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Evaluation of Healthcare Students' Knowledge on Antibiotic Use, Antimicrobial Resistance and Antimicrobial Stewardship Programs and Associated Factors in a Tertiary University in Ghana: Findings and Implications

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Citation: Sefah, I.A.; Akwaboah, E.; Sarkodie, E.; Godman, B.; Meyer, J.C. Evaluation of Healthcare Students' Knowledge on Antibiotic Use, Antimicrobial Resistance and Antimicrobial Stewardship Programs and Associated Factors in a Tertiary University in Ghana: Findings and Implications. *Antibiotics* **2022**, *11*, 1679. https://doi.org/10.3390/antibiotics11121679

Academic Editors: Islam M. Ghazi and Diaa Alrahmany

Received: 25 October 2022
Accepted: 18 November 2022
Published: 22 November 2022

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Abstract: Antimicrobial resistance (AMR) is a major public health problem globally, and Ghana is no exception. Good knowledge regarding antibiotic use, AMR, and the concept of antimicrobial stewardship (AMS) is critical among healthcare students to curb rising AMR rates in the future. Consequently, a need to ascertain this. A cross-sectional survey was undertaken among fifth-year pharmacy, medical students and fourth (final)-year nursing and physician assistantship students at the University of Health and Allied Sciences in Ghana to assess their knowledge on antibiotic use, AMR and AMS using a web-based self-administered structured questionnaire. Descriptive statistics, Fishers' exact test, and multiple logistic regression analyses were performed. A total of 160 healthcare students were interviewed, of which 56.3% ($n = 90$) were male and 58.8% ($n = 94$) were in their fourth year of study. Good knowledge of antibiotic use, AMR, and AMS was associated with the study course ($p = 0.001$) and the number of years of study ($p < 0.001$). Overall, there were differences in the level of knowledge of antibiotics among the different healthcare students and their years of study. Efforts must now be made to enhance the curricula to ensure an improved and uniform transfer of knowledge of antibiotics, AMR, and AMS among the different healthcare students to sustain the fight against AMR in Ghana given growing concerns.

Keywords: antibiotics; antimicrobial resistance; antimicrobial stewardship; COVID-19; education; Ghana; healthcare students

1. Introduction

In 2019, there were an estimated 4.95 million deaths globally associated with antimicrobial resistance (AMR), with estimates that up to 10 million lives will be lost annually to AMR by 2050 if no appropriate activities are instigated by governments and other key stakeholders to slow its progression [1,2]. There are also appreciable costs associated with AMR, with the World Bank believing that costs globally could rise to over $1 trillion per year by 2050, equivalent to 3.8% or more of gross domestic product, if the current situation

continues unabated [3,4]. This combination is a concern especially among countries in sub-Saharan Africa, which currently have the highest rates of AMR worldwide, and they are on the increase [2]. In addition, across Africa, infectious diseases continue to pose a significant threat to human existence [5,6].

Antibiotics are one of the most commonly prescribed and dispensed in Africa [7], with appreciable prescribing and dispensing for self-limiting conditions including acute respiratory tract infections (ARIs) [8–12]. There are also concerns with high rates of inappropriate prescribing of antibiotics in hospitals across countries, including African countries, exacerbated by the COVID-19 pandemic [13–16]. This is important with increased prescribing of antibiotics, especially during the recent pandemic, driving up AMR [17–22].

These concerns have resulted in a number of global, regional, and national activities, including the World Health Organization (WHO) promoting National Action Plans (NAPs) to reduce AMR [3,23–26]. One of the five strategies to reduce the impact of AMR in the Global Action Plan is the need to optimize antimicrobial use through the implementation of antimicrobial stewardship programs (ASPs) [27–29]. Ghana, similar to other African countries, has developed its NAP and is currently implementing a range of agreed activities [30–32], with the goal to improve future antibiotic utilisation, reduce possible side-effects from antibiotics as well as reduce AMR [18,19,33–38].

The effective implementation of ASPs in hospitals requires a multidisciplinary team. However, there are concerns with manpower and resource issues affecting the sustainability of interventions, and knowledge gaps among practitioners, in low- and middle-income countries (LMICs) [39–43]. This is starting to be addressed in Africa, and will continue given the high and rising rates of AMR particularly in sub-Saharan Africa as well as increasing use of 'Watch' and 'Reserve' antibiotics [2,14,35,37,38]. The knowledge of healthcare students regarding antibiotics and AMR is a key factor to improving antimicrobial utilisation as they will play an important role in the future in either the prescribing or dispensing of antimicrobials across sectors; alternatively, advising key stakeholders including physicians and patients regarding their use [8,44–46]. Increased awareness on AMR among healthcare students has been shown to be an effective approach to improving future practitioners' prescribing behavior [47]. This is important as there have been concerns with knowledge regarding antibiotics and AMR among healthcare professionals in Africa and the implications thereof [41,48–50].

However, most studies particularly in LMICs that have evaluated the knowledge of healthcare students regarding antibiotics and AMR have typically been conducted separately among medical students [47,51–56], pharmacy students [57–62], nursing and paramedic students with only a limited number of studies conducted among a combination of healthcare students [48,63–68]. This is a concern as a good uniform knowledge regarding antibiotic use, AMR, and ASPs is essential to optimize the future use of antimicrobials with all key stakeholders involved, which is in line with the goals of the Ghanaian NAP and beyond [30,32]. This is particularly important in Ghana given concerns with current high rates of AMR, considerable and inappropriate prescribing and dispensing of antibiotics across all sectors often without a prescription, and issues with poor compliance with national guidelines [12,69–75]. Currently, few hospitals in Ghana have attempted establishing ASPs. This is beginning to change with help from the UK Fleming fund in collaboration with UK institutions as well as input from the WHO giving guidance on implementing ASPs with the help of a toolkit [76,77]. This builds on successful ASPs already being implemented across Africa [35,37,38], and is in line with the goals of the Ghanian NAP [30,32]. However, to date, the Ministry of Health in Ghana is yet to roll-out a full-scale, nationwide implementation of ASPs at different levels of the healthcare system. This a concern considering the integral role AMS plays in health system strengthening by ensuring the optimum use of antimicrobials as part of key measures to combat AMR [34,36,76]. Alongside this, we are aware that educational programs can be effective in raising knowledge regarding antibiotics and ASPs in Ghana, helping to improve future antimicrobial prescribing [68,77].

Currently, little is known about antibiotics, AMR, and ASPs among healthcare students in Ghana. Consequently, we believed there was a need to conduct a study at the University of Health and Allied Sciences in Ghana, which is the only health and allied sciences university in Ghana. The objective is to evaluate healthcare students' knowledge regarding antibiotic use, AMR, and ASPs, with the findings subsequently to be used to update educational activities to address ongoing concerns in Ghana.

We are aware that there have been studies seeking to increase the prescribing of topical antibiotics for acute respiratory infections. However, the principal focus among healthcare professionals (HCPs) should be to reduce antimicrobial use for potentially self-limiting viral infections [8,78].Consequently, such studies were considered outside the scope of this paper. Similarly, we have not considered studies demonstrating inappropriate antibiotic prescribing among dentists and dental surgeons, combined with potential ways to address this including local administration of antibiotics [79,80], as we did not included dental students in our study. Finally, we have not commented on ways to increase the uptake of COVID-19 vaccines across Africa by healthcare professionals (HCPs), including Ghana, given current appreciable hesitancy to reduce future serious illness and hospitalization [81], thereby reducing inappropriate antibiotic prescribing, as this is again outside the scope of this paper.

2. Results

We will first document the characteristics of the respondents before assessing any association between their characteristics and knowledge of antibiotics, AMR and ASPs.

2.1. Characteristics of the Respondents

A total of 160 students from the University of Health and Allied Sciences comprising of 33.1% (n = 53), 25.6% (n = 41), 29.4% (n = 47), and 11.9% (n = 19) nursing, medicine, physician assistantship, and pharmacy students, respectively, were surveyed, giving a response rate of 100% among those approached. This high rate was achieved with the help of constant reminders to recruited students, including emails and WhatsApp contact.

From the interviews conducted, 56.3% (n = 90) were male, 91.9% (n = 147) were within the age group of 20–25 years, 58.8% (n = 94) were in their final fourth year, 79.4% (n = 127) had no training in antibiotics prior to entering the university, and 77.0% (n = 120) had no close friends or relatives working in health-related fields (Table 1).

Table 1. Socio-demographic characteristics of respondents (n= 160).

Variable	Frequency (n)	Percentage (%)
Age (years) (n = 160)		
20–25	147	91.9
26–31	10	6.3
>31	3	1.9
Gender (n = 160)		
Male	90	56.3
Female	70	43.8
Course of study (n = 160)		
Medicine	47	29.4
Physician assistantship	41	25.6
Nursing	53	33.1
Doctor of pharmacy	19	11.9
Year of study (n = 160)		
Fourth year	94	58.8
Fifth year	66	41.3
Close friend/relation working in a health-related field (n = 160)		
Yes	120	75.0
No	40	25.0
Exposed to any antibiotic training before university (n = 160)		
Yes	33	20.6
No	127	79.4

2.2. Association between Students' Characteristics and Their Knowledge of Antibiotic Use, AMR, ASP and Their Overall Knowledge of Antibiotics

The Fisher's exact test of independence showed a statistically significant association between the knowledge of AMR and gender ($p = 0.004$), and knowledge of antibiotics and training on antibiotics prior to entering the university ($p < 0.000$). There were associations between students' knowledge on antibiotics use, AMR, ASP, and the course of study and the year of study. Overall knowledge of antibiotics was also associated with students' course of study ($p = 0.001$) and year of study ($p < 0.001$) (Table 2).

Table 2. Association between socio-demographic characteristics of respondents and their knowledge of antibiotic use, resistance, stewardship and their overall knowledge of antibiotics.

Variable	Antibiotic Use *n* (%)		Antibiotic Resistance *n* (%)		Antibiotic Stewardship Programs *n* (%)		Overall Level of Knowledge *n* (%)	
	Good	**Poor**	**Good**	**Poor**	**Good**	**Poor**	**Good**	**Poor**
Age (N = 160)								
20–25 (*n* = 147)	115 (78.2)	32 (21.8)	83 (56.5)	64 (43.5)	112 (76.2)	35 (23.8)	109 (74.1)	38 (25.9)
26–31 (*n* = 10)	10	0	8	2	7	3	8	2
>31 (*n* = 3)	3	0	1 (33.3)	2 (66.7)	1 (33.3)	2 (66.7)	1 (33.3)	2 (66.7)
Fisher's Exact (p-value)	0.294		0.264		0.221		0.253	
Gender (N = 160)								
Male (*n* = 90)	72	18	61 (67.8)	29 (32.2)	69 (76.7)	21 (23.3)	69 (76.7)	21 (23.3)
Female (*n* = 70)	56	10	31 (44.3)	39 (55.7)	51 (72.9)	19 (27.1)	49 (51.6)	21 (18.4)
Fisher's Exact(p-value)	1.000		0.004		0.587		0.369	
Course of Study (N = 160)								
Medicine (*n* = 47)	47	0	31	16	37 (78.7)	10 (21.3)	41 (87.2)	6 (12.8)
Physician Assistantship (*n* = 41)	38 (92.7)	3 (7.3)	16 (23.6)	25	22 (53.7)	19 (46.3)	26 (63.4)	15 (36.6)
Nursing (*n* = 53)	24 (45.3)	29 (54.7)	27 (50.9)	26 (49.1)	43 (81.1)	10 (18.9)	33 (62.3)	20 (37.7)
Doctor of Pharmacy (*n* = 19)	19	0	18 (94.7)	1 (5.3)	18 (94.7)	1 (5.3)	18 (94.7)	1 (5.3)
Fisher's Exact (p-value)	0.000		0.000		0.002		0.001	
Year of study (N = 160)								
Fourth year (*n* = 94)	62	32	43 (45.7)	51 (54.3)	65 (69.1)	29 (30.9)	59 (62.8)	35 (37.2)
Fifth year (*n* = 66)	66	0	49 (74.2)	17 (25.8)	55 (83.3)	11 (16.7)	59 (89.4)	7 (10.6)
Fisher's Exact (p-value)	0.000		0.000		0.044		0.000	
Relative/friend working in a health-related field (N = 160)								
Yes (*n* = 120)	97 (80.8)	23 (19.2)	70 (58.3)	50 (41.7)	93 (77.5)	27 (22.5)	91 (75.8)	29 (24.2)
No (*n* = 40)	31 (77.5)	9 (22.5)	22	18	27 (67.5)	13 (32.5)	27 (67.5)	13 (32.5)
Fisher's Exact (*p*-value)	0.653		0.716		0.213		0.306	
Exposure to antibiotic training before university (N = 160)								
Yes (*n* = 33)	33	0	18 (54.5)	15 (45.5)	22 (66.7)	11 (33.3)	26 (78.8)	7 (21.2)
No (*n* = 127)	95 (74.8)	32 (25.2)	74 (58.3)	53 (41.7)	98 (77.2)	29 (22.8)	92 (72.4)	35 (27.6)
Fisher's Exact (p-value)	0.000		0.698		0.259		0.514	

NB: Emboldened *p*-value are those that are below the significance level of 0.05.

2.3. Multiple Logistic Regression between Students' Characteristics and Their Overall Knowledge on Antibiotics

Healthcare students' overall knowledge on antibiotics was approximately six times (OR = 5.84, CI 2.09–16.26) more likely to be good knowledge if they were in their fifth year in the SOP and SOM, than if they were in their fourth year in the SONAM and SAHS (Table 3).

Table 3. Multiple logistic regression between students' characteristics and their overall knowledge.

Variable	Adjusted Odds Ratio	95% Confidence Interval	*p*-Value
Age	0.4979	0.1746–1.4199	0.192
Gender	0.7114	0.3231–1.5661	0.398
Course of study	1.2495	0.7391–2.1120	0.406
Year of study	5.8428	2.0990–16.2637	**0.001**
Relative/friend working in a health-related field	0.7819	0.3386–1.8053	0.564
Exposure to antibiotic training before university	0.6686	0.250–1.7855	0.422

NB: The reference covariate used for the analysis of the year of study variable was the fourth year of study. Emboldened *p*-value is the one are those that are below the significance level of 0.05.

3. Discussion

We believe this is the first study of its kind in Ghana involving both health and allied science students in a single university. Encouragingly, there was a good overall level of knowledge regarding antibiotics among most of the healthcare students at the University of Health and Allied Sciences in Ghana, which is similar to some studies conducted among students in LMICs [53,54,58,59]. However, this is different from other studies conducted among students in LMICs where there have been concerns with their knowledge [46,55,56,64,82,83].

As seen, good knowledge of antibiotic use, AMR, and ASPs was associated with the study course ($p = 0.001$) and the number of years of study ($p < 0.0001$). A greater proportion of healthcare students from the School of Pharmacy (94.7%) and the School of Medicine (87.2%) in their fifth year had good knowledge of these matters versus their counterparts from the School of Nursing and Midwifery (62.3%) and the School of Allied and Health Sciences (63.4%), who were in their final year, i.e., their fourth year. This could be due to differences in the structure and depth of the curriculum among these different healthcare students regarding these key subject areas. As a result, leading to a greater exposure to the principles of antimicrobial stewardship (AMS) among the former group compared to the latter, similar to other studies conducted among LMICs [54,65,82,84]. The healthcare students from the School of Pharmacy were also observed as having a slightly better overall knowledge with respect to these subject areas. The exact cause of the differences among them is an important area for future research going forward.

The poor knowledge regarding antibiotic use, AMR, and AMS among nursing and physician assistantship students compared to other members of the healthcare team is a concern. This needs to be actively addressed going forward as good knowledge of these subjects among the entire multidisciplinary HCP team is an essential step towards optimizing the future use of antimicrobials. Consequently, immediate steps need to be taken to address these knowledge gaps among HCP students. Essential steps include an urgent review and refinement of current curricula especially among nursing and physician students to include greater input on AMR and AMS principles. This is because they are key stakeholders in the prescription, administration, and counselling on antibiotic use across all sectors in Ghana. Furthermore, there must be efforts to instigate mandatory, continuous professional development programs surrounding AMR and ASPs among all HCP groups post-qualification as Ghana strives to achieve the goals of the NAP [31,32]. This should help with combating rising rates of AMR across Ghana [31,85]. This will increasingly include hybrid approaches to learning [86], which is even more important post COVID-19 with the high inappropriate use of antimicrobials in Ghana and across countries to prevent and treat patients with COVID-19 [15,17,87,88].

We are aware of a number of limitations with this study. Firstly, this study is limited by the small sample size, as well as the non-inclusion of other core members of the AMS teams including laboratory personnel trained in microbiology. Secondly, we conducted this study in only one university in Ghana, which may affect the internal and external

validity of our findings. Lastly, we used a questionnaire derived from published studies combined with the considerable knowledge of the co-authors. However, this was not validated among our study population. This though is similar to numerous other studies undertaken by the co-authors across countries utilizing their considerable knowledge and experience in this area. Notwithstanding these concerns, we believe our findings are robust, providing guidance for future activities in the developing and refining of curricula in this University and across Ghana.

4. Materials and Methods

4.1. Study Site and Population

The University of Health and Allied Sciences located in Ho, Ghana, was established by an Act of Parliament of Ghana (Act 828, December 2011) as a public university to provide higher education in health sciences in Ghana. There are seven schools within the University. These include the School of Allied Health Sciences (SAHS), the School of Basic and Biomedical Sciences, the School of Medicine (SOM), the School of Nursing and Midwifery (SONAM), the School of Pharmacy (SOP), the School of Sports and Exercise Medicine, and the School of Public Health. While all the schools offer undergraduate and postgraduate programs, only the SOM and the SOP offer a six-year undergraduate professional doctorate program.

This study was conducted amongst four of the schools, namely the SOP, SOM, SONAM, and the SAHS. The target study population included fifth-year pharmacy and medicine students and fourth and final-year nursing and physician assistantship students. Fifth-year medical and pharmacy students were chosen as this is the final year for all classroom lectures and assessments. The sixth year is devoted mainly for clinical practice in hospitals outside the university campus, aimed at the acquisition of practical knowledge and skills, unlike their nursing and physician assistantship student counterparts who undertake similar practical training after completion of their four-year degree program.

4.2. Study Design

A cross-sectional study design was employed to evaluate the knowledge of antibiotic use, AMR, and ASP among pharmacy, medical, physician assistantship and nursing students in the University of Health and Allied Sciences.

4.3. Sample Size and Sampling Procedure

Based on a student population of 252, comprising of 30 pharmacy students, 73 medical students, 84 nursing students and 65 physician assistantship students, a minimum sample size of 153 students was calculated, using the Raosoft Inc. online sample size calculator (http://www.raosoft.com/samplesize.html (accessed on 10 May 2021)), assuming an expected frequency of 50% to yield the largest sample size, at 80% power and 95% confidence level. The sample size was increased to 160 to account for any incomplete data. Probability proportional sampling, based on the size of each school's student population, was used to estimate the number of students from each school to be included in the final sample of 160 students. Simple random sampling, using a random number generator (https://www.random.org (accessed on 10 May 2021)) was used within each school to recruit the required number of students with the help of a class list obtained from the administration for the survey, which included 19 pharmacy students, 47 medical students, 53 nursing students, and 41 physician assistants.

4.4. Data Collection

A structured self-administered 35-item questionnaire was developed using online google forms for the survey, based on published literature of similar student studies in-

cluding validated questionnaires, combined with the considerable knowledge and experience of the co-authors [54,58,60,66,89]. We have used this approach previously to investigate key issues and their implications across LMICs [8,31,81,86,90–93]. The questionnaire included firstly the socio-demographic characteristics of participating students, followed by questions aimed at assessing their knowledge about antibiotic use, antibiotic resistance, and ASPs, using three response options, namely 'Agree', 'Disagree', and 'Do not know' (Supplementary Table S1). This included 7 questions assessing students' knowledge regarding antibiotics, 12 questions on AMR, and 8 questions on ASPs.

The link for access to the questionnaire and the consent form was sent to the recruited students via both their collected e-mail addresses and WhatsApp contact numbers since these media are widely used by the students. The same questionnaire was answered by all the different categories of students who participated in the study since we wanted to assess and compare their basic knowledge on these important subject areas.

Data were collected between June 2021 and October 2021. All students who were sampled and consented to participate in the study were emailed the web-based designed questionnaire.

4.5. Data Analysis

Data generated from the completed online google forms in a Microsoft Excel format were imported into STATA version 14 (StrataCorp, College Station, TX, USA) for analysis. A total score was calculated for knowledge regarding antibiotic use, AMR, and ASPs, and dichotomized as a "good" versus "poor" score. A correct response was assigned a score of one while an incorrect response was assigned a zero score.

A total score ≥ 60% for knowledge on antibiotic use, AMR, and ASP was considered as good based on similar studies [46,60,62]. We are aware other studies have used lower and higher cut-off scores up to 80% for good knowledge [53,94,95]. However, we chose ≥ 60% based on previous published studies [46,60,62]. An overall knowledge score was subsequently determined using the same cut off score. Descriptive statistics were used to summaries variables using percentages for all categorical variables. Inferential statistics, using the Fisher's exact test of independence, and multiple logistic regression using explanatory variables that were statistically significant after the former analysis were subsequently conducted to determine associated variables and predictors of overall knowledge of antibiotics respectively.

5. Conclusions

There are disparities in the overall level of knowledge of antibiotics, AMR, and ASPs among the different healthcare students at this University in Ghana. Efforts must be made to address these concerns in updated curricula as well as the continual development post-qualification. The objective is to ensure an improved and uniform transfer of knowledge on these subjects among the different student populations. This is imperative to sustain the fight against AMR in Ghana in line with the objectives of the NAP. We will be following this up in future studies.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/antibiotics11121679/s1, Table S1: Questionnaire.

Author Contributions: Conceptualization: I.A.S. and B.G.; methodology: I.A.S., E.A. and E.S.; validation, I.A.S., E.A. and E.S.; formal analysis, I.A.S. and J.C.M.; investigation, I.A.S., E.A., E.S. and J.C.M.; resources, I.A.S.; data curation, I.A.S., E.A., E.S., B.G. and J.C.M.; writing—original draft preparation, I.A.S. and B.G.; writing—review and editing, I.A.S., E.A., E.S., B.G. and J.C.M.; supervision, I.A.S.; project administration, I.A.S. and B.G.; funding acquisition, E.A. and I.A.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Ethical approval to conduct this study was obtained from the University of Health and Allied Sciences Research Ethics Committee (UHAS-REC A.2 [25] 21–22). Furthermore, administrative approvals were sought from the Deans of the SOP, SOM, SONAM and SAHS. Confidentiality and anonymity of the information provided by participants was ensured by substituting codes for participant identifiers and keeping all data collected secured with the principal investigator using password protection.

Informed Consent Statement: Informed consent was obtained from each student who participated in the study by ensuring that a student must consent before being allowed to proceed to respond to the questionnaire.

Data Availability Statement: Additional data are available from the corresponding authors on reasonable request.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. O'Neill, J. Tackling Drug-Resistant Infections Globally: Final Report And Recommendations—The Review On Antimicrobial Resistance. 2016. Available online: https://amr-review.org/sites/default/files/160525_Final%20paper_with%20cover.pdf (accessed on 20 May 2021).
2. Global burden of bacterial antimicrobial resistance in 2019: A systematic analysis. *Lancet* **2022**, *399*, 629–655.
3. World Bank. By 2050, drug-resistant infections could cause global economic damage on par with 2008 financial crisis. 2017. Available online: https://documents1.worldbank.org/curated/en/323311493396993758/pdf/final-report.pdf (accessed on 20 May 2021).
4. Hofer, U. The cost of antimicrobial resistance. *Nat. Rev. Microbiol.* **2019**, *17*, 3.
5. Jimah, T.; Fenny, A.P.; Ogunseitan, O.A. Antibiotics stewardship in Ghana: A cross-sectional study of public knowledge, attitudes, and practices among communities. *One Health Outlook* **2020**, *2*, 12.
6. Bell, D.; Schultz Hansen, K. Relative Burdens of the COVID-19, Malaria, Tuberculosis, and HIV/AIDS Epidemics in Sub-Saharan Africa. *Am. J. Trop. Med. Hyg.* **2021**, *105*, 1510–1515.
7. Tadesse, B.T.; Ashley, E.A.; Ongarello, S.; Havumaki, J.; Wijegoonewardena, M.; González, I.J.; Dittrich, S. Antimicrobial resistance in Africa: A systematic review. *BMC Infect Dis*. **2017**, *17*, 616.
8. Godman, B.; Haque, M.; McKimm, J.; Abu Bakar, M.; Sneddon, J.; Wale, J.; Campbell, S.; Martin, A.P.; Hoxha, I.; Abilova, V.; et al. Ongoing strategies to improve the management of upper respiratory tract infections and reduce inappropriate antibiotic use particularly among lower and middle-income countries: Findings and implications for the future. *Curr. Med. Res. Opin*. **2020**, *36*, 301–327.
9. Ocan, M.; Aono, M.; Bukirwa, C.; Luyinda, E.; Ochwo, C.; Nsambu, E.; Namugonza, S.; Makoba, J.; Kandaruku, E.; Muyende, H.; et al. Medicine use practices in management of symptoms of acute upper respiratory tract infections in children (≤12 years) in Kampala city, Uganda. *BMC Public Health* **2017**, *17*, 732.
10. Godman, B.; Egwuenu, A.; Haque, M.; Malande, O.O.; Schellack, N.; Kumar, S.; Saleem., Z.; Sneddon, J.; Hoxha, I.; Islam, S. et al. Strategies to Improve Antimicrobial Utilization with a Special Focus on Developing Countries. *Life* **2021**, *11*, 528.
11. Manderson, L. Prescribing, care and resistance: Antibiotic use in urban South Africa. *Humanit. Soc. Sci. Commun.* **2020**, *7*, 77.
12. Prah, J.; Kizzie-Hayford, J.; Walker, E.; Ampofo-Asiama, A. Antibiotic prescription pattern in a Ghanaian primary health care facility. *Pan. Afr. Med. J.* **2017**, *28*, 214.
13. Versporten, A.; Zarb, P.; Caniaux, I.; Gros, M.F.; Drapier, N.; Miller, M.; Jarlier, V.; Nathwani, D.; Goossens, H.; Global-PPS Network. 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*, e619–e29.
14. 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*, 1614–1624.
15. Langford, B.J.; So, M.; Raybardhan, S.; Leung, V.; Soucy, J.R.; Westwood, D.; Daneman, N.; MacFadden, D.R. Antibiotic prescribing in patients with COVID-19: Rapid review and meta-analysis. *Clin. Microbiol. Infect* **2021**, *27*, 520–531.
16. Alshaikh, F.S.; Godman, B.; Sindi, O.N.; Seaton, R.A.; Kurdi, A. Prevalence of bacterial coinfection and patterns of antibiotics prescribing in patients with COVID-19: A systematic review and meta-analysis. *PLoS ONE* **2022**, *17*, e0272375.
17. Jeon, K.; Jeong, S.; Lee, N.; Park, M.J.; Song, W.; Kim, H.-S.; Kim, H.S.; Kim, J.-S. Impact of COVID-19 on Antimicrobial Consumption and Spread of Multidrug-Resistance in Bacterial Infections. *Antibiotics* **2022**, *11*, 535.
18. Llor, C.; Bjerrum, L. Antimicrobial resistance: Risk associated with antibiotic overuse and initiatives to reduce the problem. *Ther. Adv. Drug Saf.* **2014**, *5*, 229–241.
19. Bell, B.G.; 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.

20. Megraud, F.; Bruyndonckx, R.; Coenen, S.; Wittkop, L.; Huang, T.D.; Hoebeke, M.; Bénéjat, L.; Lehours, P.; Goossens, H,; Glupczynski, Y.; et al. Helicobacter pylori resistance to antibiotics in Europe in 2018 and its relationship to antibiotic consumption in the community. *Gut* **2021**, *70*, 1815–1822.
21. Hsu, J. How COVID-19 is accelerating the threat of antimicrobial resistance. *BMJ* **2020**, *369*, m1983.
22. Lai, C.C.; Chen, S.Y.; Ko, W.C.; Hsueh, P.R. Increased antimicrobial resistance during the COVID-19 pandemic. *Int. J. Antimicrob. Agents.* **2021**, *57*, 106324.
23. WHO. Global Action Plan On Antimicrobial Resistance. 2015. Available online: https://apps.who.int/iris/bitstream/handle/10665/193736/9789241509763_eng.pdf?sequence=1 (accessed on 20 May 2021).
24. Munkholm, L.; Rubin, O. The global governance of antimicrobial resistance: A cross-country study of alignment between the global action plan and national action plans. *Global. Health* **2020**, *16*, 109.
25. WHO. Global Antimicrobial Resistance and Use Surveillance System (GLASS) Report: 2021. Available online: https://www.who.int/publications/i/item/9789240027336 (accessed on 20 May 2021).
26. OECD Health Policy Studies. Stemming the Superbug Tide. 2018. Available online: https://www.oecd-ilibrary.org/sites/9789264307599-en/index.html?itemId=/content/publication/9789264307599-en&mimeType=text/html (accessed on 20 May 2021).
27. Inoue, H. Strategic approach for combating antimicrobial resistance (AMR). *Glob. Health Med*. **2019**, *1*, 61–64.
28. Harant, A. Assessing transparency and accountability of national action plans on antimicrobial resistance in 15 African countries. *Antimicrob. Resist Infect Control*. **2022**, *11*, 15.
29. Sadak, M.; Cramp, E.; Ashiru-Oredope, D. Antimicrobial Resistance and Stewardship in National Action Plans. *Curr. Treat. Options Infect. Dis*. **2016**, *8*, 57–71.
30. Ghana Ministry of Health, Ministry of Food and Agriculture, Ministry of Environment, Science, Technology and Innovation, Ministry of Fisheries and Aquaculture Development. Ghana National Action Plan for Antimicrobial Use and Resistance. 2017–2021. Available online: http://www.moh.gov.gh/wp-content/uploads/2018/04/NAP_FINAL_PDF_A4_19.03.2018-SIGNED-1.pdf (accessed on 20 May 2021).
31. Godman, B.; Egwuenu, A.; Wesangula, E.; Schellack, N.; Kalungia, A.C.; Tiroyakgosi, C.; Kgatlwane, J; Mwita, J.C.; Patrick, O.; Niba, L.L.;et al. Tackling antimicrobial resistance across sub-Saharan Africa: Current challenges and implications for the future. *Expert Opin. Drug Saf.* **2022**, *21*, 1089–1111.
32. Hein, W.; Aglanu, L.M.; Mensah-Sekyere, M.; Harant, A.; Brinkel, J.; Lamshöft, M.; Lorenz, E.; Eibach, D.; Amuasi, J. Fighting Antimicrobial Resistance: Development and Implementation of the Ghanaian National Action Plan (2017&2021). *Antibiotics* **2022**, *11*, 613.
33. Manning, M.L.; Septimus, E.J.; Ashley, E.S.D.; Cosgrove, S.E.; Fakih, M.G.; Schweon, S.J.; Myers, F.E.; Moody, J.A. Antimicrobial Stewardship and Infection Prevention-Leveraging the Synergy: A Position Paper Update. *Infect Control. Hosp. Epidemiol.* **2018**, *39*, 467–472.
34. Majumder, M.A.A.; Rahman, S.; Cohall, D.; Bharatha, A.; Singh, K.; Haque, M.; Gittens-St Hilaire, M. Antimicrobial Stewardship: Fighting Antimicrobial Resistance and Protecting Global Public Health. *Infect Drug Resist*. **2020**, *13*, 4713–4738.
35. Siachalinga, L.; Mufwambi, W.; Lee, I.H. Impact of antimicrobial stewardship interventions to improve antibiotic prescribing for hospital inpatients in Africa: A systematic review and meta-analysis. *J. Hosp. Infect* **2022**.
36. Nathwani, D.; Varghese, D.; Stephens, J.; Ansari, W.; Martin, S.; Charbonneau, C. Value of hospital antimicrobial stewardship programs [ASPs]: A systematic review. *Antimicrob. Resist Infect Control*. **2019**, *8*, 35.
37. Otieno, P.A.; Campbell, S.; Maley, S.; Obinju Arunga, T.; Otieno Okumu, M. A Systematic Review of Pharmacist-Led Antimicrobial Stewardship Programs in Sub-Saharan Africa. *Int. J. Clin. Pract*. **2022**, *2022*, 3639943.
38. Akpan, M.R.; Isemin, N.U.; Udoh, A.E.; Ashiru-Oredope, D. Implementation of antimicrobial stewardship programmes in African countries: A systematic literature review. *J. Glob. Antimicrob. Resist* **2020**, *22*, 317–324.
39. Cox, J.A.; Vlieghe, E.; Mendelson, M.; Wertheim, H.; Ndegwa, L.; Villegas, M.V.; Gould, I.; Hara, G.L. Antibiotic stewardship in low- and middle-income countries: The same but different? *Clin. Microbiol. Infect* **2017**, *23*, 812–818.
40. Fadare, J.O.; Ogunleye, O.; Iliyasu, G.; Adeoti, A.; Schellack, N.; Engler, D.; Massel, A.; Godman, B. Status of antimicrobial stewardship programmes in Nigerian tertiary healthcare facilities: Findings and implications. *J. Glob. Antimicrob. Resist* **2019**, *17*, 132–136.
41. Kalungia, A.C.; Mwambula, H.; Munkombwe, D.; Marshall, S.; Schellack, N.; May, C.; Jones, A.S.C.; Godman, B. 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*, 378–387.
42. Gebretekle, G.B.; Haile Mariam, D.; Abebe Taye, W.; Mulu Fentie, A.; Amogne Degu, W.; Alemayehu, T.; Beyene, T.; Libman, M.; Fenta, T.G.; Yansouni, C.P; 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.
43. Hayat, K.; Rosenthal, M.; Zhu, S.; Gillani, A.H.; Chang, J.; Bogale, A.A.; Kabba., J.A.; Yang, C.; Jiang, M.; Zhao, M.; et al. Attitude of clinicians towards hospital-based antimicrobial stewardship programs: A multicenter cross-sectional study from Punjab, Pakistan. *Expert Rev. Anti. Infect Ther.* **2019**, *17*, 661–669.
44. Atif, M.; Ihsan, B.; Malik, I.; Ahmad, N.; Saleem, Z.; Sehar, A.; Barbar, Z.-U.-D. Antibiotic stewardship program in Pakistan: A multicenter qualitative study exploring medical doctors' knowledge, perception and practices. *BMC Infect Dis*. **2021**, *21*, 374.

45. Gupta, M.K.; Vohra, C.; Raghav, P. Assessment of knowledge, attitudes, and practices about antibiotic resistance among medical students in India. *J. Family Med. Prim. Care* **2019**, *8*, 2864–2869.
46. Lubwama, M.; Onyuka, J.; Ayazika, K.T.; Ssetaba, L.J.; Siboko, J.; Daniel, O.; Mushi, M.F. Knowledge, attitudes, and perceptions about antibiotic use and antimicrobial resistance among final year undergraduate medical and pharmacy students at three universities in East Africa. *PLoS One*. **2021**, *16*, e0251301.
47. Okedo-Alex, I.; Madubueze, U.C.; Umeokonkwo, C.D.; Oka, O.U.; Adeke, A.S.; Okeke, K.C. Knowledge of antibiotic use and resistance among students of a medical school in Nigeria. *Malawi. Med. J.* **2019**, *31*, 133–137.
48. Adegbite, B.R.; Edoa, J.R.; Schaumburg, F.; Alabi, A.S.; Adegnika, A.A.; Grobusch, M.P. Knowledge and perception on antimicrobial resistance and antibiotics prescribing attitude among physicians and nurses in Lambaréné region, Gabon: A call for setting-up an antimicrobial stewardship program. *Antimicrob. Resist Infect Control*. **2022**, *11*, 44.
49. Labi, A.K.; Obeng-Nkrumah, N.; Bjerrum, S.; Aryee, N.A.A.; Ofori-Adjei, Y.A.; Yawson, A.E.; Newman, M.J. Physicians' knowledge, attitudes, and perceptions concerning antibiotic resistance: A survey in a Ghanaian tertiary care hospital. *BMC Health Serv. Res*. **2018**, *18*, 126.
50. Ogoina, D.; Iliyasu, G.; Kwaghe, V.; Otu, A.; Akase, I.E.; Adekanmbi, O.; Mahmood, D.; Iroezindu, M.; Aliyu, S.; Oyeyemi, A.S.; et al. Predictors of antibiotic prescriptions: A knowledge, attitude and practice survey among physicians in tertiary hospitals in Nigeria. *Antimicrob. Resist. Infect. Control*. **2021**, *10*, 73.
51. Higuita-Gutiérrez, L.F.; Roncancio Villamil, G.E.; Jiménez Quiceno, J.N. Knowledge, attitude, and practice regarding antibiotic use and resistance among medical students in Colombia: A cross-sectional descriptive study. *BMC Public Health* **2020**, *20*, 1861.
52. Scaioli, G.; Gualano, M.R.; Gili, R.; Masucci, S.; Bert, F.; Siliquini, R. Antibiotic use: A cross-sectional survey assessing the knowledge, attitudes and practices amongst students of a school of medicine in Italy. *PLoS ONE* **2015**, *10*, e0122476.
53. Zulu, A.; Matafwali, S.K.; Banda, M.; Mudenda, S. Assessment of knowledge, attitude and practices on antibiotic resistance among undergraduate medical students in the school of medicine at the University of Zambia. *Int. J. Basic Clin. Pharmacol.* **2020**, *9*, 8.
54. Haque, M.; Ara, T.; Haq, M.A.; Lugova, H.; Dutta, S.; Samad, N.;Abubakar, A.R.; Mohdhar, S.S.B.S.; Rahman, M.; Islam, S.; et al. Antimicrobial Prescribing Confidence and Knowledge Regarding Drug Resistance: Perception of Medical Students in Malaysia and the Implications. *Antibiotics* **2022**, *11*, 540.
55. Augie, B.M.; van Zyl, R.L.; McInerney, P.A.; Miot, J. Knowledge and perceptions about antibiotic resistance and prudent antibiotic prescribing among final year medical students in two African countries. *Int. J. Pharm. Pract*. **2021**, *29*, 508–514.
56. Wasserman, S.; Potgieter, S.; Shoul, E.; Constant, D.; Stewart, A.; Mendelson, M.; Boyles, T.H. South African medical students' perceptions and knowledge about antibiotic resistance and appropriate prescribing: Are we providing adequate training to future prescribers? *S Afr. Med. J.* **2017**, *107*, 405–410.
57. Abubakar, U.; Muhammad, H.T.; Sulaiman, S.A.S.; Ramatillah, D.L.; Amir, O. Knowledge and self-confidence of antibiotic resistance, appropriate antibiotic therapy, and antibiotic stewardship among pharmacy undergraduate students in three Asian countries. *Curr. Pharm. Teach Learn* **2020**, *12*, 265–273.
58. Hayat, K.; Jamshed, S.; Rosenthal, M.; Haq, N.U.; Chang, J.; Rasool, M.F.; Malik, U.R.; Rehman, A.U.; Khan, K.M.; Fang, U. Understanding of Pharmacy Students towards Antibiotic Use, Antibiotic Resistance and Antibiotic Stewardship Programs: A Cross-Sectional Study from Punjab, Pakistan. *Antibiotics* **2021**, *10*, 66.
59. Burger, M.; Fourie, J.; Loots, D.; Mnisi, T.; Schellack, N.; Bezuidenhout, S.; Meyer, J.C. Knowledge and perceptions of antimicrobial stewardship concepts among final year pharmacy students in pharmacy schools across South Africa. *South. Afr. J. Infect. Dis.* **2016**, *31*, 84–90.
60. Asogwa, I.; Offor, S.; Mbagwu, H. Knowledge, attitude and practice towards antibiotics use among non-medical university students in Uyo, Nigeria. *J. Adv. Med. Pharm. Sci*. **2017**, *15*, 1–11.
61. Sakeena, M.H.F.; Bennett, A.A.; Jamshed, S.; Mohamed, F.; Herath, D.R.; Gawarammana, I.; McLachlan, A.J. Investigating knowledge regarding antibiotics and antimicrobial resistance among pharmacy students in Sri Lankan universities. *BMC Infect Dis*. **2018**, *18*, 209.
62. Ahmad, A.; Khan, M.U.; Moorthy, J.; Jamshed, S.Q.; Patel, I. Comparison of knowledge and attitudes about antibiotics and resistance, and antibiotics self-practicing between Bachelor of Pharmacy and Doctor of Pharmacy students in Southern India. *Pharm; Pract.* **2015**, *13*, 523.
63. Seid, M.A.; Hussen, M.S. Knowledge and attitude towards antimicrobial resistance among final year undergraduate paramedical students at University of Gondar, Ethiopia. *BMC Infect Dis*. **2018**, *18*, 312.
64. Nisabwe, L.; Brice, H.; Umuhire, M.C.; Gwira, O.; Harelimana, J.D.; Nzeyimana, Z.; Sebatunzi, O.R.; Rusingiza, E.K.; Hahirwa, I.; Muvunyi, C.M. Knowledge and attitudes towards antibiotic use and resistance among undergraduate healthcare students at University of Rwanda. *J. Pharm. Policy Pract*. **2020**, *13*, 7.
65. Sakeena, M.H.; Bennett, A.A.; Mohamed, F.; Herath, H.M.; Gawarammane, I.; McLachlan, A.J. Investigating knowledge regarding antibiotics among pharmacy and allied health sciences students in a Sri Lankan university. *J. Infect Dev. Ctries*. **2018**, *12*, 726–732.
66. Rábano-Blanco, A.; Domínguez-Martís, E.M.; Mosteiro-Miguéns, D.G.; Freire-Garabal, M.; Novío, S. Nursing Students' Knowledge and Awareness of Antibiotic Use, Resistance and Stewardship: A Descriptive Cross-Sectional Study. *Antibiotics* **2019**, *8*, 203.

67. Kumar, S.B.P.; Santhosh, Y.L.S.; Ahamed, M.G.; Naveen, M. Survey on knowledge towards antibiotics among the nursing students. *Int. J. Pharm. Pharm. Sci.* **2011**, *3*, 227–229.
68. Kpokiri, E.E.; Ladva, M.; Dodoo, C.C.; Orman, E.; Aku, T.A.; Mensah, A.; Jato, J.; Mfoafo, K.A.; Folitse, I.; Hutton-Nyameaye, A.; et al. Knowledge, Awareness and Practice with Antimicrobial Stewardship Programmes among Healthcare Providers in a Ghanaian Tertiary Hospital. *Antibiotics* **2022**, *11*, 6.
69. Sefah, I.A.; Essah, D.O.; Kurdi, A.; Sneddon, J.; Alalbila, T.M.; Kordorwu, H.; Godman, B. Assessment of adherence to pneumonia guidelines and its determinants in an ambulatory care clinic in Ghana: Findings and implications for the future. *JAC Antimicrob. Resist.* 2021, 3, dlab080.
70. Afriyie, D.K.; Sefah, I.A.; Sneddon, J.; Malcolm, W.; McKinney, R.; Cooper, L.; Amanj, K.; Godman, B.; Seaton, R.A. Antimicrobial point prevalence surveys in two Ghanaian hospitals: Opportunities for antimicrobial stewardship. *JAC Antimicrob. Resist*. 2020, 2, dlaa001.
71. Labi, A.K.; Obeng-Nkrumah, N.; Dayie, N.; Egyir, B.; Sampane-Donkor, E.; Newman, M.J.; Opintan, J.A. Antimicrobial use in hospitalized patients: A multicentre point prevalence survey across seven hospitals in Ghana. *JAC Antimicrob. Resist*. 2021, 3, dlab087.
72. Labi, A.K.; Obeng-Nkrumah, N.; Sunkwa-Mills, G.; Bediako-Bowan, A.; Akufo, C.; Bjerrum, S.; Owusu, E.; Enweronu-Laryea, C.; Opintan, J.A.; Kurtzhals, J.A.L.; et al. Antibiotic prescribing in paediatric inpatients in Ghana: A multi-centre point prevalence survey. *BMC Pediatr*. **2018**, *18*, 391.
73. Opoku, M.M.; Bonful, H.A.; Koram, K.A. Antibiotic prescription for febrile outpatients: A health facility-based secondary data analysis for the Greater Accra region of Ghana. *BMC Health Serv. Res*. **2020**, *20*, 978.
74. Yevutsey, S.K.; Buabeng, K.O.; Aikins, M.; Anto, B.P.; Biritwum, R.B.; Frimodt-Møller, N.; Gyansa-Lutterodt, M. Situational analysis of antibiotic use and resistance in Ghana: Policy and regulation. *BMC Public Health* **2017**, *17*, 896.
75. Afari-Asiedu, S.; Oppong, F.B.; Tostmann, A.; Ali Abdulai, M.; Boamah-Kaali, E.; Gyaase, S.; Agyei, O.; Kinsman, J.; Hulscher, M.; Wertheim, H.F.L.; et al. Determinants of Inappropriate Antibiotics Use in Rural Central Ghana Using a Mixed Methods Approach. *Front Public Health* **2020**, *8*, 90.
76. WHO. Antimicrobial Stewardship Programmes in Health-Care Facilities in Low-and Middle-Income Countries: A WHO Practical Toolkit. 2019. Available online: https://apps.who.int/iris/handle/10665/329404 (accessed on 15 June 2021).
77. Sneddon, J.; Cooper, L.; Afriyie, D.K.; Sefah, I.A.; Cockburn, A.; Kerr, F.; Cameron, E.; Goldthorpe, J.; Kurdi, A.; Seaton, R.A. Supporting antimicrobial stewardship in Ghana: Evaluation of the impact of training on knowledge and attitudes of healthcare professionals in two hospitals. *JAC Antimicrob. Resist.* 2020, 2, dlaa092.
78. Essack, S.; Bell, J.; Burgoyne, D.S.; Duerden, M.; Shephard, A. Topical (local) antibiotics for respiratory infections with sore throat: An antibiotic stewardship perspective. *J. Clin. Pharm. Ther.* **2019**, *44*, 829–837.
79. Busa, A.; Parrini, S.; Chisci, G.; Pozzi, T.; Burgassi, S.; Capuano, A. Local versus systemic antibiotics effectiveness: A comparative study of postoperative oral disability in lower third molar surgery. *J. Craniofac. Surg*. **2014**, *25*, 708–709.
80. Chisci, G.; Hatia, A. Antibiotics in orthognathic surgery and postoperative infections. *Int. J. Oral. Maxillofac Surg*. **2022**.
81. Ogunleye, O.O.; Godman, B.; Fadare, J.O.; Mudenda, S.; Adeoti, A.O.; Yinka-Ogunleye, A.F.; et al. Coronavirus Disease 2019 (COVID-19) Pandemic across Africa: Current Status of Vaccinations and Implications for the Future. *Vaccines* **2022**, *10*, 1553.
82. Nogueira-Uzal, N.; Zapata-Cachafeiro, M.; Vázquez-Cancela, O.; López-Durán, A.; Herdeiro, M.T.; Figueiras, A. Does the problem begin at the beginning? Medical students' knowledge and beliefs regarding antibiotics and resistance: A systematic review. *Antimicrob. Resist. Infect Control*. **2020**, *9*, 172.
83. Zhao, A.; Xiao, S.; Kandelaki, K.; Liu, Y.; Chen, W.; Ren, R.; et al. Knowledge, Perception, and Educational Status of Antimicrobial Resistance Among Chinese Medical Students. *Microb. Drug Resist.* **2019**, *25*, 1458–1464.
84. Shahpawee, N.S.; Chaw, L.L.; Muharram, S.H.; Goh, H.P.; Hussain, Z.; Ming, L.C. University Students' Antibiotic Use and Knowledge of Antimicrobial Resistance: What Are the Common Myths? *Antibiotics* **2020**, *9*, 349.
85. Jimah, T.O.O. National Action Plan on Antimicrobial Resistance: Stakeholder analysis of implementation in Ghana. *J. Glob. Health Rep.* **2020**, *4*, 1–16. https://doi.org/0.29392/001c.13695.
86. Etando, A.; Amu, A.A.; Haque, M.; Schellack, N.; Kurdi, A.; Alrasheedy, A.A.; Timoney, A.; Mwita, J.C.; Rwegerera, G.M.; Tatrick, O.; et al. Challenges and Innovations Brought about by the COVID-19 Pandemic Regarding Medical and Pharmacy Education Especially in Africa and Implications for the Future. *Healthcare* **2021**, *9*, 1722.
87. Sefah, I.A.; Ogunleye, O.O.; Essah, D.O.; Opanga, S.A.; Butt, N.; Wamaitha, A.; et al. Rapid Assessment of the Potential Paucity and Price Increases for Suggested Medicines and Protection Equipment for COVID-19 Across Developing Countries With a Particular Focus on Africa and the Implications. *Front Pharmacol*. **2020**, *11*, 588106.
88. Jampani, M.; Chandy, S.J. Increased antimicrobial use during COVID-19: The risk of advancing the threat of antimicrobial resistance. *Health Sci. Rep*. **2021**, *4*, e459.
89. Sarwar, M.R.; Saqib, A.; Iftikhar, S.; Sadiq, T. Knowledge of community pharmacists about antibiotics, and their perceptions and practices regarding antimicrobial stewardship: A cross-sectional study in Punjab, Pakistan. *Infect Drug Resist*. **2018**, *11*, 133–145.
90. Ogunleye, O.O.; Basu, D.; Mueller, D.; Sneddon, J.; Seaton, R.A.; Yinka-Ogunleye, A.F.; et al. Response to the Novel Corona Virus (COVID-19) Pandemic Across Africa: Successes, Challenges, and Implications for the Future. *Front Pharmacol*. **2020**, *11*, 1205.

91. Hoxha, I.; Malaj, A.; Kraja, B.; Bino, S.; Oluka, M.; Marković-Peković, V.; Godman, B. Are pharmacists' good knowledge and awareness on antibiotics taken for granted? The situation in Albania and future implications across countries. *J. Glob. Antimicrob. Resist*. **2018**, *13*, 240–245.
92. Babatola, A.O.; Fadare, J.O.; Olatunya, O.S.; Obiako, R.; Enwere, O.; Kalungia, A.; Ojo, O.T.; Sunmonu, T.A.; Desalu, O.; Godman, B. Addressing antimicrobial resistance in Nigerian hospitals: Exploring physicians prescribing behavior, knowledge, and perception of antimicrobial resistance and stewardship programs. *Expert Rev. Anti. Infect Ther*. **2021**, *19*, 537–546.
93. Guma, S.P.; Godman, B.; Campbell, S.M.; Mahomed, O. Determinants of the Empiric Use of Antibiotics by General practitioners in South Africa: Observational, Analytic, Cross-Sectional Study. *Antibiotics* **2022**, *11*, 1423.
94. Mudenda, S.; Mukosha, M.; Godman, B.; Fadare, J.; Malama, S.; Munyeme, M.; Hikaambo, C.N.; Kalungia, A.C.; Hamachila, A.; Kainga, H.; et al. Knowledge, Attitudes, and Practices of Community Pharmacy Professionals on Poultry Antibiotic Dispensing, Use, and Bacterial Antimicrobial Resistance in Zambia: Implications on Antibiotic Stewardship and WHO AWaRe Classification of Antibiotics. *Antibiotics* **2022**, *11*, 1210.
95. Mudenda, S.; Hankombo, M.; Saleem, Z.; Sadiq, M.J.; Banda, M.; Munkombwe, D.; Mwila, C.; Kasanga, M.; Zulu, A.C.; Hangoma, J.M.; et al. Knowledge, Attitude, and Practices of Community Pharmacists on Antibiotic Resistance and Antimicrobial Stewardship in Lusaka, Zambia. Available online: https://www.medrxiv.org/content/10.1101/2020.08.27.20181826v2 (accessed on 24 October 2022).