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REVIEW

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Improving antibiotic utilization in West Africa: enhancing interventions through systematic review and evidence synthesis

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Abstract

Background Bacterial infection has been estimated to become the leading cause of death by 2050, causing 10 million deaths across the globe due to the surge in antibiotic resistance. Despite western sub-Saharan Africa being identified as one of the major hotspots of antimicrobial resistance (AMR) with the highest mortality, a comprehensive regional analysis of the magnitude and key drivers of AMR due to human antibiotic use has not been conducted.

Method We carried out a systematic review by conducting a comprehensive search in various databases including PubMed and Scopus for eligible articles published in the English Language between 1 January 2000 and 14 February 2024. Five key domains of antibiotic use were focused on: (1) antibiotic consumption; (2) appropriate antibiotic prescription; (3) indicators or key drivers of antibiotic use; (4) antimicrobial stewardship (AMS) interventions; (5) knowledge, attitudes and perceptions of antibiotic consumers and providers. Data were extracted from eligible papers for all the five domains under consideration and random-effects model meta-analysis was carried out for antibiotic consumption.

Results Out of the 2613 records obtained, 64 articles which were unevenly distributed in the region were eligible for inclusion in our study. These articles reported on antibiotic consumption (5), appropriate antibiotic prescription (10), indicators or key drivers of antibiotic use (10), AMS interventions (10), and 31 studies reported on knowledge, attitudes and perceptions. Antibiotic consumption for inpatients has a pooled estimate of 620.03 defined daily dose (DDD) per 100 bed-days (confidence interval [CI] 0.00–1286.67; $I^2 = 100\%$) after accounting for outliers while prescribing appropriateness ranged from 2.5% to 93.0% with a pooled estimate of 50.09 ([CI: 22.21–77.92%], $I^2 = 99.4\%$). Amoxicillin, gentamicin, amoxicillin-clavulanate, metronidazole, and ceftriaxone were the commonly consumed antibiotics. Community-acquired infection, hospital-acquired infection, and prophylaxis were the major indicators of antibiotic use. AMS was effective to varying degrees with bundled interventions and gamified antimicrobial stewardship decision support application being the most effective. Healthcare workers demonstrated acceptable antibiotic knowledge but individuals from formal and informal settings self-medicate with antibiotics and had moderate to low knowledge of antibiotic use and resistance.

Conclusion This review identified gaps in knowledge and highlighted areas where prompt actions are required, it further guides future research endeavors and policy development. The findings underscore the need for further

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implementation of AMS programs across the West African region to enhance understanding of antibiotic use patterns, prescribing practices, and the factors influencing them in the region.

Keywords West Africa, Antibiotics, Consumption, Appropriateness, Stewardship, Indicators, Antibiotic resistance

Introduction

Bacterial infections have emerged as a phenomenon that mankind must come to acknowledge and coexist with, albeit accompanied by significant consequences—namely, the burden of morbidity and mortality. To mankind rescue is antibiotic, which first discovery began with penicillin by Alexander Fleming. This initial discoveries led to the subsequent discovery and development of many other antibiotics, saving millions of lives annually [1]. The global rise of bacterial resistance to these antibiotics which is attributed to many factors such as inappropriate antibiotic consumption and multifaceted evolution of bacterial genome [2–4], is one of the greatest public health threats, exerting a disproportionately profound impact on low- and middle-income countries (LMICs) [5–7].

A recent global analysis based on predictive statistical models estimated that bacterial antimicrobial resistance (AMR) directly caused 1·27 million deaths and contributed to about 4·95 million (3·62–6·57) deaths worldwide. Disturbingly, findings reveal that the estimated all-age death rate directly linked to antimicrobial resistance was highest in the western sub-Saharan Africa region, with a staggering 27·3 deaths per 100 000 (20·9–35·3) [8]. In the context of the western sub-Saharan African region, among many factors that promote antibiotic resistance are antibiotic use; inappropriate administration, overuse and misuse [9–13]. The inherent challenges posed by the low-resource context of this region manifest in inadequate access to quality healthcare, safe water, vaccination, and poor sanitation. Consequently, a vulnerable population finds themselves exposed to infections, necessitating reliance on antibiotics for treatment, all while operating within a framework where the regulation of their usage remains largely deficient [14–19].

West Africa is a region comprising sixteen countries with an overall population of about 446,273,282 people, making up 5.47% of the total world population [20]. Each nation within this region falls under the classification of lower-middle-income countries, characterized by a diverse range of socio-economic conditions and particularly, variation of health indicators. Factors contributing to antibiotic resistance are widespread in West Africa, ranging from the high persistent burden of infectious diseases to the variability in accessing quality healthcare, the inadequate enforcement of antibiotic policies, and the mass administration of some antibiotics [21–27], rendering West Africa particularly vulnerable to AMR. Coupled with these aforementioned factors that contribute to the high antibiotic resistance in this part of the world, there has been mass administration of azithromycin and other antibiotics to minimize childhood mortality and yaws in many West African countries. The pronounced presence of AMR in West Africa is substantiated by the escalating number of scientific reports published on AMR in recent years. Despite western sub-Saharan Africa recording the highest AMR mortality, to the best of our knowledge, a comprehensive regional analysis of the magnitude and key drivers of AMR and antibiotic use in West Africa has not been conducted to date. Such an analysis is crucial as it would generate essential evidence and shed light on existing gaps. This information would play a pivotal role in guiding the implementation of policies in the region, to minimize the ever-growing threat of AMR.

Major stakeholders and previous studies assessing antimicrobial stewardship (AMS) interventions, despite being limited and diverse in nature, have highlighted the significance of closely monitoring key elements such as antibiotic consumption, prescribing appropriateness, guideline compliance, indicators of use, and patient outcomes. However, the evidence base for these key elements in West Africa is uneven. Tertiary and secondary hospitals constitute a moderate representation of this evidence, while consumers and other informal and formal private health providers, who significantly contribute to antibiotic distribution, are highly underrepresented. To bring these key concepts to light in West Africa, this systematic review focuses on antibiotic use for human health (J01 antibiotics) in West Africa from 2000 to 2024. This review focuses on five key antibiotic domains: (1) antibiotic consumption; (2) appropriate antibiotic prescription; (3) indicators or key drivers of antibiotic use; (4) AMS interventions; (5) knowledge, attitudes and perceptions of antibiotic consumers and providers.

Method

Search strategy

This systematic review adhered to the guidelines outlined by the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) [28]. On February 14, 2024, a comprehensive search was conducted by two authors in PubMed, Scopus and other databases to identify peer-reviewed original articles from West Africa. The search was limited to articles published in English between 1 January 2000 and 14 February 2024, utilizing the search terms listed in Table S1. Additionally, a reference screening process was employed to identify any additional relevant papers. The scope of this review was specifically focused on antibiotics for systematic human use, as classified under the J01 ATC category by WHO.

Inclusion and exclusion criteria

Based on the research keywords, we incorporated various types of studies including cross-sectional, prospective, and longitudinal studies. We included studies that met one or more of the following five categorized domains;

1 Antibiotic consumption; expressed as defined daily dose (DDD) per 100 bed days. All included articles are those from hospital antibiotic use. Articles that did not report antibiotic consumption in DDD and cannot be converted to DDD were excluded. We reported on antibiotics that were used in three or more of the studies. By doing so, we grouped the antibiotics into Access, Watch, and Reserve classifications according to the 2021 WHO AWaRe classification [29].
2 Examining of appropriate antibiotic prescription for the treatment of prophylaxis. This was examined based on the Gyssens method [30] or compliance with other reference guideline.
3 Indicators and key drivers of human antibiotic use. Studies that quantified the key drivers of antibiotic use were included.
4 Antimicrobial stewardship intervention evaluation studies. Included studies are those that clearly described the results of before and after the implementation of the intervention. Studies on antimicrobial stewardship implementation procedures were excluded.
5 Survey or studies assessing knowledge, attitude, and or perceptions on antibiotic use. Papers that reported the qualitative or quantitative data on this category were included.

Our selection was limited to articles that were accessible to us, available in full text, and published in the English language. The general publications excluded from our review were reviews, reports, news, views, case–control studies, preprints, commentaries, and letters to editors. In vitro studies, studies assessing cost-effectiveness, and studies on veterinary, evaluating antibacterial therapeutics activities and pharmacokinetics were all excluded. Studies with data from West African countries that were inseparable from non-West African countries were also excluded.

Quality assessment

This study was built upon previously published research articles that provided observational evidence. Rigorous measures were taken to ensure the review's quality, including careful inspection and elimination of any duplicate articles. The abstracts/full texts of the identified articles were meticulously screened and verified to ensure that only high-quality and relevant information from the literature was included in the review process. The assessment of article quality was conducted independently by the authors involved in this manuscript. We included studies that provided a set of essential items from the STROBE checklist [31] and also reported on additional themes specific to our study as shown in Table S2. In cases where conflicting decisions arose, E.S-D provided guidance and expertise to resolve any discrepancies.

Data analysis

Data was extracted from individual studies using forms developed for this review in the Microsoft Excel 2013 software. All the forms captured data such as author names, year of publication, country, type of study participants, sample size, and study period. Data on antibiotic consumption, appropriate antibiotic prescription, indicators of antibiotic use, AMS intervention, and Knowledge attitude and perception of individuals were entered separately.

In performing a meta-analysis, we used the data on antibiotic consumption and appropriate antibiotic prescription. Using R version 4.4.0, the meta package v 4.20-2 and the random-effects model, pooled estimates for antibiotic consumption for inpatients were done using the metagen function. The rate, sample size and method used were respectively DDD/100, inverse of sample size and inverse variance. Having pooled the estimates, we went ahead to do the sensitivity analysis and a further Grubbs test to check and remove outliers. Having removed the outlier, we went ahead to do a subgroup analysis based on the durations of studies, the location of studies and the healthcare level in which the studies in the subgroups were undertaken. For outpatients, no meta-analysis was done as the two studies reported in DDD/1000 and Days of Antibiotic Therapy/1000 Patient-Days respectively.

For the data on appropriate antibiotic prescription, we calculated the pooled estimate using the metaprop function and went ahead to do sensitivity analysis. Furthermore, subgroup analysis was done to understand how the pooled estimate varied by the year of study (before 2020 and after 2020), health level (either the study was done in a secondary, tertiary or mixed health facilities), location and finally reference guideline compared to others in terms of appropriateness. As many of the studies were from Ghana, the subgroup analysis on location was done based on studies from Ghana and others (from other West African countries aside from Ghana). For the reference guideline group analysis, studies in Ghana were grouped into those that used the STG guidelines or other guidelines (STG and GNDP and unspecified guidelines). Using the I^2 statistic, heterogeneity was assessed as low < 25%, moderate 25–49%, substantial 50–74%, or high 75–100%. Bias analysis was not done on the dataset for antibiotic consumption and appropriate antibiotic prescription as the number of studies was < 10.

Results

Study selection

Initially, A-H.O. and E.S-D searched and downloaded all the 2613 articles in the search results on Scopus (1345) and PubMed (1268). Subsequently, A-H.O. and E.S-D manually excluded retracted papers and eliminated 716 duplicates with the aid of Rayyan [32] and the Zotero referencing tool (version 6.0.30 made by Corporate for Digital Scholarship). In the case of duplicate articles, we included only the version with the most comprehensive dataset and excluded any others to ensure non-redundancy in the analysis. The resulting 1887 articles were examined and screened by A-H.O. and E.S-D. based on their titles and abstracts in relation to our inclusion criteria. Afterward, 1739 articles were excluded based on article title/abstract, and articles without abstracts. In total, 148 articles were subjected to full-text detailed paper screening and only 64 articles were taken into consideration for this manuscript (Fig. 1). Only 1 study was obtained from the reference list of included papers after reading its full-text screening.

Overview and DESCRIPTION OF PAPERS

In accordance with the inclusion and exclusion criteria, and the PRISMA checklist [33], we included 64 reports investigating the five outlined categories of antibiotic use in West Africa as shown in Tables 1, 2, 3, 4 and **ST3**. The studies were distributed across nine of the sixteen West African countries; Burkina Faso, Côte D'Ivoire, Gambia, Ghana, Liberia, Mali, Nigeria, Sierra Leone, and Togo. The countries with the most studied antibiotic use in descending order are Ghana (n = 33), Nigeria (n = 23), Sierra Leone (n = 4), and Liberia (n = 2), with Burkina Faso, Côte D'Ivoire, Gambia, Mali, and Togo contributing one study each. The study design of the included articles ranged from clinical trials to longitudinal and cross-sectional studies, with the latter being the most used study design. Generally, the population types ranged from patients, health care providers, and community

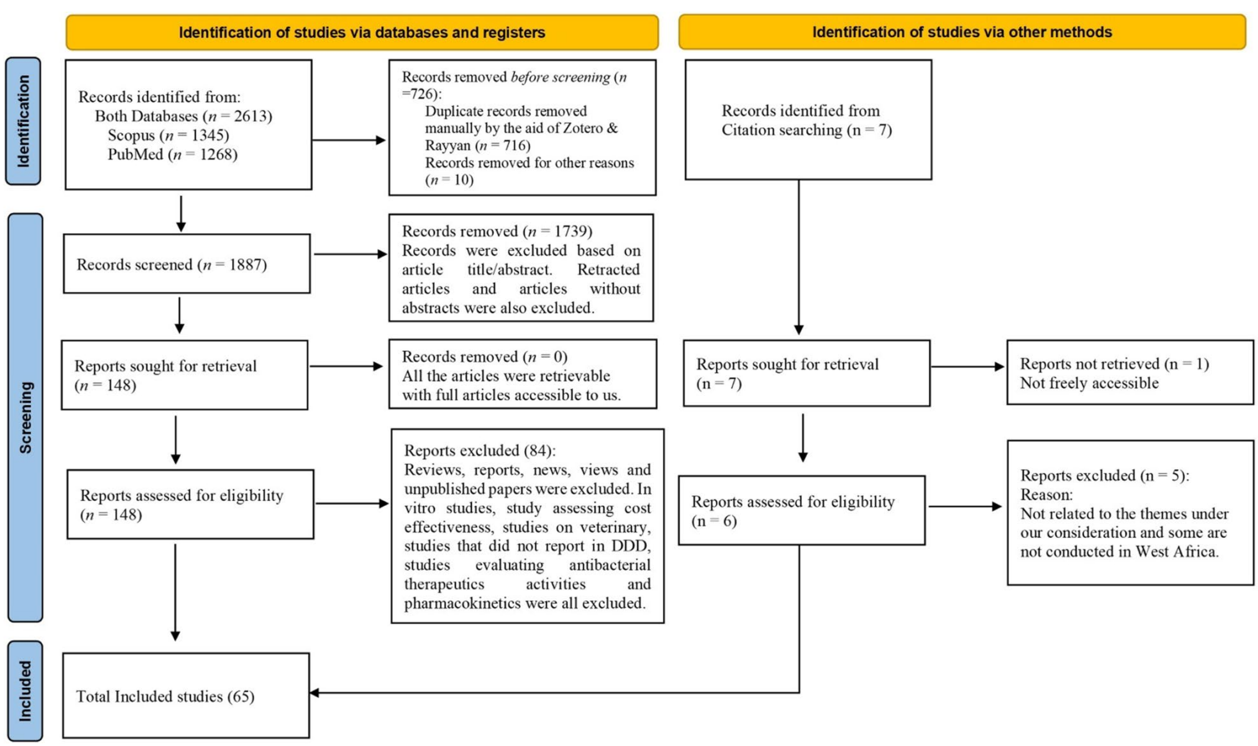

Fig. 1 A flow diagram of our systematic review process (PRISMA guide)

Table 1 Summary of studies on antibiotic consumption

Publication	Duration of study	Location	Health Care Level	Type of study population	Total No. of patients	Total antibiotics	Access Antibiotics						Watch Antibiotics									Not recommended
							AMX	GEN	AMP	AMC	SXT	MET	AZM	CAM	CTX	CAZ	CRO	CIP	LVX	MEM	CXM	CFP-SUL
Abubakar et al. [93]	May–July 2016	Nigeria	Tertiary	Women who had obstetrics and gynaecology surgeries	248	1675.3 DDD per 100 bed days	–	5.6	-	754.6	–	615.1	–	–	–	–	44.4	11.6	-	-	227.4	–
Lakoh et al. [64]	February and October 2021	Sierra Leone	Secondary- and tertiary-care health facilities	Surgical prophylaxis individuals	753	117.9 DDD per 100 bed days	1.1	2.2	15.0	14.5	–	30.8	0.1	0.1	-	-	41.6	1.0	1.9	–	0.1	–
ALabi et al. [61]	January 2016–November 2021	Ghana	Secondary health-care	In- and out-patients who attended the hospital	1 028 016	2 629 786.0 (mean; 256.7 ± 33 DDD/100 patients per year)	74.87	12.7	0.3	372.6	145.8	127.8	88.4)	39.9	0.1	0.004	41.9	82.9	5.9	0.5	287.4	–
Lakoh, Williams et al. [66]	March–October 2021	Sierra Leone	Tertiary	Patients admitted to medical or intensive care unit	468	66.9 DDD per 100 bed days	0.1	1.7	–	3.9	-	12.4	2.5	–	–	–	23.9	3.5	18.0	–	–	–
Below are Antibiotic consumption in Pediatric ward and Outpatients expressed in Days of Antibiotic Therapy/1000 Patient-Days and DDD per 1000 outpatient-days respectively																						
Chaw et al. [50]	January–December 2015	Gambia	Tertiary	All patients (aged > 28 days to 15 years) who received antibiotic therapy	917	670.7 Days of Antibiotic Therapy/1000 Patient-Days	37.1	164.2	103.0	4.0	1.4	18.0	–	–	–	–	121.1	8.7	–	–	–	–
Lakoh, John-Cole et al. [65]	April 2022	Sierra Leone	Tertiary	Pregnant women and lactating mothers, children and regular patients in the outpatient clinics	913	55.3 DDD per 1000 outpatient-days	21.9	0.01	0.04	4.67	-	7.94	0.87	4.09	–	–	0.00	4.70	1.51	–	3.04	–

The table summarizes studies on antibiotic consumption in inpatients, expressed as Defined Daily Dose (DDD) per 100 bed-days, overall and/or for individual antibiotics, and divided by primary versus secondary/tertiary care settings. A was an outlier and was not added when computing the pooled antibiotic consumption for inpatients. However, it was added as part of the subgroup analysis of inpatients to understand the heterogeneity that exist between studies that took more than a year and those that took less than a year

AMX, Amoxacillin; GEN, Gentamicin; AMP = Ampicillin; AMC = Amoxicillin-clavulanate; SXT = Sulfamethoxazoletrimethoprim; MET = Metronidazole; AZM = Azithromycin; CAM = Clarithromycin; CTX = Cefotaxime; CAZ = Ceftazidime; CRO = Ceftriaxone; CIP = Ciprofloxacin; LVX = Levofloxacin; MEM = Meropenem; CXM = Cefuroxime; *CFP-SUL = Cefoperazone-Sulbactam* members. About forty-five reports [10, 34–76] were conducted during the last ten years (2014–2024). Five studies [47, 77–80], were conducted between 2000 and 2014 but information on study periods were missing in five studies [81–92]. Out of the 64 reports, six were on antibiotic consumption and were conducted in the most recent ten years (2014–2024) [50, 61, 64–66, 93] as shown in Table 1. Ten studies [34, 41, 42, 46, 56–58, 75, 76, 80] were on antibiotic prescription appropriateness, and ten studies [34, 35, 41, 46, 53, 55, 58, 62, 63, 68] reported on indicators or key drivers of antibiotic use as Shown in Table 2 and Table 3 respectively. Ten articles [36, 37, 44, 45, 55, 59, 67, 71, 91, 92] reported on antimicrobial stewardship intervention evaluation. Thirty-one studies [10, 38–40, 43, 47–49, 51, 52, 54, 60, 69, 70, 72–74, 77–79, 81–90, 94] reported on Knowledge, attitude and perception as shown in **ST3**.

Antibiotic consumption

There were six reported data [50, 61, 64–66, 93] on antibiotic consumption, distributed across only four West African countries. The studies were mainly conducted in tertiary and secondary hospitals amassing a total population of 1,029,485 inpatients, 913 outpatients, 917 pediatric infants and were conducted between 2015 and 2022 as shown in Table 1. The pooled estimate of overall antibiotic consumption for in-patients was 620.03 DDD per 100 bed-days (95% confidence interval [CI] 0.00–1286.67; $I^2=100\%$) after removing one study for being an outlier and taking a longer duration as compared to the other studies (Fig. 2). Eliminating the outlier when computing for the overall pooled antibiotic consumption was not significant (p-value = 0.0683) although it was lower when it was removed (620.03 DDD per 100 bed-days) as compared to adding it (657,911.5250 DDD per 100 bed-days, CI [0.0000; 2,480,075.7271]) **(SF1)**. The study by (Labi et al.) took a longer duration and the result of the high DDD as compared to the other studies could be due to the need for a higher dose for patients either due to development of tolerance, occurrence of adverse events, changes in disease severity of patients or possibly the different methods used in the study. To understand this further, a subgroup analysis was performed. The studies that took less than a year had a lower pooled estimate (1469.00 DDD/100 bed days [CI: 1468.99–1469.00]) as compared to the one that took longer (2,629,786.00 [CI: 2,629,786.00–2,629,786.00]). Also, studies that took place in Nigeria had a lower (248.00 [CI: 247.99–248.00]) DDD/100 bed-days as compared to those undertaken in Sierra Leone (1221.00 [CI: 1220.98–1221.01). In terms of healthcare level, we found no difference between the DDD in either the tertiary (716.00 [CI: 715.99–716.001) and mixed levels (753.00 [CI: 752.98–753.01]).

Amoxicillin, metronidazole, gentamicin, amoxicillin-clavulanate, sulfamethoxazole-trimethoprim and cefuroxime were the commonly consumed antibiotics across all four studies. Only two studies assessed antibiotic consumption in outpatients and pediatrics. In this regard, the antibiotic consumption reported for those studies were respectively 55.3 DDD per 1000 outpatient-days and 670.7 Days of Antibiotic Therapy/1000 Patient-Days among pediatrics. The percentage of access antibiotics consumed out of the total antibiotics consumed among inpatients is 64% and watch antibiotics consumption is 27% while 9% is unknown to us. It is worth mentioning that no study reported on the use of cefoperazone-sulbactam which is a non-recommended antibiotic.

Examining appropriateness of antibiotic prescriptions

Of all the 64 studies, ten articles [34, 41, 42, 46, 56–58, 75, 76, 80] explicitly stated the appropriateness of the antibiotics by indicating compliance with a guideline. Among the ten studies, seven studies followed local guidelines, one followed an international guideline, and two did not specify the guidelines followed but none of the articles followed Gyssens method. The ten articles were distributed across four West African countries, with Ghana being the major contributor with seven studies and one study each from Nigeria, Liberia, and Sierra Leone. All the studies were conducted in a tertiary or secondary hospital except two studies [41, 56] that did not specify the healthcare level of the hospitals. The overall appropriateness of antibiotic prescribing ranged from 2.5% to 93.0% as seen in Table 2 with a pooled estimate of 50.09 ([CI: 22.21–77.92], $I^2=99.4\%$) (Fig. 3). Upon performing the sensitivity analysis, we found no study that significantly affected the pooled appropriateness of antibiotic prescribing as the studies ranged between 42.18 and 54.39% **(SF2)**.

The appropriateness of prescriptions across various subgroups, categorized by the year of study, healthcare setting, country, and guideline adherence revealed substantial heterogeneity in the results ranging from 99.2 to 99.8% **(ST1)**. For the year of study, the combined overall effect was 62.02% (CI: 46.67–75.29%, $I^2=99.5\%$), with studies before 2020 recording a higher overall appropriateness of 71.94% (CI: 69.78–74.03%) as compared to studies after 2020 (51.05% [CI: 49.20–52.90%]). The overall pooled appropriateness estimate was 62.74% (CI: 39.16–81.50%, $I^2=99.6\%$) for healthcare setting with the secondary level recording the highest 87.47% (CI: 85.52–89.24%) while the mixed category recorded the lowest (31.73% [CI: 29.10–34.44%]). For the subgroup analysis on location, we found 50.77% (CI: 24.02–77.09%) to the

Table 2 Summary of studies on appropriateness of antibiotic prescribing (according to reference guidelines)

Publication	Duration/ period of study	Location	Health care level	Study population	No. of prescriptions	Appropriate (%)								Reference guidelines
						No contra-indication/ allergy label	Indication	Drug choice	Dose	Dosing frequency	Duration	Administration route	Overall appropriate use	
Enriquez et al. [56]	November to December 2017	Liberia	–	Patients undergoing a surgical procedure	143	–	–	–	–	–	–	–	20.3%	CDC wound guidelines
[B]Sumaila and Tabong. [80]	1st of January, 2009 and 31st December, 2014	Ghana	Secondary	Outpatient children with URTIs on antibiotics	237	–	–	–	93.0%	95.6%	96.7	–	–	STG and GNDP
Ankrah et al. [46]	19–21 June 2019	Ghana	Tertiary	Patients on any antibiotics admitted before 8am in all wards on the survey day	967	–	–	–	–	–	–	–	89.0%	GNDP and KBTH-DOG
Sefah, Sneddon et al. [76]	January to December 2020	Ghana	Secondary	Dental care patients	1269	–	–	–	–	–	–	–	87.5%	STG
Sefah, Denoo et al. [75]	January to May 2021	Ghana	Tertiary	patients undergoing surgery; Surgical antimicrobial prophylaxis	597	–	–	67.0%	–	–	8.7%	–	2.5%	STG
Hope et al. [57]	1 January to 31 December 2021	Ghana		Patients with acute conjunctivitis	111	–	–	–	–	–	–	–	71.2%	STG
Aboderin et al. [34]	10–27 June 2019	Nigeria	Mixed; Tertiary and secondary	in-patients including neonates	321	–	–	–	–	–	–	–	39.4%	Unspecified guidline
Agyare et al. [42]	10th and 17th of December 2019	Ghana	Tertiary	in-patients	82	–	–	–	–	–	–	–	25%	Unspecified guidline
Kamara et al. [58]	July -August 2021	Sierra leone	Mixed; Tertiary, secondary	Acute healthcare hospitals and inpatient	883	–	–	–	–	–	–	–	29%	National treatment guideline

Table 2 (continued)

Publication	Duration/period of study	Location	Health care level	Study population	No. of prescriptions	Appropriate (%)								Reference guidelines
						No contra-indication/allergy label	Indication	Drug choice	Dose	Dosing frequency	Duration	Administration route	Overall appropriate use	
Afriyie et al. [41]	January to June 2015	Ghana	–	Out- and in-patient with pre-scribed ceftriaxone injections	251	100%	86.9%	-	100%	100%	85.7%	–	93.0	STG

STGs, The standard treatment guidelines of Ghana; GNDP, Ghana national dug program guideline; KBTHDOG, Korle Bu Teaching Hospital Department of Obstetrics and Gynaecology Guideline

[B] Was not added in computing the pooled appropriateness of antibiotic prescribing as its overall appropriateness was unavailable. The events used for the meta-analysis were derived from computing it using the overall appropriate use and no of prescriptions

Table 3 Indicators and key drivers of antibiotic use

Publication	Duration/period of study	Location	Population type	Population Size	Summary of findings	Final indicators and key drivers identified
Ankrah et al. [46]	19–21 June 2019	Ghana	Patients on any antibiotics admitted before 8am in all wards on the survey day	967	The key indicators of antibiotic use expressed in percentages are; Pneumonia 18.4%, Skin and soft tissue 11.4%, Sepsis 11.1%, Upper respiratory tract infection 7.9%, Malaria 7.6%, Infection of central nervous system 7.0%, Obstetrics/gynecology infection 7.0%, Bone and joint infection 4.8%, Gastro-intestinal infection 4.4%, Intra-abdominal sepsis 3.2%	Pneumonia, Skin and soft tissue, Sepsis, Upper respiratory tract infection, Malaria, and Infection of central nervous system
Enimil et al. [55]	September 2015 and 2019	Ghana	In-patients	386 and 630 in 2015 and 2019 respectively	The key indicators of antibiotic use expressed in percentages in 2015 and 2019 respectively, are; Pneumonia 16.9% and 23%, Skin and soft tissue 15.2% and 15.7%, Obstetric/gynaecological infections 10.7% and 3.7%, Infection of the central nervous system 5.1% and 5.2%, Sepsis 7.3% and 6.8%, Tuberculosis 6.2% and 8.9%, and Bone/joint infections 7.9% only in 2015	Pneumonia, Skin and soft tissue, and Obstetric/gynaecological infections
Darkwah et al. [53]	December 2019 and March 2020	Ghana	Outpatients and in-patients	184	The key indicators of antibiotic use expressed in proportions are; Dental and related infections 20.7%. Post-delivery prophylaxis 18.1%, Respiratory tract infections 13.8%, Gastrointestinal tract infections 12.3%, Urinary tract infections 9.0%, Skin and soft tissue infections 6.4%, Sexually transmitted infections 4.8%, Caesarean Sect. "Overview and Description of Papers"%, and Enteric fever 3.2	The top drivers identified are; Dental and related infections, Post-delivery prophylaxis, Respiratory tract infections, Gastrointestinal and urinary tract infections

Table 3 (continued)

Publication	Duration/period of study	Location	Population type	Population Size	Summary of findings	Final indicators and key drivers identified
Afriyie et al. [97]	January-June, 2015	Ghana	Outpatients and inpatients	251	The key indicators of appropriate ceftriaxone use expressed in proportions are; Co-morbidity (Malaria + other bacterial infections) (78%), Urinary tract infection (100%), Sepsis (100%), Gastroenteritis (100%), Upper respiratory tract infection (100%), Appendicitis (100%), Gastritis (100%), Food poisoning (100%), Fracture (Bone infection) (100%), Cellulitis (100%), and Enteric fever (100%). Ceftriaxone was also used inappropriately in 22% of Co-morbidity (Malaria + other bacterial infections) cases	The top drivers identified are; Co-morbidity (Malaria + other bacterial infections), Urinary tract infection, Sepsis, Gastroenteritis, Upper respiratory tract infection, Appendicitis, Gastritis, Food poisoning, Fracture (Bone infection), Cellulitis, and Enteric fever
Kamara et al. [96]	July–August, 2021	Sierra Leone	Patients	1198	The key indicators of antibiotic use expressed in proportions are; Community acquired infections (51.9%), and Surgical prophylaxis (23.8%)	The top drivers identified are; Community acquired infections, and Surgical prophylaxis
Aboderin et al. [95]	10–27 June, 2019	Nigeria	Patients	321	The key indicators of antibiotic use expressed in proportions are; Community-acquired infection (29.2%), Hospital-acquired infection (8.8%), Surgical prophylaxis (36.9%), and Medical prophylaxis (11.2%)	The top drivers identified are; Community-acquired infection, Surgical prophylaxis, and Medical prophylaxis
Labi et al. [63]	September-December, 2016	Ghana	Paediatric inpatients	716	The key indicators of antibiotic use expressed in proportions are; Community-acquired infections (61%), Hospital-acquired infections (10.3%), prophylaxis (23.7%), and Unknown reason (4.8%)	The top drivers identified are; Community-acquired infections, Hospital-acquired infections, and prophylaxis
Abubakar et al. [35]	April–May, 2019	Nigeria	Hospitalized patients	321	The key indicators of antibiotic use expressed in proportions are; Community-acquired infection (38.7%), Surgical antibiotic prophylaxis (22.5%), Hospital-acquired infection (16.3%), Medical prophylaxis (14.9%), and Unknown indication (7.6%)	The top drivers identified are; Community-acquired infection, Surgical antibiotic prophylaxis, Hospital-acquired infection, and Medical prophylaxis

Table 3 (continued)

Publication	Duration/period of study	Location	Population type	Population Size	Summary of findings	Final indicators and key drivers identified
Nnadozie et al. [68]	May, 2019	Nigeria	Inpatients	82	The key indicators of antibiotic use expressed in proportions are; Community-acquired infection (34.1%), Hospital-associated infection (9%), and Surgical prophylaxis (56.95%)	The top drivers identified are; Community-acquired infection, and Surgical prophylaxis
Labi et al. [62]	February–March, 2016	Ghana	Inpatients	677	The key indicators of antibiotic use expressed in proportions are; Community-acquired infections (40.1%), Hospital-acquired infections (21.0%), Surgical prophylaxis (33.6%), and Medical prophylaxis (5.4%)	The top drivers identified are; Community-acquired infections, Hospital-acquired infections, and Surgical prophylaxis

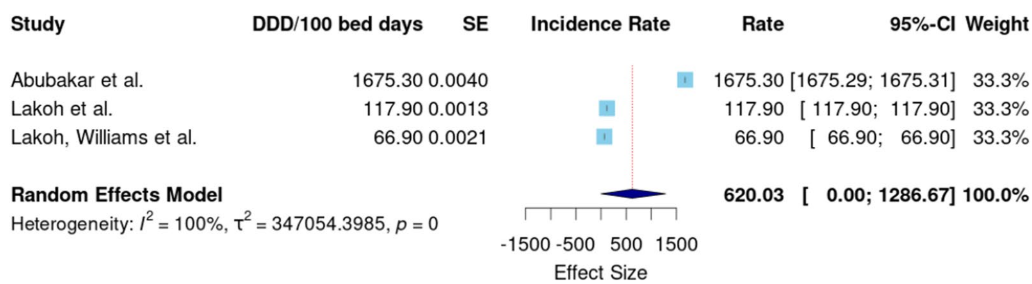

Fig. 2 Forest plot of antibiotic consumption

estimate with Ghana recording a higher appropriateness (70.74% [CI: 69.14–72.29%]) than those of other countries (30.51% [CI: 28.06–33.05%]). In terms of the guidelines being used in Ghana, the STG guideline had a lower appropriate percentage (64.50, [CI: 62.47–66.49%]) than other guidelines (83.98% [CI: 81.62–86.15%]).

Among the ten studies, there was limited information on the individual indicators of prescribing appropriateness with respect to the guideline used. This therefore makes it difficult to specifically state the indicators of prescribing appropriateness that are less followed.

Indicators and key drivers of antibiotic use

About ten articles [34, 35, 41, 46, 53, 55, 58, 62, 63, 68] reported the indicators and drivers of antibiotic use as shown in Table 3. All these studies were conducted among inpatients and outpatients with sample sizes ranging from 82 to 1198 patients of varying health conditions. All the studies identified numerous indicators of antibiotic use, of which five studies expressed the prevalence of the indicators in percentage while seven studies expressed the prevalence of the indicators in proportions. The majority of the studies [35, 62, 63, 68, 95, 96] generalized the indicators as community-acquired infection (6), hospital-acquired infection (5), and prophylaxis (5); medical and surgical. As a result, these three were the major key drivers of antibiotic use on patients (in terms of frequencies), followed by pneumonia, skin and soft tissue, sepsis, malaria, tuberculosis, respiratory, and urinary tract infections.

Antimicrobial stewardship intervention evaluation

Ten studies [36, 37, 44, 45, 55, 59, 67, 71, 91, 92] reported data on the effect of antimicrobial stewardship intervention of which all were in the hospital setting. The study's population sizes ranged from 60 to 1718 people. The interventions focused on various themes, such as knowledge and guideline compliance, antimicrobial guideline adherence, quality of antimicrobial use, antibiotic prescriptions, antibiotic utilization, compliance with surgical antibiotic prophylaxis, prescription behavior, and guideline compliance as shown in Table 4. A variety of AMS interventions were used across the studies including the utilization of the SAPG triad approach, implementation of a bundle of interventions, incorporation of rapid diagnostic tests into diagnostic algorithms, educational training and meetings, and the adoption of gamified antimicrobial stewardship decision support app (GADSA). The diverse interventions demonstrate the effectiveness of antimicrobial stewardship in each setting where it was implemented, as varying degrees of improvements were observed across the different themes of antibiotic use that were assessed.

Despite the improvement of the theme of focus of AMS in each study, the most significant was observed in the study by Sneddon et al. [92] in a hospital where the SAPG triad approach of developing and implementing AMS using information, education and quality improvement was applied to enhance the knowledge and guideline compliance of the healthcare professionals on antibiotic use and prescription. The study by Alabi et al. [44] also resulted in a significant improvement in the quality of antimicrobial use among healthcare workers in Liberia by doubling the initial utilization of suitable antimicrobials in accordance with the guideline or laboratory reports from 34.5% to 61.0%, when a bundle of three interventions (local treatment guideline, training, and regular AMS ward rounds) on the quality of antimicrobial use was implemented. The authors further observed a considerable decrease in the use of antibiotics such as ceftriaxone 51.3% to 14.2% after the implementation of (AMS) [44]. Similarly, the implementation of a bundle of interventions for Antibiotic Stewardship in Nigeria also led to a notable increase in compliance with the timing of surgical antibiotic prophylaxis, rising from 14.2% to 43.3% [36]. These findings underscore the significant impact of AMS training among healthcare workers and the effectiveness of bundled interventions in West Africa.

Knowledge, attitudes, and perceptions on antibiotic use

There were 31 reports [10, 38–40, 43, 47–49, 51, 52, 54, 60, 69, 70, 72–74, 77–79, 81–90, 94] on knowledge, attitudes and practice. These studies were conducted across different populations and the number of studies

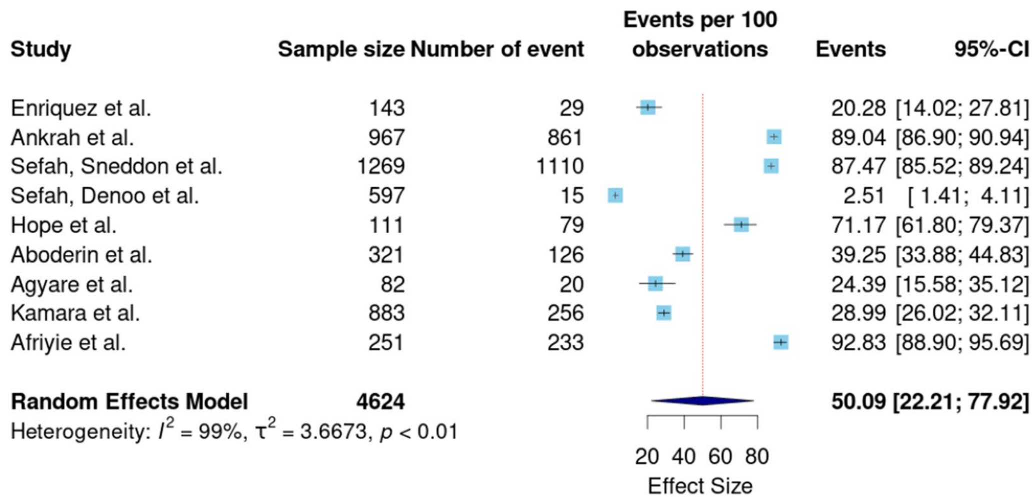

Fig. 3 Forest plot of appropriate antibiotic prescription

varied across each population; surveys among community members (8), health providers (9), health providers and community members (3), patients (2), university staff (1), and tertiary students (8) as shown in **ST3**. There were challenges in the interpretation of the study findings due to considerable differences in study populations and methodologies (specifically, questionnaires). The main themes that emerged were knowledge of antibiotics (including antibiotic use and antibiotic resistance) in the community reports, knowledge of AMR, and antibiotic prescription practices in reports on health providers, and knowledge of AMR, self-medication, and sources of antibiotics used in reports on tertiary students. Among the community respondents, there were wide variations in the knowledge of antibiotics (8 reports); overall 8.3–53.6% had good knowledge of antibiotic use [51, 94] and 33–57.4% had poor knowledge of antibiotic resistance [51, 81, 88]. High cost of antibiotics and low socioeconomic status were found to be associated with inappropriate use of antibiotics [38, 40, 60]. There was high use of antibiotics ranging from 44.1 to 72.5% among community respondents [77, 81, 94].

Among healthcare providers, the percentage of those who had good knowledge of AMR ranged from 49.2 to 88% [48, 49, 52, 69]. Prescription of antibiotics was found to be at a high rate of 98.2% in a study among 442 primary health workers [84]. Interestingly, laboratory investigations were less frequently requested and used in the prescription of antibiotics by health providers [69, 85, 98].

Tertiary students who had good knowledge of AMR were 57.5–73% [43, 70, 74, 89]. Self-medication was high among tertiary students and ranged from 47.7% to 80.1% [78, 86, 87, 99]. The major reasons for self-medication among tertiary students were cost saving (23.1–40.5%) [74, 78, 87], and convenience (40.5–55.2%) [74, 78, 87]. The main sources of antibiotics were pharmacies (29.1–85.6%) [43, 74, 86, 87], and doctor's prescriptions (68.3%) [79].

The study by Ogunleye et al. [85] in a hospital in Nigeria reveals that clinical judgment made without laboratory results among physicians was 93.9%. This observation is similar to the study by Opoku et al. [72] in Ghana where 70.11% of the participating febrile patients were prescribed antibiotics, and amongst these, 74.6% of those for whom no laboratory investigation was requested were prescribed antibiotics. Even though there was an encouraging antibiotic knowledge among healthcare workers across the studies, it is alarming to observe that, antibiotics were prescribed for common viral infections such as sore throats (75.7%), measles (37.7%), common cold and flu (21.2%) by health workers [52]. This is strikingly similar to the knowledge of community members claiming antibiotics could cure all types of infections and therefore using antibiotics in treating malaria [81] in addition to confusing antibiotics as painkillers [100].

Discussion

Though West Africa has been established as the greatest global hotspot of antibiotic resistance, culminating in the rising number of scientific reports focusing on AMR in the region, a single study unifying human antibiotic use in the region is lacking. Nonetheless, evidence-based information and data are uneven with tertiary and secondary hospitals moderately represented while other sectors such as the private healthcare providers, informal, and community members who play a major role in antibiotic distribution and consumption are highly

Table 4 Antimicrobial stewardship Intervention Evaluation Studies

Publication	Duration/period of study	Location	Population type	Population Size	Theme of Stewardship intervention	Intervention description	Summary of findings	Outcome
Sneddon, Cooper et al. [92]	–	Ghana	healthcare professionals; Nurses, Pharmacist, and Medical Doctors	60	Knowledge and guidelines compliance	SAPG triad approach in developing and implementing AMS using information, education and quality improvement to optimize the use of antimicrobials was adopted to teaching healthcare professionals in the hospitals. A knowledge quiz and an attitude and behaviors survey were then used to gather data before and after the training session. To ascertain the influence of the training on the knowledge and guidelines compliance	There was a significant increase in knowledge towards antimicrobial resistance and appropriate use of antibiotics from 9.4 in Keta Municipal Hospital, 9.2 in Ghana Police Hospital to 10.9 11.1 in the respective hospitals. A comparison of survey responses before and after the education sessions revealed that, it positively affected their perception of their role in Antibiotic Stewardship (AMS) and boosted their confidence in utilizing the Ghana Standard Treatment Guidelines	Improved knowledge and guideline compliance

Table 4 (continued)

Publication	Duration/period of study	Location	Population type	Population Size	Theme of Stewardship intervention	Intervention description	Summary of findings	Outcome
Ola-Bello et al. [71]	April—September 2019	Nigeria	All children within the age group of 0–16 years on antibiotics. But the target audience were health care workers; antibiotic Prescribers	582	Compliance with antimicrobial guidelines,	Attending clinicians conducted daily reviews of antibiotics prescribed, considering various factors such as clinical diagnosis, choice of antibiotics, dosage, duration of therapy, clinical indications, and relevant microbiology or biomarker-based investigations. These reviews involved doctors, clinical pharmacologists, and infectious disease physicians. In cases where the initial prescription was deemed inappropriate, the reviewers provided recommendations for optimizing antimicrobial therapy in accordance with the hospital's antibiotic policy, aiming for the appropriate use of antibiotics. The interventions were then assessed based on the compliance with the recommendations	Prior to the implementation of the point prevalence survey (PPS), the prevalence of antibiotic prescribing was high, with 79.9% of patients (139 patients on admission) receiving antibiotic therapy. Out of these patients, a total of 202 antibiotic therapies were administered to 111 individuals, accounting for the high prevalence of antibiotic use. However, after the ppp was implemented, A total of 1146 antimicrobials were audited for 582 patients, of which 58.1% were appropriate therapies, 59.8% appropriate prescription in accordance to the departmental guidelines, and 40.2% were inappropriate prescriptions. There was also a significant decrease of total antibiotic prescribed for a person, as it reduced to an average prescription of 1.97 drugs	Improved compliance with antimicrobial guidelines was observed

Table 4 (continued)

Publication	Duration/period of study	Location	Population type	Population Size	Theme of Stewardship intervention	Intervention description	Summary of findings	Outcome
Alabi et al. [44]	2019	Liberia	Healthcare workers	310	quality of antimicrobial use	To evaluate the impact of a bundle of three interventions (local treatment guideline, training, and regular AMS ward rounds) on the quality of antimicrobial use, a case series was conducted. The study assessed the adherence to the local treatment guideline, completeness of microbiological diagnostics (as per the treatment guideline), and clinical outcomes as primary endpoints. The assessments were conducted before and after the implementation of AMS ward rounds	There was improved adherence to local guidelines. The utilization of suitable antimicrobials, in accordance with the guideline or laboratory reports, witnessed a notable enhancement following the AMS ward round, with the percentage increasing from 34.5% to 61.0%. The use of ceftriaxone significantly decreased from 51.3% to 14.2% after the implementation of Antibiotic Stewardship (AMS) ward rounds. Approximately 79.7% of patients had their samples sent for microbiological analysis. On Day 3, a significant improvement was observed in 92.3% of the patients	Quality of antimicrobial use was and guideline compliance improved

Table 4 (continued)

Publication	Duration/period of study	Location	Population type	Population Size	Theme of Stewardship intervention	Intervention description	Summary of findings	Outcome
Adjei et al. [37]	September 2020 to September 2021	Ghana	Individuals aged 6 months to < 18 years of both sexes with acute febrile illness	1512 patients were randomized to either the intervention (n = 761) or control (n = 751) group	antibiotic prescriptions	Examining the effects of incorporating rapid diagnostic tests into diagnostic algorithms on clinical outcomes and antibiotic prescriptions in comparison to standard-of-care practices	The intervention group experienced an 11% relative risk reduction in antibiotic prescription compared to the control group. Specifically, among children aged under 5 years, there was a 14% reduction, while among non-malaria patients and those with respiratory symptoms, there were reductions of 15% and 16% respectively in antibiotic prescription rates. These findings demonstrate the effectiveness of the interventions in reducing unnecessary antibiotic prescribing across various patient subgroups	The intervention had significant impact on reducing unnecessary antibiotic prescriptions

Table 4 (continued)

Publication	Duration/period of study	Location	Population type	Population Size	Theme of Stewardship intervention	Intervention description	Summary of findings	Outcome
Abubakar et al. [36]	May and December 2016	Nigeria	All adult patients were eligible to participate in the study except HIV and cancer patients	226 and 238 surgical procedures in the pre- and post-intervention periods respectively	Antibiotic utilization and compliance with surgical antibiotic prophylaxis	A bundle of interventions for Antibiotic Stewardship was implemented, which included educational meetings, the development of a protocol, and regular audit and feedback processes	Following the interventions, there was a notable increase in compliance with the timing of surgical antibiotic prophylaxis, rising from 14.2% to 43.3%. Similarly, compliance with the duration of prophylaxis improved from 0% to 21.8%. The interventions also had a significant impact on reducing the prescription of third-generation cephalosporin by 8.6%, redundant antibiotic use by 19.1%, and overall antibiotic utilization by 3.8 defined daily doses (DDD) per procedure	The intervention had a significant positive impact as compliance with surgical antibiotic prophylaxis and antibiotic utilization were improved

Table 4 (continued)

Publication	Duration/period of study	Location	Population type	Population Size	Theme of Stewardship intervention	Intervention description	Summary of findings	Outcome
Luedtke et al. [67]	June 1st to December 31st 2019	Nigeria	Health care workers: surgeons and pharmacists who worked closely with surgical teams	–	Prescription behavior of surgeons and guideline compliance	A smartphone application, Gamified Antimicrobial Stewardship Decision Support App (GADSA), predesigned with features such as behavior change support system, decision support system and persuasive game techniques. It aids its users on antibiotic prescription based on standard guidelines. This is based on data the user enters into it	Following the feedback provided by the app, 12% of surgeons adjusted their decisions to align with the guidelines. Specifically, 10% of surgeons changed their decision regarding the necessity of Surgical Antibiotic Prophylaxis (SAP) to be in line with the guidelines. there was a similar pattern of change observed in decision-making related to the "type" and "duration" of SAP, with 6% and 5% of surgeons respectively making adjustments to comply with the guidelines	GADSA app has the potential to bring about substantial changes in prescribing behavior at the point of care within an African context

Table 4 (continued)

Publication	Duration/period of study	Location	Population type	Population Size	Theme of Stewardship intervention	Intervention description	Summary of findings	Outcome
Sneddon, Afriyie et al. [91]	–	Ghana	Hospital staff (medical, pharmacy, nursing and laboratory staff)	Over 100	–	Training of hospital staff and establishing AMS teams	The assessment of the training's impact revealed a substantial positive shift in participants' understanding of antimicrobial resistance (AMR) and appropriate antibiotic utilization. It also resulted in improved attitudes and behaviours towards AMR, a better comprehension of their role in Antimicrobial Stewardship (AMS), and increased confidence in utilizing the Ghana Standard Treatment Guidelines	Training Hospital staff on AMS is a key intervention
Enimil et al. [55]	September 2015 and 2019	Ghana	In-patients occupying beds in September	386 and 630 in 2015 and 2019 respectively	Antibiotic Usage and the use of markers for appropriate antibiotic prescription in the hospital	Global-PPS protocol on all inpatients; all adults, children and neonates	The incidence of hospital-acquired infections decreased from 6.2% (24/386) in 2015 to 4.8% (30/630) in 2019. The utilization of biomarkers that aid in diagnosis increased from 4.9% (12/247) to 7.6% (28/368)	Parameters or markers for appropriate antibiotic prescription improved

Table 4 (continued)

Publication	Duration/period of study	Location	Population type	Population Size	Theme of Stewardship intervention	Intervention description	Summary of findings	Outcome
Amponsah et al. [45]	November 2021 to May 2022	Ghana	Health care staff in the hospital	–	Antibiotic use and infections management	AMS bundled stewardship programme intervention was ran on all the healthcare workers through seminars and hybrid training. Global-Point Prevalence Survey (PPS) protocol was employed in assessing antibiotics use at hospital at baseline, midpoint and end of the project	The utilization of antibiotics decreased from 65% initially to 59.7% upon completion of the project. Similarly, the prevalence of healthcare-associated infections decreased from 17.5% at the beginning to 6.5% at the conclusion. The adoption of antibiotics from the WHO Access group started at 40% but saw an increase to 50% by the end. Furthermore, the usage of watch antibiotics decreased from 60 to 50% compared to the initial assessment. In terms of culture and susceptibility testing, there was a notable increase from 111 total requests at the outset to 330 requests during the intervention period, which played a crucial role in guiding antimicrobial therapy decisions	There was a noticeable improvement in antibiotic use and the overall quality of antimicrobial therapy during the study period

Table 4 (continued)

Publication	Duration/period of study	Location	Population type	Population Size	Theme of Stewardship intervention	Intervention description	Summary of findings	Outcome
Kiemde et al. [59]	September 2020-September 2021	Burkina Faso	Individuals presented at outpatient clinics with acute febrile disease defined as fever	1718	Antibiotic Prescriptions	A control and intervention procedure made of package consisting of diagnostic tool and algorithm of antibiotic prescription; to guide health workers on whether to prescribe an antibiotic or not for patients with febrile illnesses	There was no significant difference in the clinical outcomes of patients in the control and intervention arms. But the antibiotic prescription was significantly lower in the intervention arm: 40.6% versus 57.5% in the control arm	Reduce inappropriate antibiotic prescription

underrepresented. We therefore aimed to bridge this gap by bringing together the various components of J01 antibiotic use in West Africa, encompassing antibiotic consumption, appropriateness, uncovering the key indicators of antibiotic use, evaluating stewardship interventions, as well as Knowledge, attitude, and perception of the people in West Africa for evidence synthesis of human antibiotic use. To our knowledge, this is the first manuscript encompassing all the elements necessary to identify and curb the high antibiotic resistance as a whole.

The findings of our review reveal that antibiotic consumption in West Africa exhibits high heterogeneity and ranges from 66.9 to 2,629,786 DDD per 100 bed-days. The pooled estimate of overall antibiotic consumption was 620.03 DDD per 100 bed-days (CI: 0.00–1286.67; $I^2 = 100\%$). This finding reveals a substantially high antibiotic consumption in the region. The antibiotic consumption at 620.03 DDD per 100 bed-days in this study is far higher than the antibiotic consumption of 479.18 DDD per 1000 inhabitants per day reported by Zaha et al. (105) among surgical inpatients admitted in 2017 in a clinical emergency hospital in Romania (though the units of DDD measurement varied). Also, the high antibiotic consumption recorded in our present study is substantially higher than the WHO reports [101] of antibiotic consumption that represented 2015 data from 65 countries, which ranged from 4.4 to 27.29 DDD per 100 inhabitants per day in the African Region, 10.26 to 22.75 in the Region of the Americas, 7.66 to 38.18 European Region, 8.92 to 38.78 in the Eastern Mediterranean Region, and 5.92 to 64.41in the Western Pacific Region. The antibiotic consumption in West Africa is also higher than the 164.48 DDD/100-BD increase in antibiotic consumption in the Hazhaz medical ward reported in Eritrea [102]. Our observed high antibiotic consumption aligns with the findings of Klein et al. [12], who identified low- and lower-middle-income countries as major contributors to global antibiotic consumption. The authors reported a significant increase in antibiotic consumption, from 11.4 to 24.5 billion DDDs, representing a remarkable 114% increase.

The most consumed antibiotics were amoxicillin, gentamicin, metronidazole, amoxicillin-clavulanate (all four are access antibiotics), and ceftriaxone (watch antibiotic). This is in line with other studies in other parts of the world that also identified one or more of these antibiotics among their most consumed antibiotic but contradicts the reports of Klein et al. who identified broad-spectrum penicillin to be the most consumed global antibiotic in 2015 [12]. A study conducted in Eritrea [102] and Romania [103] also identified ceftriaxone as a major consumed antibiotic. The higher utilization of access antibiotics compared to watch antibiotics in West Africa, as we are reporting, can be attributed to their preference as essential first or second-line empiric treatment options for infectious syndromes, as recommended by WHO. These access antibiotics encompass a group of antibiotics that demonstrate efficacy against a broad spectrum of commonly encountered susceptible pathogens, while maintaining a lower potential for resistance compared to other antibiotics. Our study further identified that some healthcare professionals in West Africa prescribe antibiotics without bacteriological diagnosis as observed in other parts of the world [104, 105], therefore puts them on the edge of prescribing access antibiotics to patients, and therefore resulting in the high use of access antibiotics in the West African region. Our observed 64% access antibiotic consumption is above the 60% threshold set by WHO and higher than the watch antibiotic consumption (27%) in the region. The Access antibiotic consumption is consistent with the reports of Limato et al. [106] in Indonesia but lesser than the 69% reported in their study. The disproportionate use of Watch antibiotics we identified in this study corroborates the findings of Limato et al. [106] in Indonesia. Our finding reaffirms previous findings that, the consumption of Watch antibiotics is high in LMICs compared with high-income countries [12]. The use of different varieties of antibiotics, as observed in our study, explains the high resistance to these antibiotics in West Africa as it has well been established that, exposure of bacteria to antibiotics results in resistance over time.

The comprehensive assessment of antibiotic consumption by inpatients in our study resulted in an estimated rate of 620.03 DDD per 100 bed-days (CI: 0.00–1286.67; $I^2 = 100\%$) which surpasses the recent 134.8 per 100 bed-days antibiotic consumption reported from Indonesia [106]. This significant disparity highlights the pressing need for immediate intervention. The urgency is further underscored by projections indicating a potential 200% increase in global antibiotic consumption between 2015 and 2030 if effective policies are not implemented [12]. The considerable divergence observed in antibiotic consumption, both among inpatients and outpatients, can be attributed to a multitude of factors. From our study, some of the factors resulting in this divergence are as a result of disparities across countries and the duration of the study. Studies in Sierra Leone recorded a higher antibiotic consumption as compared to Nigeria. The disparity observed from subgroup analysis on the duration of studies may have resulted in country-level differences in antibiotic consumption. For longer studies, the reason for the higher antibiotic consumption may be due to tolerance and the need for continual increases in antibiotic consumption to augment therapy. Other factors like variations in the burden of infectious diseases, different healthcare systems and sectors, discrepancies in antibiotic accessibility, and variations in regulatory policies, among numerous others [106–108]. It is noteworthy that there was no consumption of non-recommended or reserved antibiotics in all the studies. This absence may be attributed to their unavailability in the local market and their exclusion from various local guidelines, such as the Standard Treatment Guidelines of Ghana [61, 109]. It is laudable and reassuring to mention that cefoperazone-sulbactam, which is a non-recommended antibiotic was not prescribed in any of the studies in West Africa.

Generally, rational use of antibiotics depends on its prescription alignment with a predetermined standard guideline. In this present study, the overall appropriateness of antibiotic prescribing ranged from 2.5% to 93.0% with a pooled estimate of 50.09 ([CI: 22.21–77.92], $I^2=99.4\%$). With the range being 2.5–93.0%, only a few of the studies had the prescribing appropriateness above 75%, resulting in the 50.09% pooled appropriateness recorded in this study. Moreover, many studies in the West African region report a high number of antibiotic prescribing inappropriateness [110–113]. Inappropriate antibiotic prescribing has been reported in many parts of the world [114, 115] with an estimation of less than 70% compliance with standards in hospitals in Latin America, West and Central Asia, and Africa [116]. Attaining a long-term goal of minimizing or curbing antibiotic resistance is highly unlikely if the standard guidelines put in place are not strictly followed. In the West African context, the inappropriate prescribing of antibiotics can be attributed to a complex interplay of multiple factors, which vary across settings and countries. In this study, we found that the level of antibiotic appropriateness dropped after 2020 (51.05 [CI: 49.20–52.90]) as compared to before 2020 (71.94 [CI: 69.78–74.03]), possibly due to the COVID-19 pandemic in which a lot of antibiotics were prescribed in the initial stages of the pandemic. Other factors may encompass limited availability or inadequate utilization of diagnostic facilities, physicians' non-adherence to antibiotic guidelines, financial constraints faced by patients, influence exerted by the pharmaceutical industry, and patient-related pressures [106, 116]. Higher antibiotic consumption and relatively moderate prescribing appropriateness can lead to a higher emergence of resistance. A comprehensive systematic review and meta-analysis demonstrated a remarkable 35% relative risk reduction in mortality associated with the implementation of guideline-adherent empirical therapy. However, the reasons behind the persistently low compliance with these guidelines remain complex and multifactorial [117].

In West Africa, we have identified the general key indicators of antibiotic use among inpatients and outpatients to be dominated by community-acquired infection, followed by hospital-acquired infection and prophylaxis; medical and surgical. This finding corroborates the reports of Fentie et al. [118] who also identified community-acquired infection and hospital-acquired infection to be the major cause of antibiotic use in Ethiopia. Our findings are also in line with the key indicators of antibiotic use in Thailand as reported by Anugulruengkitt et al. [119] who identified community-acquired infection as the main reason for antibiotic treatment initiation in Thailand after conducting a study across 41 hospitals. Similar to many other studies in other parts of the world, the predominant specific health conditions driving antibiotic utilization among both inpatients and outpatients in West Africa encompass pneumonia, skin and soft tissue infections, sepsis, malaria, tuberculosis, respiratory tract infections, and urinary tract infections. Furthermore, the inclusion of malaria as a condition requiring antibiotic use in some cases may be attributed to the presence of co-infections, where individuals affected by malaria also get bacterial infections. However, it is important to acknowledge that in certain instances, the classification of malaria as a condition necessitating antibiotic use could be a result of misdiagnosis, highlighting the challenges associated with accurately identifying and distinguishing between different types of infections in clinical practice.

A plethora of compelling evidence has accumulated, highlighting the favorable outcomes associated with AMS intervention programs in various regions worldwide and has become a major global strategy being advanced to curb the development and spread of antibiotic resistance [63, 120, 121]. In West Africa, AMS is still in its early stages with many of the countries having implemented AMS within the last ten years and are often limited to tertiary and secondary hospitals. Our study identified a variety of AMS intervention strategies used across the West African countries in this study. After the implementation of these interventions, varying degrees of improvements were observed across the different themes of antibiotic use that were assessed. Despite the improvement of the theme of focus of AMS in each study, the most effective strategies identified were bundled interventions (local treatment guidelines, training, and regular AMS ward rounds), the SAPG triad approach of developing and implementing AMS using information, education and quality improvement to enhance the knowledge and guideline compliance of healthcare professionals on antibiotic use and prescription. These findings highlight the profound influence of AMS training among healthcare professionals and the implementation of comprehensive bundled intervention in West Africa. This further emphasizes the effectiveness and feasibility of AMS interventions within the local context, offering substantial potential for curtailing antibiotic consumption, enhancing prescribing appropriateness, reducing the incidence of unnecessary prescriptions, and ultimately fostering improved patient care in the West African region.

A key component in addition to the key domains of antibiotic use discussed above is the knowledge, attitude and perception of the general population encompassing inpatients, outpatients, health care workers, and other healthy individuals in formal and informal settings towards the use of J01 antibiotics. In this study, health care providers demonstrated good knowledge of AMR ranging from 49.2 to 88% but employed laboratory investigation prior to antibiotic prescription less frequently. This high knowledge of health-care workers in this study corroborates the findings of Firouzabadi et al. [122] and Florian [123]. Despite the laudable range of knowledge demonstrated by healthcare workers, the persistently high levels of antibiotic consumption and inappropriate use may be attributed to the inadequate availability of appropriate antibiotic intervention structures, such as bacteriological diagnostic labs. However, it is important to recognize that other factors, originating from the patient's perspective, also contribute to this issue. One prominent theme was the glaring lack of awareness and knowledge regarding AMR and antibiotics, particularly among individuals from lower-educated or uneducated backgrounds. Additionally, a concerning trend observed across both educated and uneducated individuals was the widespread practice of self-medication with antibiotics, disregarding the need for a prescription. Among the community respondents who reported a high usage of antibiotics (ranging from 44.1% to 72.5%), there was a considerable disparity in their knowledge about antibiotics. The findings revealed a range of 8.3–53.6% of individuals possessing good knowledge regarding antibiotic use, while a higher range of 33–57.4% demonstrated poor knowledge concerning antibiotic resistance. This poor knowledge of West African antibiotic consumers on antibiotic resistance is similar to the findings of Limato et al. [106] who also observed similar trends in their systematic review of antibiotic use in Indonesia.

Our study further identified that high cost of antibiotics, knowledge of the effectiveness of some antibiotics, convenience, and low socioeconomic status were found to be associated with self-medication and inappropriate use of antibiotics, while the common source of obtaining antibiotics were from pharmacies, chemists, and hawkers. These findings are concurrent with the reports in Asia [106, 124, 125] and in Egypt [126]. Our research has revealed that the primary sources of antibiotic knowledge in West Africa encompass doctors, pharmacies, over-the-counter (OTC) sellers, drug peddlers, family members, friends, radio, and television. Notably, these sources of information are accessible to a significant portion of the population, including those residing in rural areas, as radio stations and bands are widely distributed throughout the region. Consequently, implementing comprehensive training programs on antibiotic use across various media platforms would be highly advantageous in enhancing antibiotic knowledge. By leveraging these accessible channels, such training initiatives can effectively reach and educate a diverse range of individuals, contributing to improved antibiotic practices and the prevention of antibiotic resistance.

Limitation

This systematic review had certain limitations that should be acknowledged. Firstly, there were variations in study designs and periods among the articles analyzed, which may have introduced some heterogeneity in the findings. Additionally, the reporting patterns of antibiotic consumption in West Africa were uneven, with some studies providing data in percentages rather than defined daily doses (DDD), making it challenging to standardize the data for comparison. As such, studies that did not report antibiotic consumption in DDD were not included. One additional constraint of our manuscript revolves around the pooled estimate concerning antibiotic consumption, as our investigation reveals that the majority of the available data stems from a single study conducted by Labi et al. [61], as depicted in our forest plot. Furthermore, certain studies did not meet the inclusion criteria as they solely focused on reporting the inappropriate prescribing of antibiotics, rather than assessing appropriate antibiotic prescriptions according to established guidelines. This may have introduced unintended bias in the results, as some relevant studies from the region were not included.

The heterogeneity in methodology, study design, and patient characteristics among the included studies can also impact the overall estimate of antibiotic consumption and prescribing appropriateness. Moreover, the decision to exclude non-peer-reviewed articles and information from websites may have resulted in the omission of valuable data regarding antibiotic use and effective interventions implemented by governmental or non-governmental organizations in the region. However, this exclusion was made to uphold the quality of the review, considering that non-peer-reviewed sources may not consistently adhere to recognized standards or recommended evaluation guidelines.

Conclusion

This comprehensive review serves as a valuable resource for policymakers and academics, offering a concise summary of the prevailing state of antibiotic use among humans in West Africa for the past 24 years. By identifying gaps in knowledge and highlighting areas where prompt actions are required, this review guides future research endeavors and policy development. The findings underscore the need for further implementation of AMS programs across the West African region to enhance our understanding of antibiotic use patterns, prescribing practices, and the factors influencing them in the region.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13756-024-01504-3.

Additional file1 (DOCX 699 KB)

Author contributions

Conceptualization, E.S.D., and A.-H.O.; design, E.S.D., and A.-H.O.; validation, E.S.D., A.-H.O., B.C.A., A.A.-D., A.O., B.O.-A., and G.L.; resources, E.S.D., A.-H.O., B.C.A., A.A.-D., A.O., and B.O.-A.; data acquisition, E.S.D., A.-H.O., A.A.-D., and A.O.; writing—original draft preparation, E.S.D., A.-H.O., B.C.A.; analysis, B.C.A., and G.L.; writing—review and editing, E.S.D., A.-H.O., B.C.A., A.A.-D., A.O., B.O.-A., and G.L.; supervision, E.S.D. and B.O.-A.; project administration, E.S.D.; funding acquisition, E.S.D. All authors have read and agreed to the published version of the manuscript. All authors have agreed to be personally accountable for the contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.

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Availability of data and materials

No datasets were generated or analysed during the current study.

Declarations

Competing interests

The authors declare no competing interests.

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