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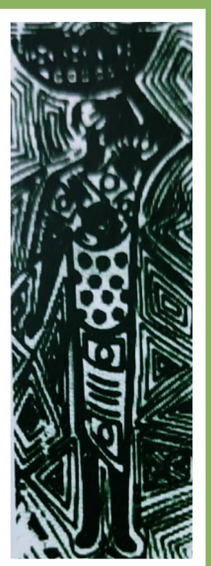

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# Understanding Antimicrobial Stewardship in Paediatric Practice: A Conceptual Framework

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**Abstract**

Antimicrobial resistance (AMR) poses a significant global health threat, with 5 million deaths linked to bacterial AMR in 2021, projected to reach 10 million by 2050. Low- and middle-income countries (LMICs) like Nigeria face a high AMR burden, particularly among children under 5, driven by infectious diseases such as neonatal sepsis and respiratory infections. Inappropriate antibiotic use, fuelled by limited diagnostics, unregulated access, and poor regulatory frameworks, exacerbates this crisis. Nigeria's National Action Plan (NAP) 2.0 (2024) prioritises antimicrobial stewardship (AMS) in healthcare facilities, yet pediatric AMS programs are scarce due to low awareness, skill gaps, and communication challenges. This review outlines the state of AMS in Nigeria, emphasising the need for paediatric-specific programs to combat AMR and reduce under-5 mortality. A conceptual framework is proposed to streamline AMS implementation, linking inputs (human resources, infrastructure, policies), processes (audits, guidelines, education), and outputs (rational antibiotic use, reduced AMR). The framework highlights synergy with Infection Prevention and Control, Diagnostic Stewardship Programmes, Patient Safety, and Behavioural Change Interventions. Key recommendations include establishing multidisciplinary AMS teams, investing in point-of-care diagnostics, providing training, and utilising digital tools like e-prescribing. The Nigerian Society for Paediatric Infectious Diseases AMS network, modelled on the UK-PAS, can drive advocacy and training.

***Keywords: Antimicrobial Resistance, Antimicrobial Stewardship, Children, Conceptual Framework, Infectious diseases.***

## Introduction

Antimicrobial resistance is one of the top 10 global health concerns, with an estimated 5 million deaths associated with bacterial AMR in 2021, and 1.14 million deaths attributed to BAMR in the same year.[1] Unchecked, this figure is estimated to reach 10 million deaths annually by 2050.[2] In 2019, low- and middle-income countries carried the highest burden of bacterial AMS, with the highest incidence of 27.3 deaths per 100,000 seen in western Sub-Saharan Africa.[3] The main drivers of AMR are antibiotic misuse and overuse, which are compounded by limited diagnostic capacities, unregulated access to antibiotics, high burden of infectious diseases and poor regulatory framework.[4, 5] These conditions are prevalent in most LMICs, including Nigeria. Paediatric populations are particularly at risk of AMR due to the high prevalence of infectious diseases and use of empirical treatment in children. A systematic review and forecast of AMR to 2050 revealed that children under five years were most affected by AMR. [1]

To address the rising burden of AMR, the World Health Organisation GAP recommends he establishment of AMS programmes in healthcare facilities. The Nigerian AMR NAP 1.0 launched in 2017, and more recently, the NAP 2.0 of 2024 highlights AMS in healthcare facilities as priority interventions to address AMR in Nigeria. Evidence abounds of the effectiveness of AMS in addressing AMR in paediatric settings. However, reviews of the

AMS programme in Nigeria reveal a lack of AMS in most paediatric settings in Nigeria. This signifies a critical gap in healthcare delivery among paediatric practices. Various reasons have been alluded to for this, including a lack of awareness, skills lag or gap in developing and delivering AMS programmes, and a lack of understanding or communication of AMS programmes to stakeholders.

This review provides an overview of the state of AMS programmes in Nigeria, highlights the essential components of an effective AMS programme, and presents a conceptual framework to support establishing AMS programmes in paediatric settings in Nigeria. It concludes with actionable steps to guide rational antibiotic use in children through a functional, sustainable AMS programme in paediatric practice in Nigeria.

## Burden of infection and AMR in children and the need for AMS Programmes

Globally, infectious diseases contribute significantly to under-5 mortality (U5M).[6] The leading causes of U5M are neonatal disorders, lower respiratory infections, diarrhoeal diseases, birth defects and malaria.[7] Nigeria has one of the highest U5MR in the world, with infectious diseases such as neonatal sepsis, lower respiratory tract infection, diarrhoeal diseases, malaria and measles playing leading roles. [6, 8, 9] Increasingly, drug-resistant organisms are playing a significant role in paediatric infections, including in Nigeria.[1, 10-16] Inappropriate antibiotic use in children is widespread.[17-19] The most common infections in children are respiratory infections and diarrhoea diseases. These are often associated with a high prevalence of antibiotic use despite being predominantly caused by viruses that do not require antibiotics.[20] Various contributing factors have been alluded to this, ranging from a physician's uncertainty as to the cause of the infection, whether bacterial or fungal, physician incompetence in evaluating the child, pressure from family, concerns or fear of withholding antibiotics from a child with untoward consequences, lack of access to laboratory diagnostics, and exceptionally rapid or point-of-care diagnostics. Emerging evidence is also highlighting the dangers of the effect of inappropriate antibiotic use in later life. These include a dysbiosis with disruption of the microbiome, increased risk of drug-resistant infections, diabetes and inflammatory conditions like asthma.[21] Antibiotic use in paediatrics is thus a prime target for antimicrobial stewardship interventions.

## Understanding the AMS Programme

Addressing the AMR burden involves engaging a wide array of stakeholders, including clinicians and scientists who are often not familiar with the concept of AMR, as well as other related medical literature and terminologies. It therefore requires that AMR and associated issues be communicated in an easily comprehensible manner by the content experts and implementers to governments, policymakers, the legislature, economic and development experts, rights groups, and the general public. Unfortunately, this is not often the case, and critical stakeholders frequently lack an understanding of the concepts of AMR. Compounding this is the absence of indigenous terminology for AMR or AMS in most affected communities. This partly explains why a survey published by the World Health Organisation in 2015 revealed only 21% of participants had heard the term AMR before, compared to 70% for antibiotic resistance.[22] Thus, AMR has been said to have a language problem.[23] This is also true for antimicrobial stewardship. Among healthcare providers, the concept of AMS is new or unknown to most, or at best, it is abstract. What makes this even more confusing is that the AMS concept applies to different strata of society: global, regional, national, sub-national, healthcare facility, and individual levels. It also applies to human, animal and environmental health sectors. Therefore, it is necessary to communicate the concept of AMS to healthcare providers, government, policymakers, consumers of healthcare

services, and stakeholders in ways that are easily comprehended and relatable.

### *Conceptual framework for AMS*

A conceptual framework for AMS can therefore be a handy tool for presenting the concept of facility AMS in a simple, comprehensible manner. A conceptual framework for antimicrobial stewardship (AMS) streamlines comprehension by visually and logically mapping how AMS programs operate within healthcare settings. It links key elements such as inputs (resources, policies), processes (interventions, audits), and outputs (outcomes like reduced resistance), while highlighting interconnections with related programs, including infection prevention and control (IPC), diagnostic stewardship, all resting on a foundation of behavioural change and patient safety initiatives (Figure 1).

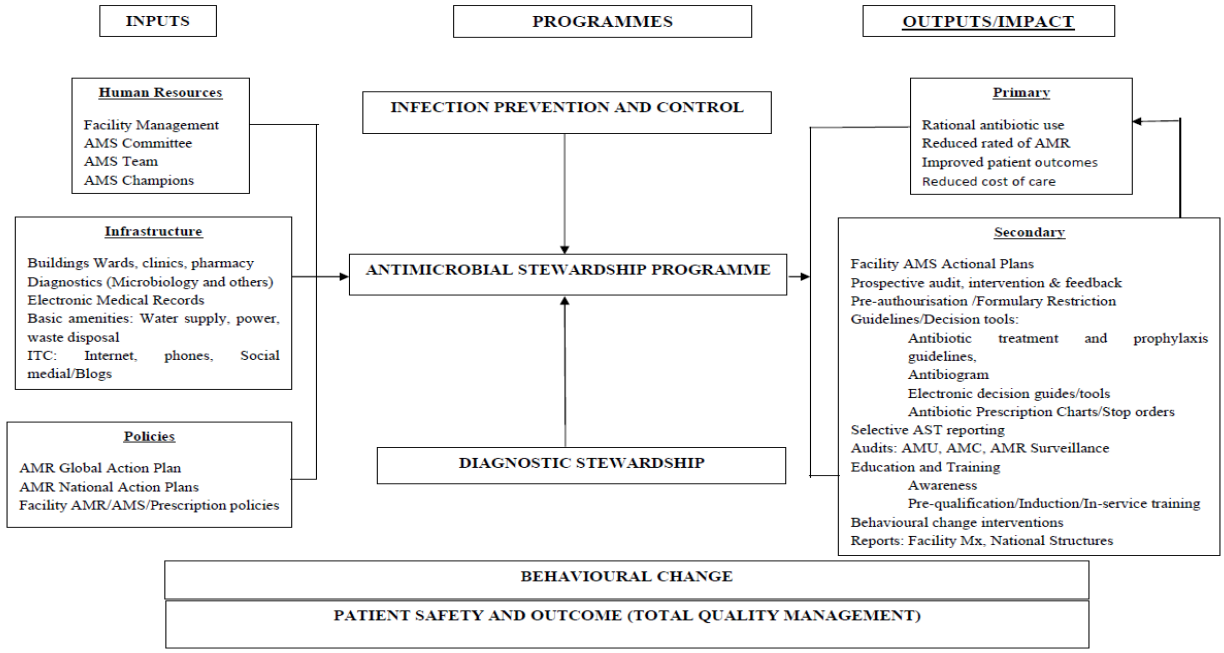


**Figure 1: Conceptual Framework of an Antimicrobial Stewardship Programme**

*The inputs for an AMS Programme*

Essential inputs for an AMS programme can be broadly grouped into three: human resources, infrastructure and policy guidance/backing. The human resource needs include a facility management team, an AMS Committee and/or Team, and AMS Champions.[24] Facility management is a key human resource component of an AMS programme, as the required policies and action plans will need their approval. In addition, the facility management is a key constituent of the AMS Committee, which is the highest decision-making authority regarding the AMS programme and interventions in the facility. Other constituent members of the AMS Committee include AMS content experts, such as infectious diseases, clinical microbiologists and AMS pharmacists/clinical pharmacologists, heads of clinical units, including nursing, clinical epidemiology, IPC and Drugs and Therapeutics Committee, information technology unit, the medical records, environmental department, patient interests' representative, quality improvement unit and a secretariat staff.[24] The AMS Team is a core of professionals involved in the day-to-day activities of implementing a facility's AMS programme. The AMS champions are another human resource needed to help overcome obstacles and barriers in the course of executing an AMS programme. These are usually people of high repute who can interface with facility management, prescribers, patients or patient

groups, and the community to ensure the objectives of an AMS programme are achieved. They may be from within or outside the healthcare facilities.

Next is the necessary infrastructure for a functional AMS programme. These include a medical microbiology laboratory, a pharmacy, admission wards and clinics, an IT infrastructure for communication and a hospital information system covering electronic medical records, laboratory and pharmacy information systems. In most LMICs, attention must be paid to adequate water and electricity power supply systems. Lastly, there are the policies and policy documents, which give validity and from which the AMS programme draws justification and alignment with global and national interventions. The WHO GAP on AMR and the Nigeria One Health NAP 2.0 are such documents. [25, 26] Health facilities may develop facility-specific AMR policies to address contextual issues while aligning with national and global policies.

*The outputs for an AMS Programme*

The main outputs desired in any AMS programme are rational use of antibiotics, reduction in AMR burden, improved patient outcomes, and often an associated reduced cost of care. Health facilities may choose any of these, or subsets thereof, as key performance indicators of the AMS programme for the facility. These primary outputs are achieved through a series of secondary outputs or AMS interventions and processes.

*AMS Programme Interventions and Processes*

Several activities and processes take place within an AMS Programme. A detailed description can be found in the WHO practical tool kit for AMS in LMIC.[24] They consist of core interventions comprising prospective audits and feedback, and pre-authorisation and formulary restriction. These are evidence-based interventions that have been found to achieve rational use of antibiotics. At least one of these is recommended for inclusion in any ASM programme. Other supplementary interventions include antibiogram and guideline development, electronic decision guides/tools, education and training, selective reporting, AMR/AMU/AMC surveillance, using data for action, and reporting, feedback, and interactive fora. One or more of these may be deployed concurrently or sequentially, depending on contextual exigencies.

*Interacting or Interrelated Programmes*

A conceptual framework for antimicrobial stewardship (AMS) programs emphasises the synergy between AMS, Infection Prevention and Control (IPC), and Diagnostic Stewardship Programs (DSP). IPC reduces hospital-acquired infections and antibiotic demand, while DSP ensures accurate, timely diagnostics for targeted antibiotic use.[27] Together, these programs enhance rational prescribing and combat antimicrobial resistance (AMR). In settings with limited human resources for the AMS programme, an approach to an integrated AMS/IPC/DSP may be deployed. [28, 29]

*The Foundation*

For any AMS programme, patient safety initiatives are the overarching goal, so all AMS programmes should align with the principal health facility's goal of ensuring patient safety. This goal is often embedded in people-centred facility quality improvement or a total quality management programme.[30] Often bedevilling irrational antibiotic use are human or institutional behaviours. Behavioural change interventions are imperative to ensure that desired changes in rational antibiotic use are achieved. There usually exists a “prescribing etiquette” amongst medical practitioners, and behavioural change interventions can be used to positively influence this, as well as help develop a "culture to culture". A guide to implementing behavioural change interventions is well developed in the WHO document on **T**ailoring **A**ntimicrobial Resistance **P**rogrammes Manual. [31]

*Beyond Understanding AMS Programmes: Strategic Value of a Conceptual Framework*

A conceptual framework for antimicrobial stewardship (AMS) programs not only improves understanding and communication of an AMS program but also clarifies the scope and sequence of required actions. In addition, the Conceptual Framework aligns resources with programme goals, fosters cross-departmental collaboration, and is a potent tool for advocacy and planning. Furthermore, it supports monitoring, evaluation, and sustainability by delineating responsibilities, clarifying elements to monitor, and integrating AMS with broader institutional goals, processes (e.g., Infection Prevention and Control [IPC] and Diagnostic Stewardship Programs [DSP]), and resource needs to ensure long-term impact.

## Theoretical Frameworks for AMS Programme Implementation

Beyond understanding AMS, theoretical frameworks provide templates for implementing specific interventions or targeting AMS programmes. Good-fit theoretical frameworks include the PDSA cycle (Prepare, Do, Study, Adjust) and the COM-B Model (Capability, Opportunity, Motivation - Behaviour). Smart models like the PDSA cycle help implement AMS interventions to reduce changing antibiotic use patterns in specific disease conditions such as asthma.[32] This is premised on a **plan** to study the factors associated with the inappropriate use of antibiotics in clinical situations and to propose a set of AMS interventions. Then **do**: which may include education and training, guideline provision, pre-authorisation and formulary restriction, or a combination of these. After this, a **study** of the impact of these interventions is evaluated. This may be in the form of antimicrobial use surveillance, antimicrobial consumption surveillance, or both. Then adjust: using the data gathered from the antimicrobial use and/or antimicrobial consumption surveillance to revise the action **plan**. This complete cycle of plan-do-study-adjust has been effectively used to reduce inappropriate use of antibiotics presenting with asthma to an emergency department.[32] The COM-B Model (Capability, Opportunity, Motivation - Behaviour) is best suited to behavioural change interventions in an AMS programme. It is premised on the proposition that the healthcare worker's capability (such as knowledge and understanding of expectations and skill set needed for a desired or required action), opportunity (contextual factors which enhances or acts as barriers to taking the desired action) and, the motivation (the perceived benefit or rewards systems that reinforces taking the desired action) are essential for the healthcare worker's behaviour. This can be used in the setting of education and training or behaviour change interventions to ensure antibiotic guideline use in AMS programmes.[33, 34] The PDSA cycle and the COM-B Model may be used to implement different AMS interventions, either in isolation or combined for a particular AMS intervention.

## Recommendations

The unacceptable high under-five mortality and AMR burden in Nigeria, driven by infectious diseases like neonatal sepsis and respiratory infections, calls for robust paediatric antimicrobial stewardship (AMS) programs. This aligns with Nigeria's One Health AMR National Action Plan (NAP) 2.0, and the conceptual framework integrating AMS, IPC, and DSP is a tool to facilitate this. A professional organisation like the Paediatric Association of Nigeria can take leadership by mandating paediatric AMS programmes in healthcare facilities. The Nigerian Society for Paediatric Infectious Diseases, which has been at the forefront of supporting paediatricians to establish AMS programmes, can provide technical assistance by supporting the establishment and training of multidisciplinary teams to actualise this mandate. Investing in microbiology diagnostic platforms and point-of-care (POC) diagnostics is essential to reduce empirical prescribing. This should be complemented by providing equitable access to quality-assured antibiotics. Added to this is the

need for innovative and sustainable finance mechanisms and the integration with electronic medical records (EMRs) for real-time AMS decisions. The underpinning role of behavioural change cannot be overemphasised**.** Reviewing the curriculum and incorporating AMS modules into medical school and pediatric residency programmes are essential imperatives. Lastly, strengthening the NISPID AMS Network, and modelled on programmes such as the UK-PAS, to coordinate training and policy advocacy should be strongly considered.[35]

## Conclusion

Nigeria can reduce its AMR burden and under-5 mortality by integrating AMS with IPC and DSP, leveraging PDSA and COM-B frameworks, and aligning with NAP 2.0. Sustainable financing, scalable diagnostics, and national networks are critical for long-term impact, positioning paediatric AMS within Universal Health Coverage agendas.

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**References**

1. Naghavi M, Vollset SE, Ikuta KS, Swetschinski LR, Gray AP, Wool EE, *et al.* Global burden of bacterial antimicrobial resistance 1990–2021: a systematic analysis with forecasts to 2050. *The Lancet* 2024;404(10459):1199-226.
2. O'Neill J. Tackling drug-resistant infections globally: final report and recommendations. 2016. Review on Antimicrobial Resistance. Wellcome Trust and HM Government. https://amr-review.org/sites/default/files/160525_Final%20paper_with%20cover.pdf
3. Murray CJ, Ikuta KS, Sharara F, Swetschinski L, Aguilar GR, Gray A, *et al.* Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *The Lancet* 2022;399(10325):629-55.
4. Holmes AH, Moore LS, Sundsfjord A, Steinbakk M, Regmi S, Karkey A, *et al.* Understanding the mechanisms and drivers of antimicrobial resistance. *The Lancet* 2016;387(10014):176-87.
5. Fadare JO, Ogunleye O, Iliyasu G, Adeoti A, Schellack N, Engler D, *et al.* Status of antimicrobial stewardship programmes in Nigerian tertiary healthcare facilities: Findings and implications. *J Glob Antimicrob Resist* 2019;17:132-6.
6. Sharrow D, Hug L, You D, Alkema L, Black R, Cousens S, *et al.* Global, regional, and national trends in under-5 mortality between 1990 and 2019 with scenario-based projections until 2030: a systematic analysis by the UN Inter-agency Group for Child Mortality Estimation. *The Lancet Global Health*. 2022;10(2):e195-e206.
7. Paulson KR, Kamath AM, Alam T, Bienhoff K, Abady GG, Abbas J, *et al.* Global, regional, and national progress towards Sustainable Development Goal 3.2 for neonatal and child health: all-cause and cause-specific mortality findings from the Global Burden of Disease Study 2019. *The Lancet* 2021;398(10303):870-905.
8. Okoroiwu HU, Edet UO, Uchendu IK, Echieh CP, Nneoyi-Egbe AF, Anyanwu SO, *et al.* Causes of infant and under-five (under-5) morbidity and mortality among hospitalised patients in Southern Nigeria: A hospital-based study. *J Public Health Res* 2024;13(1):22799036241231787.
9. Odejimi A, Quinley J, Eluwa GI, Kunnuji M, Wammanda RD, Weiss W, *et al.* Causes of deaths in neonates and children aged 1–59 months in Nigeria: verbal autopsy findings of 2019 Verbal and Social Autopsy study. *BMC Public Health* 2022;22(1):1130.
10. Obadare TO, Adejuyigbe EA, Adeyemo AT, Amupitan AA, Ugowe OJ, Anyabolu CH, *et al*. Clinical and bacteriological profiles of neonatal sepsis in a tertiary hospital, south-western Nigeria. *Germs.* 2023;13(2):137.
11. Iroh Tam P-Y, Musicha P, Kawaza K, Cornick J, Denis B, Freyne B, *et al.* Emerging resistance to empiric antimicrobial regimens for pediatric

bloodstream infections in Malawi (1998–2017). *Clin Infect Dis* 2019;69(1):61-8.
12. Sands K, Carvalho MJ, Portal E, Thomson K, Dyer C, Akpulu C, *et al.* Characterisation of antimicrobial-resistant Gram-negative bacteria that cause neonatal sepsis in seven low-and middle-income countries. *Nature Microbiol* 2021;6(4):512-23.
13. Mashau RC, Meiring ST, Dramowski A, Magobo RE, Quan VC, Perovic O, *et al.* Culture-confirmed neonatal bloodstream infections and meningitis in South Africa, 2014–19: A cross-sectional study. *The Lancet Global Health* 2022;10(8):e1170-e8.
14. Williams PC, Isaacs D, Berkley JA. Antimicrobial resistance among children in sub-Saharan Africa. *The Lancet Infect Dis* 2018;18(2):e33-e44.
15. Kowalski M, Obama BM, Catho G, Dewez JE, Merglen A, Ruef M, *et al.* Antimicrobial resistance in Enterobacterales infections among children in sub-Saharan Africa: A systematic review and meta-analysis. *EClinicalMedicine*. 2024;70.
16. Uzairue LI, Shittu OB, Ojo OE, Obuotor TM, Olanipekun G, Ajose T, *et al.* Antimicrobial resistance and virulence genes of invasive Salmonella enterica from children with bacteremia in north-central Nigeria. *SAGE Open Med* 2023;11:20503121231175322.
17. Ardillon A, Ramblière L, Kermorvant-Duchemin E, Sok T, Zo AZ, Diouf J-B, *et al.* Inappropriate antibiotic prescribing and its determinants among outpatient children in 3 low-and middle-income countries: a multicentric community-based cohort study. *PLoS Med* 2023;20(6):e1004211.
18. Hersh AL, Jackson MA, Hicks LA, Diseases CoI, Brady MT, Byington CL, *et al.* Principles of judicious antibiotic prescribing for upper respiratory tract infections in pediatrics. *Pediatrics* 2013;132(6):1146-54.
19. Hersh AL, Shapiro DJ, Pavia AT, Shah SS. Antibiotic prescribing in ambulatory pediatrics in the United States. *Pediatrics* 2011;128(6):1053-61.
20. Nyquist A-C, Gonzales R, Steiner JF, Sande MA. Antibiotic prescribing for children with colds, upper respiratory tract infections, and bronchitis. *JAMA* 1998;279(11):875-7.
21. Aversa Z, Atkinson EJ, Schafer MJ, Theiler RN, Rocca WA, Blaser MJ, *et al.* (Editors). Association of infant antibiotic exposure with childhood health outcomes. Mayo Clinic Proceedings; 2021: Elsevier.
22. Organisation WH. Antibiotic resistance: multi-country public awareness survey. Antibiotic resistance: multi-country public awareness survey 2015.
23. Mendelson M, Balasegaram M, Jinks T, Pulcini C, Sharland M. Antibiotic resistance has a language problem. *Nature News* 2017;545(7652):23.
24. World Health Organisation. Antimicrobial stewardship programmes in health-care facilities in low- and middle-income countries. A practical toolkit. Geneva: World Health Organisation; 2019.
25. World Health Organisation. Global Action Plan for Antimicrobial Resistance. Geneva: World Health Organisation, 2015.
26. Nigeria Centre for Disease Control and Prevention. One Health ANTIMICROBIAL RESISTANCE National Action Plan 2.0 2024 2028. Abuja: Nigeria Centre for Disease Control and Prevention, 2024.
27. Lewnard JA, Charani E, Gleason A, Hsu LY, Khan WA, Karkey A, *et al.* Burden of bacterial antimicrobial resistance in low-income and middle-income countries avertible by existing interventions: an evidence review and modelling analysis. *The Lancet* 2024;403(10442):2439-54.
28. WHO policy guidance on integrated antimicrobial stewardship activities. Geneva: World Health Organisation; 2021. 2021
29. Dik J-WH, Poelman R, Friedrich AW, Panday PN, Lo-Ten-Foe JR, Assen SV, *et al.* An integrated stewardship model: antimicrobial, infection prevention and diagnostic (AID). *Future Microb*. 2016;11(1):93-102.
30. Organisation WH. People-centred approach to addressing antimicrobial resistance in human health: WHO core

package of interventions to support national action plans. 2023.
31. Organisation WH. The TAP manual: an in-depth guide for planning and implementing tailoring antimicrobial resistance programmes. Copenhagen: WHO Regional Office for Europe; 2022.
32. Dorzin SE, Halaby C, Quintos ML, Noor A, El-Chaar G. Antimicrobial stewardship program using plan-do-study-act cycles to reduce unjustified antibiotic prescribing in children admitted with an asthma exacerbation. The Journal of Pediatric Pharmacol Therap 2017;22(6):436-43.
33. Shano S, Kalam MA, Afrose S, Rahman MS, Akter S, Uddin MN, *et al.* An application of COM-b model to explore factors influencing veterinarians' antimicrobial prescription behaviors: Findings from a qualitative study in Bangladesh. *Plos one.* 2024;19(12):e0315246.
34. Turner R, Hart J, Ashiru-Oredope D, Atkins L, Eades C, Felton T, *et al.* A qualitative interview study applying the COM-B model to explore how hospital-based trainers implement antimicrobial stewardship education and training in UK hospital-based care. *BMC Health Serv Res* 2023;23(1):770.
35. UK Paediatric Antimicrobial Stewardship https://uk-pas.co.uk/