 127 (19.0%) patients and in 32 diagnoses (4.8%) where there was a completely undefined site with no systemic inflammation
Umeokonkwo et al 2019,[34] Nigeria (1 hospitals) 720 bed capacity, 220 hospitalized patients	• Antibiotic use prevalence, 78.2% • Antibiotics commonly used were 3rd generation cephalosporins • Most therapeutic treatments were empirical • Surgical prophylaxis constituted 44.0% of antimicrobial prescriptions • There was limited use of guidelines but clear documentation of stop/review dates and reasons for antimicrobial use
Wambale et al 2016,[43] Republic of Congo (11 hospitals) 700 hospitalized patients	• The prevalence of the antibiotic use was 68% • Antibiotics are prescribed either alone or in combination • Most prescribed antibiotic was ampicillin (35%) followed by gentamicin (13.6%), amoxicillin (13.5%), ceftriaxone (11%) and metronidazole (10.3%) • The prevalence of combined therapy was 34.9% among patients who received more than one antibiotic. The most common route of administration was the intravenous (68.2%). • The choice of these antibiotics is usually probabilistic because the sensitivity tests were not conducted prior the antibiotic prescription and, in many hospitals, antibiotic use guidelines were not available

of microbiological tests. Switching from intravenous (IV) to oral as well as documentation of start and stop dates were among the least reported indicators. A number of these indicators are being used as part of ASPs (Table 3) to improve future antimicrobial prescribing.

The ASP studies included in Table 3 were obtained from two previous systematic reviews.[9,13] As shown in Table 3, ASPs have improved antibiotic utilization. There was a reduction in antibiotic use from pre to post ASP, as well as increased compliance to guidelines including the timing and duration of antibiotics to prevent SSIs. The implementation of ASPs was not associated with any deterioration in clinical outcomes. Most studies show that there is still room for improvement in the implementation of ASPs in hospitals alongside the need for additional funding, awareness and engagement across all levels of health-care management.

Discussion

There was a high prevalence of antibiotic use among surveyed hospitals across Africa, with most reporting prevalence rates of over 50%. Prevalence rates among the surveyed hospitals ranged from as low as 37.7% in South Africa[30] to as high as 80.1% in Nigeria.[31] Typically, two antibiotics were prescribed per patient, with the cephalosporins, penicillins and nitroimidazoles being the most prescribed antibiotics. There were appreciable concerns about the inappropriate prescribing of antibiotics, with a number of studies reporting that documentation regarding the rationale for prescribing was either missing or poor.[32–34] In one study in Tanzania, 36% of the antibiotics were given to cases in whom a bacterial infection was deemed unlikely.[33]

Overall, the prescribing and quality indicators used to assess the quality of antibiotic prescribing across Africa varied across the studies. The most reported indicators included the prevalence of antibiotic prescribing, the most prescribed antibiotic class, percentage of intravenous (IV) antibiotics, and whether microbiology tests were performed. However, any indicator subsequently instigated to improve future antibiotic use within hospitals must have clarity and be feasible to implement. Alongside this, there must be easy-to-use reliable and consistent (preferably computerized) tools to routinely collect valid data to monitor any progress.[35–37] Currently, most systems in hospitals to collect patients' details across Africa are paper based, hampering routine monitoring. However, this is likely to change with increasing implementation of the NAPs across Africa.[38]

There were also concerns with limited documentation of the reasons for prescribing in patients' notes, start and stop date reviews, and the use of culture and sensitivity testing (CST) with this leading to low rates of targeted antibiotic prescribing versus high empiric therapy across Africa. As a result, there was high use of broad spectrum antibiotics

Table 2 Antibiotic Use Quality Indicators Most Reported in sub-Saharan Africa

Study and Country	Antibiotic use Prevalence %	Highest Prevalence ABX Class	IV Antibiotics by %	IV -Oral switch / De—Escalation	Indication Documented	Start and Stop date Indicated %	Guideline Compliance %	Microbiology Culture Performed %	% Targeted Treatment	% Empirical Treatment	Surgical Prophylaxis >24hrs
Abubakar 2020,[31] Nigeria	O	O	O	X	O	X	X	X	X	X	O
Afriyie et al 2019,[10] Kenya	O	O	O	X	O	O	O	O	O	X	O
Anand Paramadhas et al 2019,[41] Botswana	O	O	O	X	X	X	X	O	X	O	O
Bediako-Bowan et al, 2019,[44] Ghana	O	O	O	X	X	X	X	O	X	X	O
Chijioke et al 2016,[49] Nigeria	O	O	X	X	X	X	X	X	X	X	X
Dlamini et al 2019,[30] South Africa	O	O	O	O	O	X	X	O	X	X	X
Fowotade et al 2020,[40] Nigeria	O	O	O	X	O	O	O	O	O	O	O
Horumpende et al 2020,[33] Tanzania	O	O	X	X	O	X	X	O	O	X	O
Labi et al 2018,[50] Ghana	O	O	O	X	O	X	O	X	X	X	X
Maina et al 2020,[42] Kenya	O	O	X	X	X	X	O	O	X	X	X
Momanyi et al 2019,[32] Kenya	O	O	X	X	O	X	O	X	X	O	O
Oduyebo et al 2018,[39] Nigeria	O	O	O	X	O	O	O	O	0	X	X
Seni et al 2019,[51] Tanzania	O	O	X	X	O	X	O	O	X	X	X
Umeokonkwo et al 2019,[34] Nigeria	O	O	O	X	O	O	O	O	O	O	X
Wambale et al 2016,[43] Congo	O	O	O	X	X	X	X	0	X	X	X

Notes: O=quality indicator assessed. X=quality indicator not assessed.
Abbreviation: IV, intravenous.

Table 3 Summary of a Number of the ASP Studies and Outcomes

Study	Intervention Employed	Outcomes	Other Observations
Abubakar et al (2019),[52] Nigeria	Development of protocol; educational meeting; audit and feedbacks, posters to improve compliance with surgical antibiotic prophylaxis practice in obstetrics and gynecology surgeries	• Increase in compliance with timing from 14.2% to 43.3% and duration from 0% to 21.8% • Reduced the prescription of third-generation cephalosporin (−8.6%), redundant antibiotic (−19.1%), antibiotic utilization (−3.8 DDD/procedure) and cost of antibiotic prophylaxis (-$4.2/procedure)	• Still room for improvement, particularly in emergency surgical procedures as antibiotics were administered after incision in many surgical procedures in emergency cases.
Aiken et al (2013),[53] Kenya	Development of an Antibiotic prophylaxis policy that advised pre-operative antibiotic prophylaxis and discouraged extended post-operative antibiotics use	• Rapid adoption of the use of pre-operative antibiotic prophylaxis (60% at 1 week; 98% at 6 weeks) • Substantial decrease in the use of post-operative antibiotics (40% of at 1 week; 10% at 6 weeks) • Marked reductions in the costs associated with antibiotic use, the number of intravenous injections performed, and nursing time spent	• Limited awareness of national clinical policy documents, resulting in a marked policy-to-practice gap. • Poor access to appropriate medicines for surgical prophylaxis. • Amongst clinicians there was a marked concern about negative outcomes, especially regarding nosocomial infections, that hindered changes in antibiotic usage. • Lack of awareness amongst hospital management of the overall potential for cost-savings associated with such a policy change.
Alabi (2022),[54] Liberia	Implementation of a bundle of three measures (local treatment guideline, training and regular ASP ward rounds) to guide antibiotic use	• Adherence to the local guideline improved for the selection of antimicrobial agents from 34.5% to 61.0%, $p<0.0005$, dosage from 15.2% to 36.5%, $p<0.0005$ and duration from 13.2% to 31.0%, $p<0.0005$ • 79.7% of patients had samples sent for microbiological analysis. Proportion of patients receiving ceftriaxone significantly reduced after the ASP ward rounds from 51.3% to 14.2% ($p<0.0005$)	• In addition to changing prescribing behavior, ASPs face the challenge of underfunding and limited access to experts, expertise and training. • Long-term engagement is therefore necessary to make ASPs in low- middle income countries sustainable.
Bashar et al (2021),[55] South Africa	Dedicated ASP weekly round	• Reduction in the volume of antibiotic consumption from a total 739.30 DDDs/1000 to 564.93 DDDs/1000 patient days • Reduction in inappropriate antibiotic use from 35% to 26% from baseline to antibiotic stewardship program stages • Increase in culture targeted therapy in both wards in the antibiotic stewardship program stage	• Possible measures to improve appropriate antibiotic use for surgical prophylaxis could include adherence to national guidelines and educational program targeting theatre staff and surgeons on rational antibiotic usage.
Bassiouny et al (2020),[56] South Africa	AMS guidelines implementation, ward rounds by a pharmacist on the surgical neonatal intensive care unit	• 86% compliance to guidelines • SSI rate decreased to 20% • Days of Therapy (DOT) per 1000 patient days showed a significant decrease in antibiotic utilization • Drug cost showed a 1185.97 Egyptian pound decrease post-intervention ($p = 0.714$) • Decreased LOS by a mean difference of 2.5 ($p = 0.027$)	• Recommended introduction of automated techniques to shorten the turnaround time of lab investigations as an essential factor for correct implementation and achievement of the ASP goals.
Boyles et al (2013),[57] South Africa	Introduction of antibiotic prescription use in 2 medical wards chart and ward rounds to improve antibiotic	• 19.6% decrease in volume with a cost reduction of 35% of the pharmacy's antibiotic budget • Increase in laboratory tests • No difference in inpatient mortality or 30-day readmission rate during the control and intervention periods	• Interventions to reduce antibiotic utilization must be introduced alongside strengthening of basic infection control practices, such as hand washing.
Brink et al (2017),[58] South Africa	Prospective audit and feedback strategy involving change management and improvement principles to achieve a reduction in SSIs across a heterogeneous group of 34 urban and rural South African hospitals	• Improvement in compliance with all process measures from 66.8% to 83.3% (representing a 24.7% increase ($p < 0.0001$) • SSI rate decreased by 19.7% from a mean group rate of 2.46 pre-intervention to 1.97 post-intervention	• ASP implementations require leadership commitment from all quarters—governmental, hospital and clinical—to acknowledge and support the cardinal role played by non-specialized pharmacists in recruiting multidisciplinary teams and in coordinating interdisciplinary engagement which was key to success.
Gebretekle et al (2020),[59] Ethiopia	Weekly audit and immediate (verbal and written) feedback sessions on antibiotic prescriptions of patients admitted in 2 pediatric and 2 adult medicine wards	• 96% of the recommendations made by the ASP team were accepted • Once the intervention ceased, total antimicrobial use increased by 51.6% and mean duration of treatment by 4.1 days/patient • Mean LOS stay as well as crude mortality also increased significantly in the post-intervention phase (LOS: 24.1 days vs 19.8 days; in hospital death 14.7 vs 6.9%)	• Implementation of ASPs need a sustained effort. • Commitment of organizational leadership required to sustain enabling antimicrobial stewardship activities.

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Table 3 (Continued).

Study	Intervention Employed	Outcomes	Other Observations
Lester et al 2020),[60] Malawi	A prescribing application for smartphones and regular point-prevalence surveys with prescriber feedback aimed to evaluate the impact of the intervention on 3GC usage and on the cost of providing antibiotics	• 53.6% reduction in the proportion of 3GC antibiotic prescriptions with no change in the case-fatality rate • The cost analysis estimated an annual savings of US$ 15,000. • Qualitative research revealed trust in the guideline and found that its accessibility through smartphones helpful to guide clinical decisions	• ASPs challenged by the dual burden of a high prevalence of severe, often drug-resistant infections alongside insecure, variable access to a range of effective antimicrobials.
Ngonzi et al (2021),[61] Uganda	An educational intervention, daily audit and feedback aimed at clinicians to increase the use of the WHO SSC and prophylactic antibiotics for cesarean delivery	• Increase in use of WHO SSC from 7% in the pre-intervention phase to 92% in the inter-vention phase (P < 0.001), and 77% in the post-intervention phase (p < 0.001). • Pre-intervention antibiotic receipt was 18% compared to 90% in the intervention phase (p < 0.001) and 84% in the post-intervention phase (P < 0.001) • The documented SSI rate in the pre-intervention phase was 15% compared to 7% in the intervention phase (p = 0.02) and 11% in the post-intervention phase (p = 0.20)	• Research to understand factors influencing the checklist use and antibiotic prophylaxis including prescriber knowledge, motivation and clinical process is required. • Implementation interventions to sustain usage and impact on clinical outcomes need to be explored.
Opondo et al (2011),[62] Kenya	Training of health workers, facilitation, supervision and face-to-face feedback, aimed to assess whether intervention reduced inappropriate use of antibiotics in children with non-bloody diarrhea and no co-morbidities requiring antibiotics	• Inappropriate antibiotic use decreased from 74% to 42% (p = 0.04)	• Modest financial investments required for comparatively substantial improvements in quality of care. • Enhanced medical education focusing on rational use of antibiotics is necessary to improve clinicians' prescribing habits.
van den Bergh et al (2020),[63] South Africa	Development of a CAP bundle of seven process measures that pharmacists used to audit compliance and provide feedback	• Overall CAP bundle compliance improved from 47·8% to 53·6% p < 0·0001) • No difference in mortality between the pre-implementation and post-implementation phase, 4·4% (vs 3·9%; (p=0·54), median LOS or IR LOS 6·0 vs 6·0 days (p=0·20) and 5·0 vs 5·0 days (p = 0·40)	• Opportunity for frontline stewards across different settings to collaborate in coordinated interventions and accelerate implementation of ASPs through upskilling existing resources and enabling interdisciplinary engagement across health systems.

Abbreviations: 3GC, 3rd generation cephalosporins; ASP, antimicrobial stewardship programs; CAP, community-acquired pneumonia; DDD, defined daily dose; LOS, length of hospital stay; SSI, surgical site infection; US, United States; WHO SSC, World Health Organization surgical safety checklist.

across Africa, namely the cephalosporins and penicillin combinations.[33,34,39–44] The low use of CST could be due to a lack of facilities within hospitals to rapidly perform such tests and their costs, especially if this is out-of-pocket.[10] This leads to most physicians prescribing empirically.[32,34,40] This issue needs addressing going forward as part of NAPs,[4] as well as improving guideline availability and adherence.[45,46] This is because our findings showed a lack of guidelines among the hospitals surveyed; alternatively, low adherence to guidelines which was as low as 4% in one study.[34,39,40] Guidelines should increasingly include antibiotics broken down by their resistance potential as seen with the WHO AWaRe classification system, with guidelines and studies using this classification growing to reduce AMR.[4,15,30] However, as mentioned, guidelines need to be evidence-based given concerns with a number of national guidelines advocating the prescribing of antibiotics for patients admitted with COVID-19.[22,25] The recent launch of the WHO AWaRe antibiotic book providing prescribing advice for a range of infections should help in this regard.[47]

There were also considerable concerns that the extent of antibiotic prophylaxis to prevent SSIs was typically more than 24 hours in the published papers with multiple doses in most cases.[10,31–33,40,41,44] This is a concern as a single dose of surgical prophylaxis before surgical incision is as effective as multiple doses.[9] In addition, as mentioned, multiple doses increase the potential for AMR as well as side-effects from the antibiotics.[9] Consequently, the appropriate use of antibiotics to prevent SSIs should be a key area when implementing interventions to improve future antibiotic use among hospitals in sub-Saharan Africa as part of future ASPs.

We have seen a growth in ASPs in Africa in recent years[12,13] which is likely to continue given concerns with rising AMR rates across Africa and the need to reduce these as part of agreed NAPs across Africa.[4] A number of these programs have been summarized in Table 3 providing guidance across Africa. In addition, there are barriers that need to be addressed within hospitals across Africa to enhance their routine instigation (Table S1).

From this review, considerable challenges and gaps have been identified to improve future antibiotic prescribing, which have resulted in a number of suggestions and recommendations that can be considered going forward. Firstly, we understand the potential hazards associated with high prevalence rates for antibiotics in hospitals in sub-Saharan Africa, especially if this includes appreciable inappropriate prescribing. Concerns include further enhancing AMR across Africa, increasing morbidity, mortality and costs.[4] Appreciable utilization of antibiotics is usually accompanied with inappropriate use, particularly where there are currently no guidelines and limited microbiological testing resulting in considerable empiric prescribing.[7,48] Consequently, we recommend strategies to enhance adherence to evidence-based robust guidelines in hospitals, which are increasingly likely to be based on the WHO AWaRe guidance.[47] As seen, adherence to guidelines is associated with improved antibiotic use. The implementation of guidelines should be in association with education and training of HCPs on best practices, including all aspects of successfully undertaking ASPs and monitoring their impact.

As observed, in most cases there is currently a lack of microbiological testing across Africa. This is enhanced by the lack of microbiological infrastructures along with co-payment costs where these occur. This will continue leading to continued prescribing of broad-spectrum antibiotics unless pro-actively addressed as part of reaching agreed NAP goals.

There are numerous quality indicators that are currently being used across Africa to assess the quality of antibiotic prescribing. The choice of quality indicators will though be dependent on the setting, available resources and current systems to routinely collect patient-level data.[36,48] Agreed quality indicators can subsequently be used to monitor improvements in prescribing as part of ongoing ASPs to achieve NAP goals.

ASPs have proven to be effective in improving antibiotic use without deterioration in clinical outcomes.[13] Consequently, they should be prioritized as part of ongoing programs to achieve the objectives included in the NAPs among the various African countries. Initially, this may include training programs and other activities to address current barriers (Table S1). As a result, help ensure all key HCPs within the hospitals are fully conversant and trained with undertaking ASPs.[10]

Following this, the long-term engagement of government, hospital administrators, health-care professionals and academics should become routine to ensure sustainability of key programs to achieve NAP objectives through provision of committed leadership, financial support and interdisciplinary engagement. Educational programs and training to raise awareness and uptake of guidelines including appropriate use of SSI antibiotics targeting HCPs need also to be considered where pertinent alongside improving routine data collection.

Finally, research activities should be supported to provide more data on antibiotic utilization, impact of interventions and direction for the future.

Conclusion and Next Steps

There is high prevalence of antibiotic prescribing in hospitals in sub-Saharan Africa. Antibiotic prescribing is usually empirical due to lack of microbiology testing. In addition, there are often no guidelines or low adherence to guidelines when available. This results into inappropriate prescribing of antibiotics such as their long duration prescription to prevent SSI. A number of quality indicators are being employed to improve antibiotic utilization as part of ASPs, which will continue to grow. Activities across sub-Saharan Africa to document current antimicrobial utilization patterns among hospitals and ongoing concerns should continuously be supported. We recommend activities including ongoing PPS research alongside, implementation and evaluation of agreed ASPs following identified improvement gaps to improve future practice.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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References

1. O'neill J. Antimicrobial resistance: tackling a crisis for the health and wealth of nations; 2014:4–5. Available from: https://amr-review.org/sites/default/files/AMR%20Review%20Paper%20-%20Tackling%20a%20crisis%20for%20the%20health%20and%20wealth%20of%20nations_1.pdf. Accessed June 15, 2021.
2. Murray C, Ikuta K, Sharara F, et al. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *Lancet*. 2022;399(10325):629–655. doi:10.1016/S0140-6736(21)02724-0
3. Ayukekbong JA, Ntemgwa M, Atabe AN. The threat of antimicrobial resistance in developing countries: causes and control strategies. *Antimicrob Resist Infect Control*. 2017;6(1):47. doi:10.1186/s13756-017-0208-x
4. Godman B, Egwuenu A, Wesangula E, et al. Tackling antimicrobial resistance across sub-Saharan Africa: current challenges and implications for the future. *Expert Opin Drug Saf*. 2022;21(8):1089–1111. doi:10.1080/14740338.2022.2106368
5. Versporten A, Zarb P, Caniaux I, et al. Antimicrobial consumption and resistance in adult hospital inpatients in 53 countries: results of an internet-based global point prevalence survey. *Lancet Glob Health*. 2018;6(6):e619–e629. doi:10.1016/S2214-109X(18)30186-4
6. Cox JA, Vlieghe E, Mendelson M, et al. Antibiotic stewardship in low- and middle-income countries: the same but different? *Clin Microbiol Infect*. 2017;23(11):812–818. doi:10.1016/j.cmi.2017.07.010
7. Godman B, Egwuenu A, Haque M, et al. Strategies to improve antimicrobial utilization with a special focus on developing countries. *Life*. 2021;11:6. doi:10.3390/life11060528
8. Fadare JO, Ogunleye O, Iliyasu G, et al. Status of antimicrobial stewardship programmes in Nigerian tertiary healthcare facilities: findings and implications. *J Glob Antimicrob Resist*. 2019;17:132–136. doi:10.1016/j.jgar.2018.11.025
9. Mwita JC, Ogunleye OO, Olalekan A. Key issues surrounding appropriate antibiotic use for prevention of surgical site infections in low- and middle-income countries: a narrative review and the implications. *Int J Gen Med*. 2021;14:515–530. doi:10.2147/IJGM.S253216
10. Afriyie DK, Sefah IA, Sneddon J, et al. Antimicrobial point prevalence surveys in two Ghanaian hospitals: opportunities for antimicrobial stewardship. *JAC*. 2020;2(1):dlaa001. doi:10.1093/jacamr/dlaa001
11. World Health Organisation. WHO Global strategy for containment of antimicrobial resistance; 2001. Available from: https://www.who.int/publications/i/item/who-global-strategy-for-containment-of-antimicrobial-resistance. Accessed June 21, 2021.
12. Akpan MR, Isemin NU, Udoh AE, Ashiru-Oredope D. Implementation of antimicrobial stewardship programmes in African countries: a systematic literature review. *J Glob Antimicrob Resist*. 2020;22:317–324. doi:10.1016/j.jgar.2020.03.009
13. Siachalinga L, Mufwambi W, Lee IH. Impact of antimicrobial stewardship interventions to improve antibiotic prescribing for hospital inpatients in Africa: a systematic review and meta-analysis. *J Hosp Infect*. 2022;129:124–143. doi:10.1016/j.jhin.2022.07.031
14. de With K, Allerberger F, Amann S, et al. Strategies to enhance rational use of antibiotics in hospital: a guideline by the German Society for Infectious Diseases. *Infection*. 2016;44(3):395–439. doi:10.1007/s15010-016-0885-z
15. Klein EY, Milkowska-Shibata M, Tseng KK, et al. Assessment of WHO antibiotic consumption and access targets in 76 countries, 2000–15: an analysis of pharmaceutical sales data. *Lancet Infect Dis*. 2021;21(1):107–115. doi:10.1016/S1473-3099(20)30332-7
16. Pauwels I, Versporten A, Drapier N, Vlieghe E, Goossens H. Hospital antibiotic prescribing patterns in adult patients according to the WHO Access, Watch and Reserve classification (AWaRe): results from a worldwide point prevalence survey in 69 countries. *J Antimicrob Chemother*. 2021;76(6):1614–1624. doi:10.1093/jac/dkab050
17. Kalungia AC, Mwambula H, Munkombwe D, Marshall S, Schellack N. Antimicrobial stewardship knowledge and perception among physicians and pharmacists at leading tertiary teaching hospitals in Zambia: implications for future policy and practice. *J Chemother*. 2019;31(7–8):378–387. doi:10.1080/1120009X.2019.1622293
18. Mpundu M. Moving from paper to action – the status of National AMR action plans in African countries; 2020. Available from: https://revive.gardp.org/moving-from-paper-to-action-The-status-of-national-amr-action-plans-in-african-countries/. Accessed March 31, 2023.
19. Harant A. Assessing transparency and accountability of national action plans on antimicrobial resistance in 15 African countries. *Antimicrob Resist Infect Control*. 2022;11(1):15. doi:10.1186/s13756-021-01040-4
20. Saleem Z, Godman B, Cook A, et al. Ongoing efforts to improve Antimicrobial Utilization in Hospitals among African countries and implications for the future. *Antibiotics*. 2022;11(12):1824. doi:10.3390/antibiotics11121824
21. Campbell SMM, Johanna C, Godman B. Why compliance to national prescribing guidelines is important especially across sub-Saharan Africa and suggestions for the future. *J Biomedl Pharm Sci*. 2021;4:6.
22. Sefah IA, Sarkodie SA, Pichierri G, Schellack N, Godman B. Assessing the clinical characteristics and management of COVID-19 among pediatric patients in Ghana: findings and Implications. *Antibiotics*. 2023;12(2):283. doi:10.3390/antibiotics12020283
23. Langford BJ, So M, Raybardhan S, et al. Bacterial co-infection and secondary infection in patients with COVID-19: a living rapid review and meta-analysis. *Clin Microbiol Infect*. 2020;26(12):1622–1629. doi:10.1016/j.cmi.2020.07.016
24. Alshaikh FS, Godman B, Sindi ON, Andrew Seaton R, Kurdi A. Prevalence of bacterial coinfection and patterns of antibiotics prescribing in patients with COVID-19: a systematic review and metaanalysis. *PLoS One*. 2022. doi:10.1371/journal.pone.0272375
25. Adebisi YA, Jimoh ND, Ogunkola IO, et al. The use of antibiotics in COVID-19 management: a rapid review of national treatment guidelines in 10 African countries. *Trop Med Health*. 2021;49(1):51. doi:10.1186/s41182-021-00344-w
26. Ramzan K, Shafiq S, Raees I, et al. Co-Infections, secondary infections, and antimicrobial use in patients hospitalized with COVID-19 during the first five waves of the pandemic in Pakistan; findings and implications. *Antibiotics*. 2022;11:6. doi:10.3390/antibiotics11060789

27. Ogunleye OO, Oyawole MR, Odunuga PT, et al. A multicentre point prevalence study of antibiotics utilization in hospitalized patients in an urban secondary and a tertiary healthcare facilities in Nigeria: findings and implications. *Expert Rev Anti Infect Ther*. 2021;2021:1–10.
28. Bell BG, Schellevis F, Stobberingh E, Goossens H, Pringle M. A systematic review and meta-analysis of the effects of antibiotic consumption on antibiotic resistance. *BMC Infect Dis*. 2014;14:13. doi:10.1186/1471-2334-14-13
29. Schuts EC, Hulscher MEJL, Mouton JW, et al. Current evidence on hospital antimicrobial stewardship objectives: a systematic review and meta-analysis. *Lancet Infect Dis*. 2016;16(7):847–856. doi:10.1016/S1473-3099(16)00065-7
30. Dlamini NN, Meyer JC, Kruger D, Kurdi A, Godman B, Schellack N. Feasibility of using point prevalence surveys to assess antimicrobial utilisation in public hospitals in South Africa: a pilot study and implications. *Hosp Pract*. 2019;47(2):88–95. doi:10.1080/21548331.2019.1592880
31. Abubakar U. Antibiotic use among hospitalized patients in northern Nigeria: a multicenter point-prevalence survey. *BMC Infect Dis*. 2020;20(1):86. doi:10.1186/s12879-020-4815-4
32. Momanyi L, Opanga S, Nyamu D, Oluka M, Kurdi A, Godman B. Antibiotic prescribing patterns at a leading referral hospital in Kenya: a point prevalence survey. *J Res Pharm Prac*. 2019;8(3):149. doi:10.4103/jrpp.JRPP_18_68
33. Horumpende PG, Mshana SE, Mouw EF, Mmbaga BT, Chilongola JO, de Mast Q. Point prevalence survey of antimicrobial use in three hospitals in North-Eastern Tanzania. *Antimicrob Resist Infect Control*. 2020;9(1):1–6. doi:10.1186/s13756-020-00809-3
34. Umeokonkwo CD, Madubueze UC, Onah CK, et al. Point prevalence survey of antimicrobial prescription in a tertiary hospital in South East Nigeria: a call for improved antibiotic stewardship. *J Glob Antimicrob Resist*. 2019;17:291–295. doi:10.1016/j.jgar.2019.01.013
35. Campbell SM, Braspenning J, Hutchinson A, Marshall M. Research methods used in developing and applying quality indicators in primary care. *Qual Saf Health Care*. 2002;11(4):358–364. doi:10.1136/qhc.11.4.358
36. Campbell SM, Godman BB, Diògene E, et al. Quality indicators as a tool in improving the introduction of new medicines. *Basic Clin Pharmacol Toxicol*. 2015;2015:116.
37. Campbell SM, Kontopantelis E, Hannon K, Burke M, Barber A, Lester HE. Framework and indicator testing protocol for developing and piloting quality indicators for the UK quality and outcomes framework. *BMC Fam Pract*. 2011;12:85. doi:10.1186/1471-2296-12-85
38. Godman B, Fadare J, Kwon H-Y. Evidence-based public policy making for medicines across countries: findings and implications for the future. *J Comp Eff Res*. 2021;10(12):1019–1052. doi:10.2217/cer-2020-0273
39. Oduyebo O, Olayinka A, Iregbu K, et al. A point prevalence survey of antimicrobial prescribing in four Nigerian tertiary hospitals. *Ann Trop Pathol*. 2017;8(1):42. doi:10.4103/atp.atp_38_17
40. Fowotade A, Fasuyi T, Aigbovo O, et al. Point prevalence survey of antimicrobial prescribing in a Nigerian hospital: findings and implications on antimicrobial resistance. *West Afr J Med*. 2020;37(3):216–220.
41. Anand Paramadhas BD, Tiroyakgosi C, Mpinda-Joseph P, et al. Point prevalence study of antimicrobial use among hospitals across Botswana; findings and implications. *Expert Rev Anti Infect Ther*. 2019;17(7):535–546. doi:10.1080/14787210.2019.1629288
42. Maina M, Mwaniki P, Odira E, et al. Antibiotic use in Kenyan public hospitals: prevalence, appropriateness and link to guideline availability. *Int J Infect Dis*. 2020;99:10–18. doi:10.1016/j.ijid.2020.07.084
43. Wambale J, Mulwahali E, Iyamba JML, Mathe DM, Kavuo SK. Point prevalence study of antibiotic use in hospitals in Butembo. *Int J Medical Sci*. 2016;8(12):133–139. doi:10.5897/IJMMS2016.1249
44. Bediako-Bowan AAA, Owusu E, Labi AK, et al. Antibiotic use in surgical units of selected hospitals in Ghana: a multi-centre point prevalence survey. *BMC Public Health*. 2019;19(1):797. doi:10.1186/s12889-019-7162-x
45. Niaz Q, Godman B, Massele A, et al. Validity of World Health Organisation prescribing indicators in Namibia's primary health care: findings and implications. *Int J Qual Health Care*. 2019;31(5):338–345. doi:10.1093/intqhc/mzy172
46. Niaz Q, Godman B. Compliance to prescribing guidelines among public health care facilities in Namibia; findings and implications. *J Clin Pharm Ther*. 2020;42(4):1227–1236.
47. World Health Organization. *The WHO AWaRe (Access, Watch, Reserve) Antibiotic Book*. Geneva: World Health Organization; 2022. Available from: https://www.who.int/publications/i/item/9789240062382. Accessed March 31, 2023.
48. World Health Organization. WHO methodology for point prevalence survey on antibiotic use in hospitals, version 1.1; 2018. Available from: https://apps.who.int/iris/handle/10665/280063. Accessed July 20, 2021.
49. Chijioke A, Amadi ES, Ukwandu NCD, et al. "Prevalence of antimicrobial use in major hospitals in Owerri, Nigeria". *EC Microbiol*. 2016;3:522–527.
50. Labi A-K, Obeng-Nkrumah N, Sunkwa-Mills G, et al. Antibiotic prescribing in paediatric inpatients in Ghana: a multi-centre point prevalence survey. *BMC Pediatr*. 2018;18(1):1–9. doi:10.1186/s12887-018-1367-5
51. Seni J, Mapunjo SG, Wittenauer R, et al. Antimicrobial use across six referral hospitals in Tanzania: a point prevalence survey. *BMJ open*. 2020;10(12):e042819. doi:10.1136/bmjopen-2020-042819
52. Abubakar U, Sulaiman SAS, Adesiyun AG. Impact of pharmacist-led antibiotic stewardship interventions on compliance with surgical antibiotic prophylaxis in obstetric and gynecologic surgeries in Nigeria. *PLoS One*. 2019;14(3):e0213395. doi:10.1371/journal.pone.0213395
53. Aiken AM, Wanyoro AK, Mwangi J, Juma F, Mugoya IK, Scott JAG. Changing Use of Surgical Antibiotic Prophylaxis in Thika Hospital, Kenya: a quality improvement intervention with an interrupted time series design. *PLoS One*. 2013;8(11):e78942. doi:10.1371/journal.pone.0078942
54. Alabi AS, Picka S, Sirleaf R, et al. Implementation of an antimicrobial stewardship programme in three regional hospitals in the south-east of Liberia: lessons learned. *JAC Antimicrob Resist*. 2022;4(3):dlac069. doi:10.1093/jacamr/dlac069
55. Bashar MA, Miot J, Shoul E, van Zyl RL. Shoul E and van Zyl RL. Impact of an antibiotic stewardship programme in a surgical setting. *S Afr J Infect Dis*. 2021;36(1):307. doi:10.4102/sajid.v36i1.307
56. Bassiouny DM, Hassan RM, Shalaby A, Halim MMA, Wassef MA. Establishment of an antimicrobial stewardship strategy on the surgical NICU at Cairo University specialized pediatric hospital. *J Pediatr Surg*. 2020;55(9):1959–1964. doi:10.1016/j.jpedsurg.2019.12.005
57. Boyles TH, Whitelaw A, Bamford C, et al. Antibiotic stewardship ward rounds and a dedicated prescription chart reduce antibiotic consumption and pharmacy costs without affecting inpatient mortality or Re-Admission rates. *PLoS One*. 2013;8(12):e79747. doi:10.1371/journal.pone.0079747
58. Brink AJ, Messina AP, Feldman C, Richards GA, van den Bergh D. From guidelines to practice: a pharmacist-driven prospective audit and feedback improvement model for peri-operative antibiotic prophylaxis in 34 South African hospitals. *J Antimicrob Chemother*. 2016;72(4):1227–1234. doi:10.1093/jac/dkw523
59. Gebretekle GB, Mariam DH, Taye WA, et al. Half of prescribed antibiotics are not needed: a pharmacist-led antimicrobial stewardship intervention and clinical outcomes in a referral hospital in Ethiopia. *Front Public Health*. 2020;8:109. doi:10.3389/fpubh.2020.00109

60. Lester R, Haigh K, Wood A, et al. Sustained reduction in third-generation cephalosporin usage in adult inpatients following introduction of an antimicrobial stewardship program in a large, Urban Hospital in Malawi. *Clin Infect Dis*. 2020;71(9):e478–e486. doi:10.1093/cid/ciaa162
61. Ngonzi J, Bebell LM, Boatin AA, et al. Impact of an educational intervention on WHO surgical safety checklist and pre-operative antibiotic use at a referral hospital in southwestern Uganda. *Int J Qual Health Care*. 2021;33(3):mzab089. doi:10.1093/intqhc/mzab089
62. Opondo C, Ayieko P, Ntoburi S, et al. Effect of a multi-faceted quality improvement intervention on inappropriate antibiotic use in children with non-bloody diarrhoea admitted to district hospitals in Kenya. *BMC Pediatr*. 2011;11(1):109. doi:10.1186/1471-2431-11-109
63. van den Bergh D, Messina AP, Goff DA, et al. A pharmacist-led prospective antibiotic stewardship intervention improves compliance to community-acquired pneumonia guidelines in 39 public and private hospitals across South Africa. *Int J Antimicrob Agents*. 2020;56(6):106189. doi:10.1016/j.ijantimicag.2020.106189