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# Status of antimicrobial stewardship programmes in Nigerian tertiary healthcare facilities: Findings and implications

Joseph O. Fadare[a], Olayinka Ogunleye[b], Garba Iliyasu[c], Adekunle Adeoti[d], Natalie Schellack[e], Deirdre Engler[e], Amos Massele[f], Brian Godman[e,g,h,i,*]

[a] Department of Pharmacology and Therapeutics, College of Medicine, Ekiti State University, Ado-Ekiti, Nigeria
[b] Departments of Pharmacology and Medicine, Lagos State University College of Medicine and Teaching Hospital, Ikeja, Lagos, Nigeria
[c] Infectious Diseases Unit, Department of Medicine, Bayero University, Kano, Nigeria
[d] Department of Medicine, College of Medicine, Ekiti State University, Ado-Ekiti, Nigeria
[e] School of Pharmacy, Sefako Makgatho Health Sciences University, Ga-Rankuwa, Pretoria, South Africa
[f] Department of Biomedical Sciences, Faculty of Medicine, University of Botswana, Gaborone, Botswana
[g] Division of Clinical Pharmacology, Karolinska Institute, Stockholm, Sweden
[h] Strathclyde Institute of Pharmacy and Biomedical Sciences, University of Strathclyde, Glasgow, UK
[i] Health Economics Centre, Liverpool University Management School, Chatham Street, Liverpool, UK

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ABSTRACT

*Objectives:* The problem of antimicrobial resistance (AMR) is increasing worldwide, with health-related and economic consequences. This is a concern in Africa, including Nigeria, the most populous country in Africa, with its high rates of infectious diseases. Approaches to reducing AMR include instigating antimicrobial stewardship programmes (ASPs) in hospitals. Currently, no information is available regarding the extent of ASPs in Nigerian hospitals. Consequently, the objective was to address this starting in tertiary hospitals.

*Methods:* This was a cross-sectional, questionnaire-based study among tertiary healthcare facilities. Tertiary hospitals were chosen initially since if there are concerns in these training hospitals, such concerns will likely to be exacerbated in other hospitals.

*Results:* Completed questionnaires were received from 17 of 25 tertiary healthcare facilities across five of the six geopolitical regions of Nigeria. Ten (59%), four (24%), two (12%) and one (6%) respondents were in internal medicine, infectious diseases, medical microbiology and clinical pharmacology, respectively. Only six healthcare facilities (35%) had a formal organisational structure and a team responsible for ASP. Facility-specific treatment recommendations, based on local AMR patterns, were available in only four facilities (24%). Policies on approval for prescribing specified antimicrobials and formal procedures for reviewing their appropriateness after 48 h were present in only two facilities (12%). A cumulative antimicrobial susceptibility report for the previous year was available in only two facilities (12%), and only one facility routinely monitored antimicrobial use.

*Conclusion:* Significant inadequacies in the availability of ASPs were observed. This needs to be urgently addressed to reduce AMR rates in Nigeria.



## 1. Introduction

Antimicrobial resistance (AMR) is a growing public-health problem with consequences including therapeutic failure, increasing morbidity and mortality, and higher healthcare costs [1–3]. Inappropriate use of antimicrobials, especially in hospitals, has been shown to be responsible for the development of resistance to different classes of antimicrobial agents, especially those used for the treatment of nosocomial infections [4], with a pan-European study identifying a direct link between the quantity of antibiotics consumed and AMR [5]. The situation regarding rising AMR rates is compounded by the slow development of novel antimicrobial agents during the past two decades [3]. Establishment of antimicrobial stewardship programmes (ASPs) in healthcare institutions, as well as regulation of access to and prescribing of antimicrobials, are

* Corresponding author. Present address: Division of Clinical Pharmacology, Karolinska Institute, Karolinska University Hospital Huddinge, SE 141 86 Stockholm, Sweden.
*E-mail addresses:* Brian.godman@strath.ac.uk, Brian.Godman@ki.se (B. Godman).

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some of the approaches aimed at reducing AMR [6–9]. The principal function of ASPs is the promotion of rational use of antimicrobials in the hospital setting through formulary restrictions and pre-authorisation [6,9,10]. Additional strategies are prospective audit and feedback to prescribers as well as guideline development and dissemination [10–12]. Many developed countries have well-entrenched ASPs that have resulted in better patient outcomes and a reduction in healthcare costs [13]. A meta-analysis of studies evaluating the effect of ASPs in inpatient settings in the USA showed that there was decreased antimicrobial use and an improvement in AMR patterns following the instigation of ASPs [14]. A significant reduction in healthcare costs, especially relating to the direct cost of antimicrobials and indirect costs (reduction in hospital stay and improved therapeutic outcomes), has been recorded with ASPs in studies conducted in Saudi Arabia, Sweden and China [15–17]. Similarly, the impact of a functional ASP has been demonstrated in South Africa, with a reduction in the quantity of antimicrobial use and costs in the hospital without negatively affecting patient outcomes [18]. However, optimal strategies for ASPs, including membership and activities, have yet to be fully defined [9].

Inappropriate use of antimicrobials is well documented in many studies conducted across Nigeria [19,20]. This is worrisome not only because of the associated potential adverse effects and drug–drug interactions, but also because of the financial impact as only a small proportion of the population in Nigeria currently enjoys the coverage of a health insurance scheme [21]. In view of this, the presence of any programme promoting improved use of antimicrobials by physicians in healthcare facilities should be encouraged, although concerns exist about the most appropriate method [9,22]. Currently, there is little information regarding the availability and functionality of ASPs in Nigerian hospitals. This lack of information needs to be urgently addressed given the size of the population in Nigeria versus other African countries as well as growing AMR rates in Nigeria [23–25].

The principal objective of this study was to investigate the availability and mode of operation of ASPs among selected tertiary healthcare facilities across different regions of Nigeria as a basis for providing future direction.

## 2. Methods

### 2.1. Study setting

This study was conducted among public sector, tertiary healthcare facilities located in different regions of Nigeria. Nigeria is the most populous country in Africa with an estimated population of over 170 million. The country, which is divided into six geopolitical zones, also operates a federal system comprising 36 states and one Federal Capital Territory. Tertiary healthcare facilities comprise mainly Federal Medical Centres and University Teaching Hospitals, and they are the best equipped in terms of personnel and equipment. Consequently, if there are issues regarding the nature and extent of ASPs among tertiary hospitals, these issues and concerns are likely to be magnified in secondary hospitals. There is some benefit for healthcare professionals to be part of hospital ASPs, either financial or as part of career development, although this may not be universal.

The healthcare needs of the Nigerian population are catered for both by private and public healthcare facilities. The public healthcare system of the country currently comprises three levels of care: primary, secondary and tertiary. The primary level of care incorporates health centres, whilst the secondary level comprises general hospitals. As mentioned, tertiary health care comprises mainly Federal Medical Centres and University Teaching Hospitals. Presently there are 50 University Teaching Hospitals owned by the federal or state governments in Nigeria.

### 2.2. Study design

A descriptive cross-sectional survey was conducted using a self-administered mailed questionnaire in order to ascertain the extent and nature of ongoing ASPs among tertiary hospitals.

### 2.3. Sampling

Purposive sampling was undertaken using hospitals with reliable personal contacts. Five tertiary healthcare facilities in each of five of the six geopolitical regions of the country were selected for this initial study since personnel with the highest levels of qualifications and expertise are mostly found in such centres. The North East zone was excluded because of ongoing militant insurgency in the region during the study period.

### 2.4. Data collection instrument

The study instrument was an adaptation of the instrument developed by the Transatlantic Taskforce on Antimicrobial Resistance (TATFAR) Expert Panel on Stewardship Structure and Process Indicators [26]. The 17-item instrument consists of core indicators categorised into infrastructure, policy and practice, and monitoring and feedback (Appendix A).

### 2.5. Data collection process

Questionnaires were sent via email to the focal persons of the selected institutions following initial contact by telephone. The focal person for each selected tertiary hospital was either a consultant medical microbiologist, clinical pharmacologist or consultant physician. A time frame of 2 weeks was allowed for return of the completed questionnaires as well as via email. Return of the completed questionnaire by respondents was taken as consent to participate in the study.

### 2.6. Data analysis

Data from the questionnaires were coded and entered into a Microsoft Excel spreadsheet (Microsoft Corp., Redmond, WA), were cleaned and were imported into IBM SPSS Statistics v.19 (IBM Corp., Armonk, NY) for analysis. Results were expressed as frequencies and percentages. For non-quantitative data, content analysis using themes was used to summarise the responses.

### 2.7. Ethical considerations

This study was exempt from ethical approval according to the National Code of Health Research Ethics of Nigeria because it dealt with information of existing programmes and services with the primary aim of improving the future outcome of patients with infection among hospitals in Nigeria.

## 3. Results

Completed questionnaires were received from 17 of 25 tertiary healthcare facilities across five of the six geopolitical regions of the country.

According to the area of specialisation, ten (59%), four (24%), two (12%) and one (6%) respondents were specialists in internal medicine, infectious diseases, medical microbiology and clinical pharmacology, respectively. Only four healthcare facilities (24%) had formal ASPs, whilst another two had other committees responsible for monitoring antimicrobial use in their facilities. None of the surveyed healthcare facilities gave financial compensation for the time dedicated to antimicrobial stewardship

activities. In the area of policy and practice, four hospitals (24%) had treatment guidelines based on local antimicrobial susceptibility patterns, whilst pre-authorisation for certain antibiotics was currently being practiced in only two hospitals. A review of prescribed antimicrobial agents after 48 h was carried out in only three (18%) of the tertiary healthcare facilities.

With regard to monitoring and feedback, only two centres had produced a cumulative antimicrobial susceptibility report in the preceding year. Similarly, regular audit of surgical antimicrobial prophylaxis was being undertaken in only four tertiary healthcare facilities. Monitoring of antimicrobial consumption using either defined daily dose (DDD) or days of therapy was currently being undertaken in only one healthcare facility. Full details regarding the availability and functionality of other components of the ASPs are shown in Table 1.

## 4. Discussion

### 4.1. General

Instigation of ASPs is one of the major interventions against AMR worldwide. However, in the current study only four (24%) of the surveyed tertiary facilities in Nigeria had an ASP in existence, increasing to 35% when formalised structures and teams responsible for stewardship programmes are included (Table 1). This will have a significant impact on the rational use of antimicrobials and attendant patient outcomes in Nigeria unless addressed, especially if these findings are replicated or even worse in secondary care facilities that currently lack the infrastructure of tertiary facilities. Having said this, these concerns are also seen in more developed countries where there are also variable rates of ASPs [9,16,27,28]. A study conducted in 2013 among 38 children's hospitals in the USA concluded that only 16 of them had existing ASPs, whilst 15 were in the process of establishing them [28]. Another study characterising the structure and functioning of ASPs in Veterans Affairs healthcare facilities across the USA in 2012 also found ASP teams present in only 38% of the surveyed hospitals [29]. The relatively low number of healthcare facilities having functional ASPs was also highlighted in a 2014 study conducted in Queensland, Australia, with only 19% of facilities having an ASP [30]. In contrast, 92.6% of hospitals surveyed in a Korean study had functional ASPs [27].

Research has shown the positive impact of having infectious diseases physicians, clinical microbiologists, clinical pharmacologists and clinical pharmacists trained in infectious diseases in addition to management staff as members of the ASP team [6]. In that study, a physician was identified as the team leader of the ASP in five (83%) of the healthcare facilities where an ASP had been instigated, whilst three tertiary facilities (50%) had a pharmacist responsible for appropriate antimicrobial use. Due to manpower constraints, especially in clinical subspecialties such as infectious diseases, clinical microbiology and clinical pharmacology in Nigeria, it is impossible currently to meet these membership criteria in existing ASPs. However, physicians from other subspecialties, nurses and other healthcare professionals such as pharmacists can be incorporated after prerequisite training to facilitate the functioning of ASPs in their facilities. This is already happening in other countries [8] and has already led to the development of guidelines and positioning statements among pharmacists and other professionals in South Africa [10,31].

**Table 1**
Collated responses from completed questionnaires.

| Statement | *N* (%) | |
|---|---|---|
| | Yes | No |
| Infrastructure | | |
| Does your facility have a formal antimicrobial stewardship programme accountable for ensuring appropriate antimicrobial use | 4 (24) | 13 (76) |
| Does your facility have a formal organisational structure responsible for antimicrobial stewardship (e.g. multidisciplinary committee focused on appropriate antimicrobial use, pharmacy committee, patient safety committee or other relevant structure)? | 6 (35) | 11 (65) |
| Is an antimicrobial stewardship team available at your facility (e.g. more than one staff member supporting clinical decisions to ensure appropriate antimicrobial use)? | 6 (35) | 11 (65) |
| Is there a physician identified as a leader for antimicrobial stewardship activities at your facility? | 5 (29) | 12 (71) |
| Is there a pharmacist responsible for ensuring appropriate antimicrobial use at your facility? | 3 (18) | 14 (82) |
| Does your facility provide any salary support for dedicated time for antimicrobial stewardship activities [e.g. percentage of full-time equivalent (FTE) staff for ensuring appropriate antimicrobial use]? | 0 (0) | 17 (100) |
| Does your facility have the information technology (IT) capability to support the needs of the antimicrobial stewardship activities? | 4 (24) | 13 (76) |
| Policy and practice | | |
| Does your facility have facility-specific treatment recommendations based on local antimicrobial susceptibility to assist with antimicrobial selection for common clinical conditions? | 4 (24) | 13 (76) |
| Does your facility have a written policy that requires prescribers to document an indication in the medical record or during order entry for all antimicrobial prescriptions? | 7 (41) | 10 (59) |
| Is it routine practice for specified antimicrobial agents to be approved by a physician or pharmacist in your facility (e.g. pre-authorisation)? | 2 (12) | 15 (88) |
| Is there a formal procedure for a physician, pharmacist or other staff member to review the appropriateness of an antimicrobial at or after 48 h from the initial order (post-prescription review)? | 3 (18) | 14 (82) |
| Monitoring and feedback | | |
| Has your facility produced a cumulative antimicrobial susceptibility report in the past year? | 2 (12) | 15 (88) |
| Does your facility monitor whether the indication is captured in the medical record for all antimicrobial prescriptions? | 4 (24) | 13 (76) |
| Does your facility audit or review surgical antimicrobial prophylaxis choice and duration? | 4 (24) | 13 (76) |
| Are results of antimicrobial audits or reviews communicated directly with prescribers? | 2 (12) | 15 (88) |
| Does your facility monitor antimicrobial use by grams [defined daily dose (DDD)] or counts (days of therapy) of antimicrobial (s) by patients per days? | 1 (6) | 16 (94) |
| Has an annual report focused on antimicrobial stewardship (summary of antimicrobial use and/or practice improvement initiatives) been produced for your facility in the past year? | 1 (6) | 16 (94) |

None of the centres that participated in the current study had any special salary or funding support for the members of their ASP teams. This is not peculiar to Nigeria as lack of adequate funding for ASP teams has been identified in studies conducted in different parts of the world [30].

### 4.2. Policy and practice

At the level of policy and practice, only four tertiary hospitals (24%) had facility-specific treatment recommendations based on local antimicrobial susceptibility (Table 1). This suggests that treatment with antimicrobials in the majority of these hospitals was being undertaken empirically, with potential consequences such as therapeutic failure, higher costs of healthcare and increasing levels of AMR.

Pre-authorisation is typically the most common form of intervention used in ASPs; however, only 12% of tertiary hospitals in this study had pre-authorisation programmes in place. In practice, this means that all cadres of physicians (from interns to consultants) can prescribe any type of antimicrobial, even the so-called 'reserved' antimicrobials. This is in contrast to 92.6% and 88% of hospitals in South Korea and Australia, respectively, having pre-authorisation as a core interventional strategy [27,30]. In a study conducted in the USA, pre-authorisation of ciprofloxacin prescriptions was associated with a positive effect on the susceptibility of *Escherichia coli* isolates to ciprofloxacin [32]. The importance of pre-authorisation in reducing the use of broad-spectrum antibiotics, and its associated higher healthcare costs, has also been reported in other studies [33,34]. Another way of limiting inappropriate use of antimicrobials in the hospital setting is post-prescription review after 48 h when the results of the microbial culture and susceptibility would have been reported. In this study, only three hospitals (18%) had post-prescription reviews in place. Whilst this may indicate a lack of consideration of bacterial culture and susceptibility in some cases, most physicians would typically review the prescribed antimicrobials based on culture and susceptibility results without a formal post-prescription review. The clinical advantages of a post-prescription review, which has been shown in several studies, include a reduction in patient exposure to antibiotics, shortening the duration of hospital stay, and a reduction in the rate of relapse of infections [35].

### 4.3. Monitoring and feedback

Local knowledge of antimicrobial susceptibility is essential especially when choosing antibiotics for empirical treatment of infections. Only two hospitals (12%) in this study had produced a cumulative antimicrobial susceptibility report in the preceding year. Although there have been several small and isolated cross-sectional antimicrobial susceptibility and/or resistance studies conducted in Nigerian hospitals [36,37], a need exists for more comprehensive, annual, facility-sponsored studies to be conducted using either Clinical and Laboratory Standards Institute (CLSI) or European Committee on Antimicrobial Susceptibility Testing (EUCAST) guidelines [38]. This should be a priority for the future, building on examples in other African countries [39], with ongoing plans also in place among a number of African countries as part of National Antimicrobial Plans to improve susceptibility testing and their use, with the findings guiding future empirical use [39].

Documentation of the indication for antibiotic use is also important as part of ASPs in order to improve the quality of prescribing. Indications for antimicrobial use were captured in patients' case notes in only four (24%) of the participating hospitals. Use of surgical antimicrobial prophylaxis was also only monitored in four participating hospitals (24%) in this study. This practice was typically suboptimal, which is a concern as non-compliance with guidelines regarding the use of antimicrobial surgical prophylaxis would likely contribute to the development of AMR. We also see concerns with the use of surgical antimicrobial prophylaxis in other African countries [40,41,42]. Finally, only one hospital monitored antimicrobial use in its facility using either of the standard indices and tools for quantification of drug use, namely DDD or days of therapy. This, however, might be a consequence of inadequate knowledge of drug utilisation research methodology in Nigeria, which is starting to be addressed with the formation of Pan-African groups such as the MURIA group (Medicines Utilisation Research in Africa) with the help of the World Health Organization (WHO) and others [43,44]. The lack of usage of standard tools and methodologies limits the ability of physicians and other healthcare providers to monitor the quantity and quality of antibiotic use over time in their facilities. It also does not allow for a correlation of antibiotic consumption and resistance patterns within their facilities to improve future antibiotic prescribing. This is starting to be addressed in Africa with the growth in point prevalence antimicrobial studies as well as assessing antimicrobial prescribing against national guidelines [12,40,44–46].

### 4.4. Limitations

This study was conducted only in public tertiary-level healthcare facilities across several regions of Nigeria and, as such, the findings may not reflect the reality among all private and faith-based healthcare facilities; however, there was a good geographical spread. In addition, if concerns regarding ASPs were found in public tertiary hospitals in Nigeria, these are likely to be magnified in secondary care hospitals with their lack of trained specialists and other structures. The purposive nature of the sampling approach used may also be associated with an element of bias. We also explored descriptively the availability and structure of ASPs but did not investigate in depth how ASPs function in practice. This will be followed up through mixed methods research in the future. The impact of the ASP services on antimicrobial utilisation and resistance was also not explored, and this will be another area for future research. However, we believe that our findings are robust, necessitating an urgent need for the Nigerian Government to instigate ASPs starting in tertiary hospitals and progressing wider in order to reduce current AMR rates.

## 5. Conclusions

ASPs are lacking in a substantive proportion of Nigerian tertiary hospitals and, furthermore, they function suboptimally where available. Given the highlighted problems of inappropriate antimicrobial use in Nigeria and its associated consequences, there is an urgent need for concerted efforts to make ASPs functional in Nigeria, starting initially with tertiary healthcare facilities. This could begin with educational programmes in healthcare facilities, organised by the Ministry of Health, highlighting the importance of appropriate antibiotic use and followed-up with structures to monitor the establishment of ASPs and their influence on future antibiotic use. The programme could thereafter be cascaded to secondary and primary care levels for optimal results across the country.

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None.

## Competing interests

None declared.

## Ethical approval

Not required.

## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jgar.2018.11.025.

## References


[1] Prestinaci F, Pezzotti P, Pantosti A. Antimicrobial resistance: a global multifaceted phenomenon. Pathog Glob Health 2015;109:309–18.
[2] Michael CA, Dominey-Howes D, Labbate M. The antimicrobial resistance crisis: causes, consequences, and management. Front Public Health 2014;2:145.
[3] O'Neill J. Securing new drugs for future generations: the pipeline of antibiotics. The Review of Antimicrobial Resistance. https://amr-review.org/sites/default/files/SECURING%20NEW%20DRUGS%20FOR%20FUTURE%20GENERATIONS%20FINAL%20WEB_0.pdf. [Accessed 1 April 2019].
[4] Djuric O, Jovanovic S, Stosovic B, Tosic T, Jovanovic M, Markovic-Denic L. Antimicrobial resistance of selected invasive bacteria in a tertiary care center: results of a prospective surveillance study. J Infect Dev Ctries 2016;10:1325–31.
[5] Riedel S, Beekmann SE, Heilmann KP, Richter SS, Garcia-de-Lomas J, Ferech M, et al. Antimicrobial use in Europe and antimicrobial resistance in *Streptococcus pneumoniae*. Eur J Clin Microbiol Infect Dis 2007;26:485–90.
[6] MacDougall C, Polk RE. Antimicrobial stewardship programs in health care systems. Clin Microbiol Rev 2005;18:638–56.
[7] Davey P, Marwick CA, Scott CL, Charani E, McNeil K, Brown E, et al. Interventions to improve antibiotic prescribing practices for hospital inpatients. Cochrane Database Syst Rev 2017;2:CD003543.
[8] Goff DA, Mendelson M. Antibiotic stewardship hits a home run for patients. Lancet Infect Dis 2017;17:892–3.
[9] Sartelli M, Labricciosa FM, Barbadoro P, Pagani L, Ansaloni L, Brink AJ, et al. The Global Alliance for Infections in Surgery: defining a model for antimicrobial stewardship—results from an international cross-sectional survey. World J Emerg Surg 2017;12:34.
[10] Schellack N, Bronkhorst E, Coetzee R, Godman B, Gous AGS, Kolman S, et al. SASOCP position statement on the pharmacist's role in antibiotic stewardship 2018. S Afr J Infect Dis 2018;33:28–35.
[11] Nasr Z, Paravattil B, Wilby KJ. The impact of antimicrobial stewardship strategies on antibiotic appropriateness and prescribing behaviours in selected countries in the Middle East: a systematic review. East Mediterr Health J 2017;23:430–40.
[12] Nakwatumbah S, Kibuule D, Godman B, Haakuria V, Kalemeera F, Baker A, et al. Compliance to guidelines for the prescribing of antibiotics in acute infections at Namibia's national referral hospital: a pilot study and the implications. Expert Rev Anti Infect Ther 2017;15:713–21.
[13] Standiford HC, Chan S, Tripoli M, Weekes E, Forrest GN. Antimicrobial stewardship at a large tertiary care academic medical center: cost analysis before, during, and after a 7-year program. Infect Control Hosp Epidemiol 2012;33:338–45.
[14] Wagner B, Filice GA, Drekonja D, Greer N, MacDonald R, Rutks I, et al. Antimicrobial stewardship programs in inpatient hospital settings: a systematic review. Infect Control Hosp Epidemiol 2014;35:1209–28.
[15] Amer MR, Akhras NS, Mahmood WA, Al-Jazairi AS. Antimicrobial stewardship program implementation in a medical intensive care unit at a tertiary care hospital in Saudi Arabia. Ann Saudi Med 2013;33:547–54.
[16] Lanbeck P, Ragnarson Tennvall G, Resman F. A cost analysis of introducing an infectious disease specialist-guided antimicrobial stewardship in an area with relatively low prevalence of antimicrobial resistance. BMC Health Serv Res 2016;16:311.
[17] Hou D, Wang Q, Jiang C, Tian C, Li H, Ji B. Evaluation of the short-term effects of antimicrobial stewardship in the intensive care unit at a tertiary hospital in China. PLoS One 2014;9:e101447.
[18] Boyles TH, Whitelaw A, Bamford C, Moodley M, Bonorchis K, Morris V, et al. Antibiotic stewardship ward rounds and a dedicated prescription chart reduce antibiotic consumption and pharmacy costs without affecting inpatient mortality or re-admission rates. PLoS One 2013;8:e79747.
[19] Ekwochi U, Chinawa JM, Osuorah CD, Odetunde OI, Obu HA, Agwu S. The use of unprescribed antibiotics in management of upper respiratory tract infection in children in Enugu, South East Nigeria. J Trop Pediatr 2014;60:249–52.
[20] Fadare J, Olatunya O, Oluwayemi O, Ogundare O. Drug prescribing pattern for under-fives in a paediatric clinic in South-Western Nigeria. Ethiop J Health Sci 2015;25:73–8.
[21] Fadare JO, Adeoti AO, Aina F, Solomon OA, Ijalana JO. The influence of health insurance scheme on the drug prescribing pattern in a Nigerian tertiary healthcare facility. Niger Med J 2015;56:344–8.
[22] Hulscher M, Prins JM. Antibiotic stewardship: does it work in hospital practice? A review of the evidence base. Clin Microbiol Infect 2017;23:799–805.
[23] Olufunmiso O, Tolulope I, Roger C. Multidrug and vancomycin resistance among clinical isolates of *Staphylococcus aureus* from different teaching hospitals in Nigeria. Afr Health Sci 2017;17:797–807.
[24] Bernabe KJ, Langendorf C, Ford N, Ronat JB, Murphy RA. Antimicrobial resistance in West Africa: a systematic review and meta-analysis. Int J Antimicrob Agents 2017;50:629–39.
[25] Adenipekun EO, Jackson CR, Ramadan H, Iwalokun BA, Oyedeji KS, Frye JG, et al. Prevalence and multidrug resistance of *Escherichia coli* from community-acquired infections in Lagos, Nigeria. J Infect Dev Ctries 2016;10:920–31.
[26] Pollack LA, Plachouras D, Sinkowitz-Cochran R, Gruhler H, Monnet DL, Weber JT. A concise set of structure and process indicators to assess and compare antimicrobial stewardship programs among EU and US hospitals: results from a multinational expert panel. Infect Control Hosp Epidemiol 2016;37:1201–11.
[27] Kim B, Kim J. A survey of antimicrobial stewardship programs in Korea, 2015. J Korean Med Sci 2016;31:1553–9.
[28] Newland JG, Gerber JS, Weissman SJ, Shah SS, Turgeon C, Hedican EB, et al. Prevalence and characteristics of antimicrobial stewardship programs at freestanding children's hospitals in the United States. Infect Control Hosp Epidemiol 2014;35:265–71.
[29] Chou AF, Graber CJ, Jones M, Zhang Y, Goetz MB, Madaras-Kelly K, et al. Characteristics of antimicrobial stewardship programs at Veterans Affairs hospitals: results of a nationwide survey. Infect Control Hosp Epidemiol 2016;37:647–54.
[30] Avent ML, Hall L, Davis L, Allen M, Roberts JA, Unwin S, et al. Antimicrobial stewardship activities: a survey of Queensland hospitals. Aust Health Rev 2014;38:557–63.
[31] National Department of Health of South Africa. Antimicrobial resistance. National Strategy Framework 2014-2024. https://www.health-e.org.za/wp-content/uploads/2015/09/Antimicrobial-Resistance-National-Strategy-Framework-2014-2024.pdf. [Accessed 1 April 2019].
[32] O'Brien KA, Zhang J, Mauldin PD, Gomez J, Hurst JM, Sean Boger M, et al. Impact of a stewardship-initiated restriction on empirical use of ciprofloxacin on nonsusceptibility of *Escherichia coli* urinary isolates to ciprofloxacin. Pharmacotherapy 2015;35:464–9.
[33] Lee KR, Bagga B, Arnold SR. Reduction of broad-spectrum antimicrobial use in a tertiary children's hospital post antimicrobial stewardship program guideline implementation. Pediatr Crit Care Med 2016;17:187–93.
[34] Seah XF, Ong YL, Tan SW, Krishnaswamy G, Chong CY, Tan NW, et al. Impact of an antimicrobial stewardship program on the use of carbapenems in a tertiary women's and children's hospital, Singapore. Pharmacotherapy 2014;34:1141–50.
[35] Lesprit P, Landelle C, Brun-Buisson C. Clinical impact of unsolicited post-prescription antibiotic review in surgical and medical wards: a randomized controlled trial. Clin Microbiol Infect 2013;19:E91–7.
[36] Akinkunmi EO, Adesunkanmi AR, Lamikanra A. Pattern of pathogens from surgical wound infections in a Nigerian hospital and their antimicrobial susceptibility profiles. Afr Health Sci 2014;14:802–9.
[37] Iliyasu G, Daiyab FM, Tiamiyu AB, Abubakar S, Habib ZG, Sarki AM, et al. Nosocomial infections and resistance pattern of common bacterial isolates in an intensive care unit of a tertiary hospital in Nigeria: a 4-year review. J Crit Care 2016;34:116–20.
[38] Kassim A, Omuse G, Premji Z, Revathi G. Comparison of Clinical Laboratory Standards Institute and European Committee on Antimicrobial Susceptibility Testing guidelines for the interpretation of antibiotic susceptibility at a university teaching hospital in Nairobi, Kenya: a cross-sectional study. Ann Clin Microbiol Antimicrob 2016;15:21.
[39] Meyer JC, Schellack N, Stokes J, Lancaster R, Zeeman H, Defty D, et al. Ongoing initiatives to improve the quality and efficiency of medicine use within the public healthcare system in South Africa; a preliminary study. Front Pharmacol 2017;8:751.
[40] Tiroyakgosi C, Matome M, Summers E, Mashalla Y, Paramadhas BA, Souda S, et al. Ongoing initiatives to improve the use of antibiotics in Botswana: University of Botswana symposium meeting report. Expert Rev Anti Infect Ther 2018;16:381–4.
[41] Opanga SA, Mwang'ombe NJ, Okalebo FA, Godman B, Oluka M, Kuria KAM. Determinants of the effectiveness of antimicrobial prophylaxis among neurotrauma patients at a referral hospital in Kenya: findings and implications. J Infect Dis Prev Med 2017;5:3.
[42] Mwita JC, Souda S, Magafu M, Massele A, Godman B, Mwandri M. Prophylactic antibiotics to prevent surgical site infections in Botswana: findings and implications. Hosp Pract 2018;46:97–102.
[43] Massele A, Burger J, Katende-Kyenda NL, Kalemeera F, Kenaope T, Kibuule D, et al. Outcome of the first Medicines Utilization Research in Africa group meeting to promote sustainable and rational medicine use in Africa. Expert Rev Pharmacoeconom Outcomes Res 2015;15:885–8.
[44] Massele A, Tiroyakgosi C, Matome M, Desta A, Muller A, Paramadhas BD, et al. Research activities to improve the utilization of antibiotics in Africa. Expert Review Pharmacoeconom Outcomes Res 2017;17:1–4.
[45] Versporten A, Zarb P, Caniaux I, Gros MF, Drapier N, Miller M, et al. Antimicrobial consumption and resistance in adult hospital inpatients in 53 countries: results of an internet-based global point prevalence survey. Lancet Glob Health 2018;6:e619–29 Erratum in: Lancet Glob Health 2018;6:e968.
[46] Dlamini N, Meyer JC, Kruger D, Kurdi A, Godman B, Schellack N. Feasibility of using point prevalence surveys to assess antimicrobial utilisation in public hospitals in South Africa: a pilot study and implications. Hosp Pract 2019;47:88–95.